Research outputs:

16S rRNA gene sequencing and radioisotopic analysis reveal the composition of ammonia acclimatized methanogenic consortia

Different mesophilic and thermophilic methanogenic consortia were acclimatised and enriched to extreme total ammonia (9.0 and 5.0 g NH4+-N L-1, respectively) and free ammonia (1.0 and 1.4 g NH3-N L-1, respectively) levels in this study. [2-14C] acetate radioisotopic analyses showed the dominance of aceticlastic methanogenesis in all enriched consortia. According to 16S rRNA gene sequencing result, in mesophilic consortia, methylotrophic Methanomassiliicoccus luminyensis was predominant, followed by aceticlastic Methanosarcina soligelidi. A possible scenario explaining the dominance of M. luminyensis includes the use of methylamine produced by Tissierella spp. and biomass build-up by metabolizing acetate. Nevertheless, further studies are needed to pinpoint the exact metabolic pathway of M. luminyensis. In thermophilic consortia, aceticlastic Methanosarcina thermophila was the sole dominant methanogen. Overall, results derived from this study demonstrated the efficient biomethanation ability of these ammonia-tolerant methanogenic consortia, indicating a potential application of these consortia to solve ammonia toxicity problems in future full-scale reactors.
Microbial electrolytic disinfection process for highly efficient Escherichia coli inactivation

Water quality deterioration caused by a wide variety of recalcitrant organics and pathogenic microorganisms has become a serious concern worldwide. Bio-electro-Fenton systems have been considered as cost-effective and highly efficient water treatment platform technology. While it has been extensively studied for recalcitrant organics removal, its application potential towards water disinfection (e.g., inactivation of pathogens) is still unknown. This study investigated the inactivation of Escherichia coli in a microbial electrolysis cell based bio-electro-Fenton system (renamed as microbial electrolytic-Fenton cell) with the aim to broaden the application of microbial electrochemistry. Results showed that a 4-log reduction of Escherichia coli (10⁷ to hundreds CFU/mL) was achieved with an external applied voltage of 0.2 V, 0.3 mM Fe²⁺ and cathodic pH of 3.0. However, non-notable inactivation was observed in the control experiments without external voltage or Fe²⁺ dose. The disinfection effect was enhanced when cathode air flow rate increased from 7 to 41 mL/min and was also in proportion to the increase of Fe²⁺ concentration from 0.15 to 0.45 mmol/mL. Fatal cell membrane destruction by [rad]OH was identified as one potential mechanism for disinfection. This study successfully demonstrated the feasibility of bio-electro-Fenton process for pathogens inactivation, which offers insight for the future development of sustainable, efficient, and cost-effective biological water treatment technology.

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Scopus rating (2015): CiteScore 2.75
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BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 3.03
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Acclimation to extremely high ammonia levels in continuous biomethanation process and the associated microbial community dynamics

Acclimated anaerobic communities to high ammonia levels can offer a solution to the ammonia toxicity problem in biogas reactors. In the current study, a stepwise acclimation strategy up to 10 g NH4+-N L−1 was performed in mesophilic (37 ± 1 °C) continuously stirred tank reactors. The reactors were co-digesting (20/80 based on volatile solid) cattle slurry and microalgae, a protein-rich, 3rd generation biomass. Throughout the acclimation period, methane production was stable with more than 95% of the uninhibited yield. Next generation 16S rRNA gene sequencing revealed a dramatic microbiome change throughout the ammonia acclimation process. Clostridium ultunense, a syntrophic acetate oxidizing bacteria, increased significantly alongside with hydrogenotrophic methanogen Methanoculleus spp., indicating strong hydrogenotrophic methanogenic activity at extreme ammonia levels (>7 g NH4+-N L−1). Overall, this study demonstrated for the first time that acclimation of methanogenic communities to extreme ammonia levels in continuous AD process is possible, by developing a specialised acclimation AD microbiome.
BFI (2018): BFI-level 2
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Scopus rating (2017): CiteScore 6.28 SJR 2.029 SNIP 1.799
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BFI (2016): BFI-level 2
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Web of Science (2016): Impact factor 5.651
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.47 SJR 2.243 SNIP 1.897
Web of Science (2015): Impact factor 4.917
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.3 SJR 2.399 SNIP 2.087
Web of Science (2014): Impact factor 4.494
Web of Science (2014): Indexed yes
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ISI indexed (2013): ISI indexed yes
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BFI (2012): BFI-level 2
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BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 5.56 SJR 2.308 SNIP 2.507
Web of Science (2011): Impact factor 4.98
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Scopus rating (2010): SJR 2.089 SNIP 2.344
Web of Science (2010): Impact factor 4.365
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BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.915 SNIP 2.236
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.736 SNIP 2.74
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.403 SNIP 2.396
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.314 SNIP 2.003
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.278 SNIP 1.98
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.19 SNIP 1.655
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.942 SNIP 1.665
Web of Science (2003): Indexed yes
Amino acids production focusing on fermentation technologies – A review

Amino acids are attractive and promising biochemicals with market capacity requirements constantly increasing. Their applicability ranges from animal feed additives, flavour enhancers and ingredients in cosmetic to specialty nutrients in pharmaceutical and medical fields.

This review gives an overview of the processes applied for amino acids production and points out the main advantages and disadvantages of each.

Due to the advances made in the genetic engineering techniques, the biotechnological processes, and in particular the fermentation with the aid of strains such as Corynebacterium glutamicum or Escherichia coli, play a significant role in the industrial production of amino acids. Despite the numerous advantages of the fermentative amino acids production, the process still needs significant improvements leading to increased productivity and reduction of the production costs.

Although the production processes of amino acids have been extensively investigated in previous studies, a comprehensive overview of the developments in bioprocess technology has not been reported yet. This review states the importance of the fermentation process for industrial amino acids production, underlining the strengths and the weaknesses of the process. Moreover, the potential of innovative approaches utilizing macro and microalgae or bacteria are presented.

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BFI (2015): BFI-level 2
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Anaerobic co-digestion of macroalgal biomass with cattle manure under high salinity conditions

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A novel process for volatile fatty acids production from syngas by integrating with mesophilic alkaline fermentation of waste activated sludge

The present study proposed and demonstrated a novel process for the bioconversion of syngas (mainly CO and H2) to valuable volatile fatty acids (VFA) by integrating with mesophilic alkaline fermentation of waste activated sludge (WAS). The results showed that although pH 9 was suitable for VFA production from WAS, 62.5% of the consumed CO was converted to methane due to the presence of hydrogenogenic pathway for CO conversion. The increase of pH from 9 to 9.5 inhibited the methane production from CO because of the possible presence of only acetogenic pathway for CO conversion. However, methane was still produced from H2 contained in syngas through hydrogenotrophic methanogenesis, and around 32–34% of the consumed syngas was converted to methane. At both pH 9 and 9.5, methane was produced by hydrogenotrophic methanogens Methanobacteriales. Further increase of pH to 10 effectively inhibited methane production from syngas, and efficient VFA (mainly acetate with the concentration of around 135mM) production by simultaneous conversion of syngas and WAS was achieved. High acetate concentrations (>150mM) were shown to have serious negative effects on the conversion of syngas. The addition of syngas to the mesophilic alkaline fermentation of WAS at pH 10 not only resulted in the enrichment of some known bacteria related with syngas conversion, but also changed the microbial community compositions for the fermentation of WAS.
A proposed mechanism for the ammonia-LCFA synergetic co-inhibition effect on anaerobic digestion process

Ammonia and long chain fatty acids (LCFA) are two major inhibitors of the anaerobic digestion (AD) process. The individual inhibitory effect of each of these two inhibitors is well established; however, the combined co-inhibition effect has not been thoroughly assessed yet. In the current study, the ammonia-LCFA synergetic co-inhibition effect was investigated in both batch and continuous experiments. In the batch experiments, a clear ammonia-LCFA synergetic co-inhibitory effect was identified when the LCFA concentrations were higher than 0.05 g oleate L⁻¹ and ammonia levels between 4.0 and 7.0 NH₄⁺-N L⁻¹. This synergetic effect for LCFA and ammonia levels above 1.1 g oleate L⁻¹ and 4.5 NH₄⁺-N L⁻¹, respectively, was validated in continuous reactors experiments. Nevertheless, adaptation of the AD microbiome to this synergetic co-inhibition could occur after a period of continuous operation. A potential mechanism to explain the synergetic co-inhibition lies on the initial inhibition of methanogens caused by ammonia resulting in increased VFA and hydrogen concentrations, which in turn renders β-oxidation of LCFA thermodynamically unfavourable and thereby brings about...
further excess accumulation of LCFA and consequently higher unspecific toxicity of all AD steps. This is a vicious cycle, which makes the combined inhibition of the two toxicants more severe, compared to the sum of their individual inhibition effects at the same operational conditions.

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BFI (2015): BFI-level 1
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BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 2.72
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 3.03
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Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
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BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 2.95
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BFI (2010): BFI-level 1
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Web of Science (2010): Indexed yes
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BFI (2008): BFI-level 1
Bioelectrochemical systems serve anaerobic digestion process for process monitoring and biogas upgrading

Bioelectrochemical systems (BESs), which employ microbes as catalysts to convert chemical energy stored in organic matter into sustainable electricity and high-value chemicals, is an emerging and promising technology. BESs have broad applications including wastewater treatment, chemical production, resource recovery and waste remediation. Recently, new concepts of integrating BES with anaerobic digestion (AD) for process optimization have been proposed. The purpose of this work was to optimize the AD process using BES in two aspects: developing a new volatile fatty acid (VFA) monitoring system which can be used as the AD process indicator, and for improving biogas quality by removing CO2.

Firstly, a microbial desalination cell (MDC) was developed for measuring VFAs concentrations during AD process. The response time was approx. 5 h and the detection range was 1 to 200 mM. Secondly, in order to reduce the construction cost and response time, microbial electrolysis cell (MEC) was employed as VFA biosensor. The response of the biosensor was only 1 h due to the faster transfer of VFAs supported by the external voltage. The produced H2 could potentially contribute to the energy needs for operating the biosensor and thereby to a self-sustaining system. Thirdly, to improve biogas quality, a microbial electrolytic capture, separation and regeneration cell (MESC) was developed. In MESC, acid and alkaline generation, CO2 capture, biogas upgrading and wastewater treatment were simultaneously achieved.

Bio-Electro-Fenton processes for wastewater treatment: advances and prospects

Water quality deterioration caused by a wide variety of persistent organic pollutants (POPs) has become a serious concern worldwide. Traditional advanced oxidation process (e.g., Fenton reaction) is often inadequate, unsafe, and require post-treatment to remove residual H2O2. In this context, the bioelectrochemical technology assisted advanced oxidation reactions (namely bio-electro-Fenton system) have found a niche where they can become dominant in the near future, especially for POPs removal. Compared to traditional Electro-Fenton technologies, the bio-Electro-Fenton system greatly reduced the expenses on wastewater treatment in terms of electric energy consumption and operation costs. The bio-electro-Fenton system is becoming a versatile platform technology and offers a new solution for emerging environmental issues related to wastewater treatment. This paper critically reviews the existing literature about the degradation of POPs in bio-electro-Fenton system, especially with respect to the treatment performance associated with reactor design and main operating parameters. The review aims to assist researchers and engineers to gain fundamental understandings and critical view of bio-electro-Fenton system, and hopefully with the knowledge it could bring new opportunities for the future development of this promising wastewater treatment technology.
Bio-Electro-Fenton systems, Bioelectrochemical technology, Persistent organic pollutants (POPs), Wastewater treatment, Hydrogen peroxide

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Bio-Electro-Fenton process for the degradation of Non-Steroidal Anti-Inflammatory Drugs in wastewater

Non-Steroidal Anti-Inflammatory Drugs (NSAIDs) are ubiquitous municipal wastewater pollutants of which several are resistant to degradation in conventional wastewater treatment, and represent a major environmental health concern worldwide. An alternative treatment, the bio-electro-Fenton process, has received increasing attention in past years. In this process the strong oxidant •HO is formed using the electrons derived from bacterial oxidation of organic substrate. In this work, a laboratory scale microbial electrolysis cell based bio-electro-Fenton process was developed for the treatment of four different NSAIDs. The system was demonstrated to remove low concentration NSAIDs from water and wastewater and all tested parameters (cathode pH, cathode air-flow, cathode Fe2+ concentration, applied voltage, NSAIDs concentration and reaction time) were found to affect the apparent first order rate constant and removal efficiency for NSAIDs. Optimum parameter values were found to be pH = 2, Fe+2 = 7.5 mM, air-flow = 8 mL min-1, applied voltage = 0.3 V; the apparent rate constant was higher for higher NSAIDs initial concentration. For reaction times of 5 hours removal efficiencies were 59%-61% for Ketoprofen, 87%-97% for Diclofenac, 80%-86% for Ibuprofen and 75%-81% for Naproxen. Prolonged reaction times lead to substantial increase in removal efficiencies for Ketoprofen and Naproxen. Finally results obtained with real wastewater show lower removal rate constants than with distilled water matrices suggesting interference from wastewater components in the NSAIDs oxidation process. The results offer insight into future developments of an efficient platform for wastewater treatment technology targeting micropollutants.

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BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 4.92
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ISI indexed (2013): ISI indexed yes
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BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 3.92
Web of Science (2012): Impact factor 3.473
ISI indexed (2012): ISI indexed yes
Biogas and its opportunities—A review

Biogas production is a well-established technology primarily for the generation of renewable energy and also for the valorization of organic residues. Biogas is the end product of a biological mediated process, the so called anaerobic digestion, in which different microorganisms, follow diverse metabolic pathways to decompose the organic matter. The process has been known since ancient times and was widely applied at domestic households providing heat and power for hundreds of years. Nowadays, the biogas sector is rapidly growing and novel achievements create the foundation for constituting biogas plants as advanced bioenergy factories. In this context, the biogas plants are the basis of a circular economy concept targeting nutrients recycling, reduction of greenhouse gas emissions and biorefinery purposes. This review summarizes the current state-of-the-art and presents future perspectives related to the anaerobic digestion process for biogas production. Moreover, a historical retrospective of biogas sector from the early years of its development till its recent advancements gives an outlook of the opportunities that are opening up for process optimisation.

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Web of Science (2016): Impact factor 1.716

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Biogas upgrading and utilization: Current status and perspectives

Biogas production is an established sustainable process for simultaneous generation of renewable energy and treatment of organic wastes. The increasing interest of utilizing biogas as a substitute to natural gas or its exploitation as transport fuel opened new avenues in the development of biogas upgrading techniques. The present work is a critical review that summarizes state-of-the-art technologies for biogas upgrading and enhancement with particular attention to the emerging biological methanation processes. The review includes comprehensive description of the main principles of various biogas upgrading methodologies, scientific and technical outcomes related to their biomethanation efficiency, challenges that have to be addressed for further development and incentives and feasibility of the upgrading concepts.
Co-digestion and model simulations of source separated municipal organic waste with cattle manure under batch and continuously stirred tank reactors
This study investigates the co-digestion of source separated municipal organic waste (SSMOW), pretreated using a biopulper, and cattle manure both in batch and continuous stirred tank reactors. The optimum co-digestion feeding mixture was consisted of 90% SSMOW and 10% cattle manure on organic matter basis, yielding 443 mLCH4/gVS. The high performance of the co-digestion was explained by the fact that the efficient pulping pretreatment boosted the methane production from SSMOW and that the added livestock slurry provided the buffer capacity to avoid inhibition occurred by intermediates’ accumulation. Moreover, batch assays focused on the effect of inoculum to substrate ratio (ISR) were performed. Results showed that the reduction of ISR had slight impact on extending the lag phase, without affecting the rest kinetic parameters. The efficiency of the codigestion process in continuously fed reactor was comparable with the results obtained from the batch assay (i.e. <95% of the maximum expected value). Finally, the outputs from an applied mathematical model were in good agreement with the experimental data obtained from the continuous reactor operation, demonstrating that the BioModel can serve as a reliable tool to predict the process performance under real-scale conditions.

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BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 6.04 SJR 2.232 SNIP 2.109
Web of Science (2016): Impact factor 5.589
Web of Science (2016): Indexed yes
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Scopus rating (2014): CiteScore 5.35 SJR 1.789 SNIP 2.791
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Scopus rating (2013): CiteScore 4.49 SJR 1.613 SNIP 2.534
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Scopus rating (2012): CiteScore 3.72 SJR 1.674 SNIP 2.242
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BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 3.03 SJR 1.24 SNIP 1.82
Web of Science (2011): Impact factor 2.216
Converting mesophilic upflow sludge blanket (UASB) reactors to thermophilic by applying axenic methanogenic culture bioaugmentation

The application of thermophilic conditions in anaerobic digesters leads to higher methane production rates and better sanitation of the effluents compared to mesophilic operation. However, an increase in operational temperature is challenging due to the tremendous selective pressure imposed on the microbial consortium. The adaptation of microbial community to a new environment or condition can be accelerated by a process known as “bioaugmentation” or “microbial community manipulation”, during which exogenous microorganisms harbouring specific metabolic activities are introduced to the reactor. The aim of the current study was to rapidly convert the operational temperature of up-flow anaerobic sludge blanket (UASB) reactors from mesophilic to thermophilic conditions by applying microbial community manipulation techniques. Three different bioaugmentation strategies were compared and it was proven that the injection of axenic methanogenic culture was the most efficient approach leading to improved biomethanation process with 40% higher methane production rate compared to the control reactor. Microbial community analyses revealed that during bioaugmentation, the exogenous hydrogenotrophic methanogen could be encapsulated in granular structures and concomitantly promote the growth of syntrophic fatty acid oxidizing bacteria. The results derived from the current study indicated that microbial community manipulation is an efficient alternative method to speed up transition of UASB reactors from mesophilic to thermophilic conditions.
Current as an indicator of ammonia concentration during wastewater treatment in an integrated microbial electrolysis cell - Nitrification system

A key challenge for ammonia monitoring during nitrogen removal process is the extra cost and toxic reagent consuming. Herein the feasibility of current generated by an integrated microbial electrolysis cell (MEC) - nitrification reactor as an indicator of initial ammonia levels (NH3/NH4+) in wastewater was explored. In this loop system, ammonia was first oxidized to nitrate in the nitrification reactor, and then the effluent was introduced into the cathode of MEC where nitrate was reduced as electron acceptor. The correlation between current and ammonia concentration was first investigated with synthetic ammonia-rich wastewater. A good linear relationship (R2=0.9419) was observed between current (0.5130–3.906mA) and ammonia levels (0–62.1mg NH4+-N/L). Such linear relationship was always obtained regardless of the tested external power supply or wastewater pH. The external electrochemical cell was proved to be an effective pre-conditioning method to remove the disturbance from other possible electron acceptors. Finally, the integrated system was further tested with real waste streams and the results showed no significant difference (p>0.05) with measurements by conventional methods. This study, for the first time, demonstrated the potential application of the integrated MEC - nitrification system for ammonia monitoring in addition to water treatment.

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BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 4.74 SJR 1.355 SNIP 1.177
Web of Science (2016): Impact factor 4.798
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 4.86 SJR 1.321 SNIP 1.324
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BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 3.99 SJR 1.644 SNIP 1.574
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Deciphering the microbial ecology in bio- gas reactors for optimizing the anaerobic digestion process

Anaerobic digestion (AD) is a microbial mediated process where organic compounds are degraded to biogas (CH4 and CO2). AD occurs in many natural anoxic environments and is an essential step for global carbon circle. Engineered AD systems, i.e. biogas reactors, enhance methanogenic activity by applying empirical operational conditions, in order to accelerate the methane production for energetic purposes. In Denmark, biogas produced from AD has a considerable share in renewable energy with the expectation to expand. Thus, the more effective operation of biogas plants will significantly benefit Denmark’s sustainable development. As AD relies on complex microbial activity, a more comprehensive understanding of the AD microbial consortia and their activity provides the fundamental knowledge for process control and optimization.

In AD, the microbial metabolisms are mostly thermodynamically constrained and the obligatory syntrophy is an essential intermediary step. Thus, the majority of AD microbiota remains uncharacterized since in the past it was mainly investigated using cultivated-based methods. The advent of more powerful sequencing technology (i.e. next generation sequencing, NGS) and newly developed bioinformatic methods enable researchers to perform in-situ analyses on uncharacterized microbial communities. The applications of NGS technology were proved to be effective tools to reveal AD microbial ecology. However, the detailed mechanisms of microbial activity are still far from fully elucidated due to the intricacy of AD process.

This Ph.D. project relied on comprehensive investigations of microbial communities in order to optimize the AD process and elucidate the fundamental metabolisms. Specifically, in the case of process optimization, 16S rRNA amplicon sequencing was used to identify, analyse and solve the operational challenges during the start-up of thermophilic up-flow anaerobic sludge blanket (UASB) reactors. To elucidate the microbial metabolisms, genome-centric metagenomics was applied to characterize methanogenic communities degrading a set of defined substrates. In addition, the Ph.D. study also expands the understanding of AD microbial ecology by proposing and characterizing a novel Candidatus species.
ubiquitously present in AD systems. 

The start-up of thermophilic UASB reactors was investigated in lab-scale reactors inoculated with mesophilic granules. After increasing the operational temperature from mesophilic to thermophilic, volatile fatty acids (VFAs) and alcohols were found as the main digestion products. Methane production, on the other hand, only initiated after bicarbonate addition as external pH control. The dynamicity of microbial community composition in the granules during the temperature shift suggested that the majority of the mesophilic microbes could not tolerate the thermophilic conditions. Moreover, it was demonstrated that the fermentative thermophiles first evolved in the liquid phase of UASB reactor and then were encapsulated in the granular structure of the sludge. The growth of these bacteria rapidly restored the hydrolysis, acidogenesis and acetogenesis in the reactor. On the contrary, the thermophilic methanogens grew much slower than fermentative bacteria leading to severe process imbalance (i.e. accumulation of VFAs and alcohols). Thus, the evolvement of thermophilic methanogens was recognized as the biological ‘bottleneck’ during the temperature transition. To overcome the identified obstacle, bioaugmentation, i.e. provision of exogenous microbes, was proposed to accelerate the microbial community adaptation. The best strategy found to perform bioaugmentation was the injection of axenic methanogenic cultures. This practice significantly increased the thermophilic methane production rate by 40% compared with the control reactor (i.e. without bioaugmentation). The enhancement of methane production was attributed to the evolvement of exogenous Methanothermobacter thermotogotrophicus and the concomitant growth of its syntrophic partners in the granular structure. The positive effects brought by bioaugmentation were persistent in UASB reactor due to the retention of the microbes in the granular sludge.

For the investigation of the basic microbial metabolism and ecology, methanogenic microbial communities were enriched in a lab-scale continuous stirred-tank reactor (CSTR) fed with synthetic feedstocks. In the experiment, the substrates used were stepwise simplified (i.e. polysaccharide, monosaccharide, short chain fatty acids, acetate) to mimic the four steps of AD process. During the continuous operation, the microbial community was substantially simplified, because the microbes that could not metabolize the specific compounds were washed out. The overall microbial community consisted of only 35 metagenome assembled genomes (MAGs) (31 bacterial and 4 archaeal). The abundance of these MAGs dramatically varied in the communities adapted to different substrates. The shifts in microbial community composition indicate that MAGs have specific functional roles in AD food chain and their roles cannot always be physiologically defined in accordance with 4 AD steps. Moreover, the explicit degradation pathways were reconstructed from the functional annotation of MAGs. It is notable that, a novel glucose degradation model was proposed with the syntrophic activity of Clostridiaceae sp. and Methanoculleus thermophilus. In this model, acetate is not produced as intermediate compound. The genome-centric metagenomics reveals a considerable number of MAGs that could not be taxonomically assigned to characterized species. A MAG extracted from co-assembly of 8 AD metagenomes was especially emphasized due to its ubiquity in AD system and its high abundance under specific conditions. From the functional annotation and gene expression profile, it is confirmed that this MAG performs hydrogenotrophic methanogenesis in AD system and is found dominant from the reactors where H2 was added. This genome is present in 40 different samples from both full-scale and lab-scale AD reactors. The MAG was found in higher abundance during thermophilic reactor operations with relatively short hydraulic retention times. The phylogenetic assignment was based on 400 conserved genes and on 16S rRNA genes. The two methods concordantly showed that this MAG is closely related to Methanoculleus bourgensis MS2T. However, the average nucleotide identity between M. bourgensis MS2T and the selected MAG was only 89%, which is too low similarity to assign the MAG at the species level. Thus, we propose a novel Candidatus species inside the Methanoculleus genus. According to the metabolic traits, it is named as Candidatus Methanoculleus thermohydrogenotrophicum, sp. nov. 

Overall, the results from this Ph.D. study bring new knowledge on the AD process based on NGS technology. Practically, the gained information regarding microbial community composition and dynamicity was directly used to solve technical challenges in AD operations. Fundamentally, deeper insights into the microbial metabolisms and ecology substantially expanded the current understanding of AD. The revealed knowledge provides pivotal prerequisites for future AD process control and optimization.

**General information**

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**Effect of different ammonia sources on aceticlastic and hydrogenotrophic methanogens**

Ammonium chloride (NH₄Cl) was usually used as a model ammonia source to simulate ammonia inhibition during anaerobic digestion (AD) of nitrogen-rich feedstocks. However, ammonia in AD originates mainly from degradation of proteins, urea and nucleic acids, which is distinct from NH₄Cl. Thus, in this study, the inhibitory effect of a “natural”
ammonia source (urea) and NH₄Cl, on four pure methanogenic strains (aceticlastic: Methanosarcina thermophila, Methanosarcina barkeri; hydrogenotrophic: Methanoculleus bourgensis, Methanoculleus thermophilus), was assessed under mesophilic (37°C) and thermophilic (55°C) conditions. The results showed that urea hydrolysis increased pH significantly to unsuitable levels for methanogenic growth, while NH₄Cl had a negligible effect on pH. After adjusting initial pH to 7 and 8, urea was significantly stronger inhibitor with longer lag phases to methanogenesis compared to NH₄Cl. Overall, urea seems to be more toxic on both aceticlastic and hydrogenotrophic methanogens compared to NH₄Cl under the same total and free ammonia levels.

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- BFI (2015): BFI-level 2
- Scopus rating (2015): CiteScore 5.47 SJR 2.243 SNIP 1.897
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- Scopus rating (2013): CiteScore 5.97 SJR 2.405 SNIP 2.477
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- ISI indexed (2012): ISI indexed yes
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- Scopus rating (2011): CiteScore 5.56 SJR 2.308 SNIP 2.507
- Web of Science (2011): Impact factor 4.98
- ISI indexed (2011): ISI indexed yes
- Web of Science (2011): Indexed yes
- BFI (2010): BFI-level 2
- Scopus rating (2010): SJR 2.089 SNIP 2.344
Electricity generation and microbial communities in microbial fuel cell powered by macroalgal biomass

The potential of macroalgae Laminaria digitata as substrate for bioelectricity production was examined in a microbial fuel cell (MFC). A maximum voltage of 0.5V was achieved without any lag time due to the high concentration of glucose and mannitol in the hydrolysate. Total chemical oxygen demand removal efficiency reached over 95% at the end of batch run. Glucose and mannitol were degraded through isobutyrate as intermediate. The 16S rRNA gene high throughout sequencing analysis of anodic biofilm revealed complex microbial composition dominated by Bacteroidetes (39.4%), Firmicutes (20.1%), Proteobacteria (11.5%), Euryarchaeota (3.1%), Deferribacteres (1.3%), Spirochaetes (1.0%), Chloro flexi (0.7%), Actinobacteria (0.5%), and others (22.4%). The predominance of Bacteroidetes, Firmicutes and Proteobacteria demonstrated their importance for substrate degradation and simultaneous power generation. These results demonstrate that macroalgae hydrolysate can be used as a renewable carbon source of microbial electrochemical systems for various environmental applications.

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Energy recovery from wastewater microalgae through anaerobic digestion process: Methane potential, continuous reactor operation and modelling aspects

A mixture of piggery slurry and algal species (mainly composed of Nannochloropsis limnetica), grown in municipal wastewater, were used as substrates for biogas production. Mono- and co-digestion experiments were performed at batch and continuous reactor operation. The mono-digestion of wastewater microalgae led to the highest methane yield (408 ± 34 NmL/gVS). However, for manure-based biogas plants, a 60:40 v/v piggery slurry to wastewater microalgae ratio in terms of organic matter was identified as the most efficient mixture in batch assays (355 ± 27 NmL/gVS). The advantage of co-digestion was also evidenced under continuous reactor operation, which had markedly higher biogas production (23%, p<0.05) compared to the mono-digestion of livestock manure. Moreover, it was demonstrated that the co-digestion process resulted in a more robust process as indicated by lower accumulation of acetate (i.e. presented during mono-digestion of piggery slurry) and propionate (i.e. recorded during mono-digestion of wastewater microalgae). The experimental data were compared with dynamic modelling (BioModel). A new set of biodegradability parameters was estimated and employed to improve the simulations of mono-digestion scenarios. Subsequently, the co-digestion scenario was used for model validation. Results obtained from simulations showed that the co-digestion can lead to relatively high methane productivity and prevent process instabilities.
Evaluation of microalgae production coupled with wastewater treatment

In the present study the feasibility of microalgae production coupled with wastewater treatment was assessed. Continuous cultivation of Chlorella sorokiniana with wastewater was tested in lab-scale flat panel photobioreactors. Biomass productivity was determined for four dilution rates (4.32 d⁻¹, 3.6 d⁻¹, 1.8 d⁻¹ and 0.72 d⁻¹). The productivity peak was 1.524 g l⁻¹d⁻¹ at the dilution rate of 2.41 d⁻¹. Nitrogen and phosphorus removals were found to be inversely proportional to dilution rates, while COD removal was found to be 50% at all the tested conditions. The biomass obtained at the highest dilution rate was characterized for its content of lipids, proteins and pigments. The average yields of fatty acid methyl esters (FAME), protein, lutein, chlorophylls and β-carotene was 62.4 mg, 388.2 mg, 1.03 mg, 11.82 mg and 0.44 mg per gram dry biomass, respectively. Economic analysis revealed that potentially more than 70% of revenue was from the production of pigments, i.e. chlorophyllin (59.6%), lutein (8.9%) and β-carotene (5.0%) while reduction in discharging costs of the treated wastewaters could account for 19.6% of the revenue. Due to the low yield of FAME and the low market price of biodiesel, the revenue from the above was found to be the least profitable (1.4%). Even when taking into account all these different revenues combined, this cultivation strategy was found with the current prices to be uneconomical. Power consumption for artificial light was responsible for the 94.5% of the production costs.

General information

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BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.61 SJR 0.503 SNIP 0.675
Web of Science (2017): Impact factor 1.666
Factors influencing the fate of antibiotic resistance genes during thermochemical pretreatment and anaerobic digestion of pharmaceutical waste sludge

The prevalence of antibiotic resistance genes (ARGs) in waste sludge, especially for the pharmaceutical waste sludge, presents great potential risks to human health. Although ARGs and factors affecting their spreading are of major importance for human health, the factors influencing the fate of ARGs during sludge treatment, especially for pharmaceutical sludge treatment are not yet well understood. In order to be able to minimize ARGs spreading, it is important to find what is influencing their spreading. Therefore, certain factors, such as the sludge characteristics, bacterial diversity and community composition, and mobile genetic elements (MGEs) during the advanced AD of pharmaceutical sludge with different pretreatments were studied, and their affinity with ARGs was elucidated by Spearman correlation analysis. Furthermore, multiple linear regression was introduced to evaluate the importance of the various factors. Results showed that 59.7%–88.3% of the variations in individual ARGs and total ARGs can be explained by the corresponding factors. Bacterial diversity rather than specific bacterial community composition affected the fate of ARGs, whereas alkalinity was the most important factor on ARGs among all sludge characteristics investigated in this study. Besides, 66.4% of variation of total ARGs was driven by the changes of MGEs. Multiple linear regression models also reveal the collective effect of these factors on ARGs, and the contributions of each factor impact on ARGs. This study provides more comprehension about the factors impact on the fate of ARGs during pharmaceutical sludge treatment, and offers an approach to evaluate the importance of each factor, which method could be introduced for evaluation of factors influencing ARGs during other types of sludge or wastewater treatment.
Hybrid biogas upgrading in a two-stage thermophilic reactor

The aim of this study is to propose a hybrid biogas upgrading configuration composed of two-stage thermophilic reactors. Hydrogen is directly injected in the first stage reactor. The output gas from the first reactor (in-situ biogas upgrade) is subsequently transferred to a second upflow reactor (ex-situ upgrade), in which enriched hydrogenotrophic culture is responsible for the hydrogenation of carbon dioxide to methane. The overall objective of the work was to perform an initial methane enrichment in the in-situ reactor, avoiding deterioration of the process due to elevated pH levels, and subsequently, to complete the biogas upgrading process in the ex-situ chamber. The methane content in the first stage reactor reached on average 87% and the corresponding value in the second stage was 91%, with a maximum of 95%. A remarkable accumulation of volatile fatty acids was observed in the first reactor (in-situ) after 8 days of continuous hydrogen injection reaching a concentration of 5.6 g/L. Nevertheless, after an adaptation period, the system managed to recover and the volatile fatty acids decreased to 2.5 g/L. No pH drop was recorded during the period characterised by increased volatile fatty acids concentration mainly due to the consumption of the endogenous carbon dioxide by hydrogenotrophic methanogens. The effect of hydrogen injection on the microbial community in both reactors was analysed by 16S rRNA gene amplicon sequencing. The results demonstrated an increment in relative abundance of hydrogenotrophic methanogens and homoacetogens in the in-situ reactor, while the microbial community in the ex-situ
chamber was simpler and dominated by hydrogenotrophic methanogens.

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Scopus rating (2017): CiteScore 6.85 SJR 2.537 SNIP 2.233
Web of Science (2017): Impact factor 6.377
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 6.04 SJR 2.232 SNIP 2.109
Web of Science (2016): Impact factor 5.589
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 5.24 SJR 2.023 SNIP 2.079
Web of Science (2015): Impact factor 4.801
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 5.35 SJR 1.789 SNIP 2.791
Web of Science (2014): Impact factor 4.38
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 4.49 SJR 1.613 SNIP 2.534
Web of Science (2013): Impact factor 3.59
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Scopus rating (2012): CiteScore 3.72 SJR 1.674 SNIP 2.242
Web of Science (2012): Impact factor 2.775
ISI indexed (2012): ISI indexed yes
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BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 3.03 SJR 1.24 SNIP 1.82
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ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.35 SNIP 1.735
Web of Science (2010): Impact factor 2.072
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BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.302 SNIP 1.798
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.471 SNIP 1.886
Hydrogen-Fueled Microbial Pathways in Biogas Upgrading Systems Revealed by Genome-Centric Metagenomics

Biogas upgrading via carbon dioxide hydrogenation is an emerging technology for electrofuel production. The biomethanation efficiency is strongly dependent on a balanced microbial consortium, whose high-resolution characterization along with their functional potential and interactions are pivotal for process optimization. The present work is the first genome-centric metagenomic study on mesophilic and thermophilic biogas upgrading reactors aiming to define the metabolic profile of more than 200 uncultivated microbes involved in hydrogen assisted methanogenesis. The outcomes from predictive functional analyses were correlated with microbial abundance variations to clarify the effect of process parameters on the community. The operational temperature significantly influenced the microbial richness of the reactors, while the H2 addition distinctively alternated the abundance of the taxa. Two different Methanoculleus species (one mesophilic and one thermophilic) were identified as the main responsible ones for methane metabolism. Finally, it was demonstrated that the addition of H2 exerted a selective pressure on the concerted or syntrophic interactions of specific microbes functionally related to carbon fixation, propionate and butanoate metabolisms. Novel bacteria were identified as candidate syntrophic acetate oxidizers (e.g., Tepidanaerobacter sp. DTU063), while the addition of H2 favored the proliferation of potential homoacetogens (e.g., Clostridia sp. DTU183). Population genomes encoding genes of Wood-Ljungdahl pathway were mainly thermophilic, while propionate degraders were mostly identified at mesophilic conditions. Finally, putative syntrophic interactions were identified between microbes that have either versatile metabolic abilities or are obligate/facultative syntrophs.
Impact of graphene on ZnO assisted photocatalysis for degradation of lignin rich substrates by UV/Iodide process

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Integrated production of cellulosic bioethanol and succinic acid from rapeseed straw after dilute-acid pretreatment
The aim of this study was to develop an integrated biofuel (cellulosic bioethanol) and biochemical (succinic acid) production process from rapeseed straw after dilute-acid pretreatment. Rapeseed straw pretreatment at 20% (w/v) solid loading and subsequent hydrolysis with Cellic® CTeC2 resulted in high glucose yield (80%) and ethanol output (122-125 kg of EtOH/Mg of rapeseed straw). Supplementation the enzymatic process with 10% dosage of endoxylanases (Cellic® HTec2) reduced the hydrolysis time required to achieve the maximum glucan conversion by 44-46% and increased the
xylose yield by 10% compared to the process with Cellic® CTec2. Significantly higher amounts of succinic acid were produced after fermentation of pretreatment liquor (48 kg/Mg of rapeseed straw, succinic acid yield: 60%) compared to fermentation of xylose-rich residue after ethanol production (35-37 kg/Mg of rapeseed straw, succinic yield: 68-71%). Results obtained in this study clearly proved the biorefinery potential of rapeseed straw.
Life cycle assessment of castor-based biorefinery: a well to wheel LCA

Purpose: Diminishing fossil resources and environmental concerns associated with their vast utilization have been in focus by energy policy makers and researchers. Among the different scenarios put forth to commercialize biofuels, various biorefinery concepts have aroused global interests because of their ability in converting biomass into a spectrum of marketable products and bioenergies. This study was aimed at developing different novel castor-based biorefinery scenarios for generating biodiesel and other co-products, i.e., ethanol and biogas. In these scenarios, glycerin, heat, and electricity were also considered as byproducts. Developed scenarios were also compared with a fossil reference system delivering the same amount of energy through the combustion of neat diesel.

Materials and methods: Life cycle assessment (LCA) was used to investigate the environmental consequences of castor biodiesel production and consumption with a biorefinery approach. All the input and output flows from the cultivation stage to the combustion in diesel engines as well as changes in soil organic carbon (SOC) were taken into account. Impact 2002+ method was used to quantify the environmental consequences. Results and discussion: The LCA results demonstrated that in comparison with the fossil reference system, only one scenario (i.e., Sc-3 with co-production of significant amounts of biodiesel and biomethane) had 16% lower GHG emissions without even considering the improving effect of SOC. Moreover, resource damage category of this scenario was 50% lower than that of neat diesel combustion. The results proved that from a life cycle perspective, energy should be given priority in biorefineries because it is essential for a biorefinery to have a positive energy balance in order to be considered as a sustainable source of energy. Despite a positive effect on energy and GHG balances, these biorefineries had negative environmental impacts on the other damage categories like Human Health and Ecosystem Quality.

Conclusions: Although biorefineries offer unique features as promising solutions for mitigating climate change and reducing dependence on fossil fuels, the selection of biomass processing options and management decisions can affect the final results in terms of environmental evaluations and energy balance. Moreover, if biorefineries are focused on transportation fuel production, a great deal of effort should still be made to have better environmental performance in Human Health and Ecosystem Quality damage categories. This study highly recommends that future studies focus towards biomass processing options and process optimization to guarantee the future of the most sustainable biofuels.

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Organisations: Department of Environmental Engineering, Residual Resource Engineering, University of Tehran, Biofuel Research Team (BRTeam), Isfahan University of Technology, University of Isfahan
Life cycle assessment of different strategies for energy and nutrient recovery from source sorted organic fraction of household waste

This study attempted to apply life cycle assessment (LCA) methodology to compare distinctive management strategies when biologically treating source-sorted organic household waste (SSOHW). The management strategies included different pretreatment methods of SSOHW prior to anaerobic digestion and different biogas applications. Biopulp technology, screw press, and disc screen were chosen as three available pretreatment methods and electricity production, combined heat and power (CHP) production, as well as biogas upgrading were selected as three downstream management strategies. In all scenarios, the produced digestate was assumed for nutrient recovery and reject fractions from pretreatment step were considered to be incinerated. A consequential LCA was employed and long term marginal data was adapted to credit the amount of recovered energy and nutrient. The composition of SSOHW collected in Denmark was used to investigate the impact of created scenarios on several damage categories, i.e., Global warming potential, Human health, Ecosystem quality, and Resources. Moreover, the scenarios were also compared in terms of energy ratio to find the strategy resulting in the highest energy payback. The results showed that scenarios developed under the biopulp technology outperformed their counterparts in which other pretreatment methods were used. This was mostly due to the higher energy and nutrient recovery caused by correct sorting of SSOHW into reject and substrate fractions. Moreover, based on the results obtained, it can be concluded that CHP production would be the best downstream management option while the results were so sensitive to the source of substituted energy.

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Scopus rating (2016): CiteScore 5.83 SJR 1.659 SNIP 2.502
Web of Science (2016): Impact factor 5.715
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.57 SJR 1.635 SNIP 2.375
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BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 4.6 SJR 1.665 SNIP 2.481
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BFI (2013): BFI-level 2
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Web of Science (2013): Impact factor 3.59
ISI indexed (2013): ISI indexed yes
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BFI (2012): BFI-level 2
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Web of Science (2012): Impact factor 3.398
ISI indexed (2012): ISI indexed yes
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BFI (2010): BFI-level 2
Scopus rating (2010): SJR 0.961 SNIP 1.564
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 0.81 SNIP 1.347
Web of Science (2009): Indexed yes
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Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.921 SNIP 1.497
Web of Science (2007): Indexed yes
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Scopus rating (2005): SJR 0.547 SNIP 1.324
Scopus rating (2004): SJR 0.766 SNIP 1.784
Scopus rating (2003): SJR 0.503 SNIP 1.113
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.529 SNIP 1.044
Web of Science (2002): Indexed yes
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Research output: Research - peer-review › Journal article – Annual report year: 2018
Mechanical pretreatment for increased biogas production from lignocellulosic biomass; predicting the methane yield from structural plant components

Lignocellulosic substrates are associated with limited biodegradability due to the structural complexity. For that reason, a pretreatment step is mandatory for efficient biomass transformation which will lead to increased bioenergy output. The aim of the present study was to assess the efficiency of two pretreatment machines to enhance the methane yield of meadow grass. Specifically, the application of shearing forces with a rotated plastic sweeping brush against a steel roller significantly increased biomass biodegradability by 20% under relatively gentle operation conditions (600rpm). The more intense operation (1200rpm) was not associated with higher methane yield enhancement. Regarding an alternative machine, in which the brush was replaced with a coarse steel roller resulted in a more distinct effect (+27%) despite the lower rotating speed (~400rpm). Moreover, the association of the substrate's individual chemical components and the practical methane yield was assessed, establishing single and multiple linear regression models. However, the estimation accuracy was rather low with either single (regressor: lignin, R²: 0.50) or multiple linear regression analyses (regressors: arabinan-lignin-protein, R²: 0.61). Results showed that poorly lignified plant tissue containing relatively high fractions of protein and arabinan is more susceptible to anaerobic digestion.

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Tsapekos, P., Kougias, P., Angelidaki, I.
Pages: 903-910
Publication date: 2018
Peer-reviewed: Yes

Publication information
Journal: Waste Management
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Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 4.94 SJR 1.456 SNIP 2.059
Web of Science (2017): Impact factor 4.723
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 4 SJR 1.407 SNIP 2.159
Web of Science (2016): Impact factor 4.03
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 4.33 SJR 1.732 SNIP 2.263
Web of Science (2015): Impact factor 3.829
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.43 SJR 1.763 SNIP 2.49
Web of Science (2014): Impact factor 3.22
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 3.39 SJR 1.815 SNIP 2.413
Web of Science (2013): Impact factor 3.157
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 2.91 SJR 1.59 SNIP 2.18
Web of Science (2012): Impact factor 2.485
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Metagenomic binning reveals the functional roles of core abundant microorganisms in twelve full-scale biogas plants

The aim of this work was to elucidate the microbial ecology in twelve mesophilic and thermophilic full-scale biogas plants using a genome-centric metagenomic approach. In this study both biogas plants treating manure and those treating sludge from waste water treatment plants were considered. The identification of 132 Metagenome-Assembled Genomes (MAGs) and analysis of their abundance profile in different samples allowed the identification of the most abundant core members of the anaerobic digestion microbiome. Canonical correspondence analysis was used to determine the influence of biotic and environmental factors on MAGs abundance and to investigate the methanogenic performance of the biogas plants. Prediction of the functional properties of MAGs was obtained analyzing their KEGG pathways and their carbohydrate active domains. Network analysis allowed investigation of species-species associations and shed light on syntrophic interactions between members belonging to the anaerobic digestion dark matter (phylum Fermentibacteria). By stratifying and comparing different levels of information, it was predicted that some MAGs have a crucial role in the manure-supplemented thermophilic biogas plants and it was highlighted the importance of the glycine cleavage system in complementing the “truncated” Wood-Ljungdahl pathway.

General information

State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering, Fudan University
Pages: 123-134
Publication date: 2018
Peer-reviewed: Yes
Microalgal process-monitoring based on high-selectivity spectroscopy tools: status and future perspectives

Microalgae are well known for their ability to accumulate lipids intracellularly, which can be used for biofuels and mitigate CO2 emissions. However, due to economic challenges, microalgae bioprocesses have maneuvered towards the simultaneous production of food, feed, fuel, and various high-value chemicals in a biorefinery concept. On-line and in-line monitoring of macromolecules such as lipids, proteins, carbohydrates, and high-value pigments will be more critical to maintain product quality and consistency for downstream processing in a biorefinery to maintain and valorize these markets. The main contribution of this review is to present current and prospective advances of on-line and in-line process analytical technology (PAT), with high-selectivity – the capability of monitoring several analytes simultaneously – in the interest of improving product quality, productivity, and process automation of a microalgal biorefinery. The high-selectivity PAT under consideration are mid-infrared (MIR), near-infrared (NIR), and Raman vibrational spectroscopies. The current review contains a critical assessment of these technologies in the context of recent advances in software and hardware in order to move microalgae production towards process automation through multivariate process control (MVPC) and software sensors trained on “big data”. The paper will also include a comprehensive overview of off-line implementations of vibrational spectroscopy in microalgal research as it pertains to spectral interpretation and process automation to aid and motivate development.

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Podevin, M. P. A., Fotidis, I., Angelidaki, I.
Pages: 704-718
Publication date: 2018
Peer-reviewed: Yes

Publication information
Journal: Critical Reviews in Biotechnology
Volume: 38
Issue number: 5
ISSN (Print): 0738-8551
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 4.89 SJR 1.243 SNIP 1.427
Web of Science (2017): Impact factor 5.239
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.91 SJR 1.285 SNIP 1.5
Web of Science (2016): Impact factor 6.542
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Microbial electrochemical separation of CO₂ for biogas upgrading

Biogas upgrading to natural gas quality has been under focus the recent years for increasing the utilization potential of biogas. Conventional methods for CO₂ removal are expensive and have environmental challenges, such as increased emissions of methane in the atmosphere with serious greenhouse impact. In this study, an innovative microbial electrochemical separation cell (MESC) was developed to in-situ separate and regenerate CO₂ via alkali and acid regeneration. The MESC was tested under different applied voltages, inlet biogas rates and electrolyte concentrations. Pure biomethane was obtained at 1.2 V, inlet biogas rate of 0.088 mL/h/mL reactor and NaCl concentration of 100 mM at a 5-day operation. Meanwhile, the organic matter of the domestic wastewater in the anode was almost completely removed at the end. The study demonstrated a new sustainable way to simultaneously upgrade biogas and treat wastewater which can be used as proof of concept for further investigation.

General information
State: Published
Organisations: Department of Environmental Engineering, Water Technologies, Residual Resource Engineering
Contributors: Kokkoli, A., Zhang, Y., Angelidaki, I.
Pages: 380-386
Publication date: 2018
Peer-reviewed: Yes

Publication information
Journal: Bioresource Technology
Volume: 247
ISSN (Print): 0960-8524
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 6.28 SJR 2.029 SNIP 1.799
Web of Science (2017): Impact factor 5.807
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.94 SJR 2.215 SNIP 1.932
Web of Science (2016): Impact factor 5.651
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.47 SJR 2.243 SNIP 1.897
Web of Science (2015): Impact factor 4.917
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.3 SJR 2.399 SNIP 2.087
Web of Science (2014): Impact factor 4.494
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 5.97 SJR 2.405 SNIP 2.477
Web of Science (2013): Impact factor 5.039
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.25 SJR 2.334 SNIP 2.461
Web of Science (2012): Impact factor 4.75
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 5.56 SJR 2.308 SNIP 2.507
Web of Science (2011): Impact factor 4.98
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.089 SNIP 2.344
Web of Science (2010): Impact factor 4.365
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.915 SNIP 2.236
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.736 SNIP 2.74
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.403 SNIP 2.396
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.314 SNIP 2.003
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.278 SNIP 1.98
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.19 SNIP 1.655
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.942 SNIP 1.665
**Microbial fuel cell-based biosensor for toxic carbon monoxide monitoring**

This study presents an innovative microbial fuel cell-based biosensor for carbon monoxide (CO) monitoring. The hypothesis for the function of the biosensor is that CO inhibits bacterial activity in the anode and thereby reduces electricity production. A mature electrochemically active biofilm on the anode was exposed to CO gas at varied concentrations. A proportional linear relationship ($R^2 = 0.987$) between CO concentration and voltage drop (0.8 to 24 mV) in the range of 10% and 70% of CO concentration was observed. Notably, no further decrease of voltage output was observed by further increasing CO concentration over 70%. Besides, the response time of the biosensor was 1 h. The compact design and simple operation of the biosensor makes it easy to be integrated in existing CO-based industrial facilities either as a forewarning sensor for CO toxicity or even as an individual on-line monitoring device.

**General information**

State: Published  
Organisations: Department of Environmental Engineering, Residual Resource Engineering, South China University of Technology  
Contributors: Zhou, S., Huang, S., Li, Y., Zhao, N., Li, H., Angelidaki, I., Zhang, Y.  
Pages: 368-371  
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Peer-reviewed: Yes  

**Publication information**

Journal: Talanta  
Volume: 186  
ISSN (Print): 0039-9140  
Ratings:  
BFI (2018): BFI-level 1  
Web of Science (2018): Indexed yes  
BFI (2017): BFI-level 1  
Scopus rating (2017): CiteScore 4.26 SJR 1.186 SNIP 1.163  
Web of Science (2017): Impact factor 4.244  
Web of Science (2017): Indexed yes  
BFI (2016): BFI-level 1  
Scopus rating (2016): CiteScore 4.19 SJR 1.168 SNIP 1.276  
Web of Science (2016): Impact factor 4.162  
Web of Science (2016): Indexed yes  
BFI (2015): BFI-level 1  
Scopus rating (2015): CiteScore 3.99 SJR 1.173 SNIP 1.316  
Web of Science (2015): Impact factor 4.035  
Web of Science (2015): Indexed yes  
BFI (2014): BFI-level 1  
Scopus rating (2014): CiteScore 3.71 SJR 1.192 SNIP 1.284  
Web of Science (2014): Impact factor 3.545  
Web of Science (2014): Indexed yes  
BFI (2013): BFI-level 1  
Scopus rating (2013): CiteScore 3.74 SJR 1.2 SNIP 1.385  
Web of Science (2013): Impact factor 3.511
Nickel spiking to improve the methane yield of sewage sludge

The presence of micro-nutrients can be stimulatory for the anaerobic digestion (AD) of hardly degradable wastes and thus, improve process performance. Among the essential trace elements, nickel is involved in multiple important enzymes necessary for efficient AD. The present study investigates the effect of nickel spiked sewage sludge on batch and continuous mode operation. Metal spiking was conducted in the form of nanoparticles (Ni-NPs) and salt (NiCl2·6H2O). Results from batch assays showed that 5mgNi-Salt/kgVS in the presence of Nitrilotriacetic acid (NTA) enhanced the methane yield by ~10% compared to the untreated sample. The impact of Ni-NPs in the AD process was also positive, but slightly lower compared to the effect of NiCl2·6H2O. The stimulatory impact of Ni was also revealed in continuously fed digester boosting the methane yield by ~8%. Overall, the improved methane production indicated that methanogenic archaea were favoured by the simultaneous supplementation of Ni and NTA.

General information

State: Accepted/In press
Organisations: Department of Environmental Engineering, Residual Resource Engineering, Chinese Academy of Sciences
Contributors: Tsapekos, P., Alvarado-Morales, M., Tong, J., Angelidaki, I.
Publication date: 2018
Nutrient recovery from industrial wastewater as single cell protein by a co-culture of green microalgae and methanotrophs

Conventional water treatment technologies remove nutrients via resource intensive processes. However, new approaches for nutrient recycling are needed to provide food to the increasing population. This work explores the use of microbial biomass as a means to recover nutrients from industrial wastewater and upcycle them to feed grade single cell protein. Results demonstrated that both algae and bacteria could remove or assimilate most of the organic carbon present in the wastewater (~95% removal for monocultures and 91% for the algal-bacterial consortium). However, their growth stopped before nutrients and substrates in the gas phase (i.e., methane and oxygen for methanotrophs and carbon dioxide for algae) were depleted. Likely, algal growth was light limited and stopped after organic carbon was consumed. Methanotrophs growth could be limited by trace elements (e.g., copper). Nevertheless, for all cultures the protein content (45% of dry weight, DW, for methanotrophs; 52.5% of DW for algae; and 27.6% of DW for consortium) and amino acid profile was suitable for substitution of conventional protein sources. Further research should focus on increasing productivity of biomass grown on wastewater resources.

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering, Water Technologies, Technical University of Denmark
Pages: 129-135
Publication date: 2018
Peer-reviewed: Yes

Publication information
Journal: Biochemical Engineering Journal
Volume: 134
ISSN (Print): 1369-703X
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 3.18
Web of Science (2017): Impact factor 6.735
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.16
Web of Science (2016): Impact factor 6.216
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 2.75
Web of Science (2015): Impact factor 5.31
Web of Science (2015): Indexed yes
Performance and genome-centric metagenomics of thermophilic single and two-stage anaerobic digesters treating cheese wastes

The present research is the first comprehensive study regarding the thermophilic anaerobic degradation of cheese wastewater, which combines the evaluation of different reactor configurations (i.e. single and two-stage continuous stirred tank reactors) on the process efficiency and the in-depth characterization of the microbial community structure using genome-centric metagenomics. Both reactor configurations showed acidification problems under the tested organic loading rates (OLRs) of 3.6 and 2.4 g COD/L-reactor day and the hydraulic retention time (HRT) of 15 days. However, the two-stage design reached a methane yield equal to 95% of the theoretical value, in contrast with the single stage configuration, which reached a maximum of 33% of the theoretical methane yield. The metagenomic analysis identified 22 new population genomes and revealed that the microbial compositions between the two configurations were remarkably different, demonstrating a higher methanogenic biodiversity in the two-stage configuration. In fact, the acidogenic reactor of the serial configuration was almost solely composed by the lactose degrader Bifidobacterium crudilactis UC0001. The predictive functional analyses of the main population genomes highlighted specific metabolic pathways responsible for the AD process and the mechanisms of main intermediates production. Particularly, the acetate accumulation experienced by the single stage configuration was mainly correlated to the low abundant syntrophic acetate oxidizer Tepidanaerobacter acetatoxydans UC0018 and to the absence of aceticlastic methanogens.

General information

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Organisations: Department of Environmental Engineering, Residual Resource Engineering, University of Padova, Catholic University of the Sacred Heart, Technical University of Denmark
Pages: 181-191
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Journal: Water Research
Volume: 134
ISSN (Print): 0043-1354
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 7.55 SJR 2.601 SNIP 2.358
Web of Science (2017): Impact factor 7.051
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 7.49 SJR 2.663 SNIP 2.563
Web of Science (2016): Impact factor 6.942
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 6.63 SJR 2.665 SNIP 2.482
Web of Science (2015): Impact factor 5.991
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 6.13 SJR 2.946 SNIP 2.702
Web of Science (2014): Impact factor 5.528
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 6.02 SJR 2.956 SNIP 2.676
Web of Science (2013): Impact factor 5.323
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.15 SJR 2.914 SNIP 2.442
Web of Science (2012): Impact factor 4.655
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 5.43 SJR 2.862 SNIP 2.355
Web of Science (2011): Impact factor 4.865
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.592 SNIP 2.192
Web of Science (2010): Impact factor 4.546
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.319 SNIP 2.224
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.073 SNIP 2.178
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.94 SNIP 2.184
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.902 SNIP 2.233
Web of Science (2006): Indexed yes
Biofouling is a major problem in water membrane processes, especially in seawater reverse osmosis plants. Inactivation of Vibrio fischeri (a well-known marine bacterium forming biofilm) through photocatalysis via visible light was investigated in this work using active Fe2O3-TiO2 nanoparticles. Five Fe2O3-TiO2 photocatalysts with different weight percentage of Fe2O3 (0–5wt%) were synthesized using an ultrasonic-assisted co-precipitation method. The photocatalysts were characterized by powder X-ray diffraction (XRD), BET surface area, transmission electron microscopy (TEM) plus selected area electron diffraction (SAED) patterns, scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDX) and diffuse-reflectance spectroscopy (DRS). Based on the design of experiments, the synthesized photocatalysts were tested for inactivation of V. fischeri under visible light irradiation at different temperatures (25–35°C) and different photocatalyst dosage (0.1–2g/L). The photocatalytic microbial inactivation experiments were performed in artificial seawater appropriate for growth of the marine bacterium. The results revealed that the highest inactivation efficiency of V. fischeri was achieved when 1g/L of 2.5wt% Fe2O3-TiO2 were used, at 35°C. Photocatalytic inactivation of microorganisms using visible light-driven Fe2O3-TiO2 photocatalysts, could introduce an innovative green method in pretreatment units of reverse osmosis plants to control the membrane biofouling.

Photocatalytic Inactivation of Vibrio fischeri using Fe₂O₃-TiO₂-based Nanoparticles

Biofouling is a major problem in water membrane processes, especially in seawater reverse osmosis plants. Inactivation of Vibrio fischeri (a well-known marine bacterium forming biofilm) through photocatalysis via visible light was investigated in this work using active Fe₂O₃-TiO₂ nanoparticles. Five Fe₂O₃-TiO₂ photocatalysts with different weight percentage of Fe₂O₃ (0–5wt%) were synthesized using an ultrasonic-assisted co-precipitation method. The photocatalysts were characterized by powder X-ray diffraction (XRD), BET surface area, transmission electron microscopy (TEM) plus selected area electron diffraction (SAED) patterns, scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDX) and diffuse-reflectance spectroscopy (DRS). Based on the design of experiments, the synthesized photocatalysts were tested for inactivation of V. fischeri under visible light irradiation at different temperatures (25–35°C) and different photocatalyst dosage (0.1–2g/L). The photocatalytic microbial inactivation experiments were performed in artificial seawater appropriate for growth of the marine bacterium. The results revealed that the highest inactivation efficiency of V. fischeri was achieved when 1g/L of 2.5wt% Fe₂O₃-TiO₂ were used, at 35°C. Photocatalytic inactivation of microorganisms using visible light-driven Fe₂O₃-TiO₂ photocatalysts, could introduce an innovative green method in pretreatment units of reverse osmosis plants to control the membrane biofouling.

General Information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering, Iranian Research Organization for Science and Technology (IROST)
Contributors: Baniamerian, H., Safavi, M., Alvarado-Morales, M., Tsapekos, P., Angelidaki, I., Shokrollahzadeh, S.
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 4.59 SJR 1.605 SNIP 1.413
Web of Science (2017): Impact factor 4.732
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 4.12 SJR 1.413 SNIP 1.326
Three distinctive start-up strategies of biogas reactors fed with source-sorted organic fraction of municipal solid waste were investigated to reveal the most reliable procedure for rapid process stabilization. Moreover, the experimental results were compared with mathematical modeling outputs. The initial inoculations to start-up the reactors were 10, 50 and 100% of the final working volume. While a constant feeding rate of 7.8gVS/d was considered for the control reactor, the organic loading rate for fed-batch reactors with 10 and 50% inoculation was progressively increased during a period of 60 and 13 days, respectively. The results clearly demonstrated that an exponentially feeding strategy, considering 50% inoculation relative to final volume, can significantly decrease the alternatively prolonged period to reach steady conditions, as observed by high biogas and methane production rates. The combination of both experimental and modelling/simulation succeeded in optimizing the start-up process for anaerobic digestion of biopulp under mesophilic conditions.
Research in organic waste as resources: How to implement circular bio-economy in the urban context?

General information
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Organisations: Department of Environmental Engineering, Residual Resource Engineering, Water Technologies
Publication date: 2018
Media of output: PowerPoint

Event information
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Location: Herning, Denmark
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Source: PublicationPreSubmission
Source-ID: 149423814
Research output: Research - peer-review › Journal article – Annual report year: 2018

Salinity-gradient energy driven microbial electrosynthesis of value-added chemicals from CO₂ reduction
Biological conversion of CO₂ to value-added chemicals and biofuels has emerged as an attractive strategy to address the energy and environmental concerns caused by the over-reliance on fossil fuels. In this study, an innovative microbial reverse-electrodialysis electrolysis cell (MREC), which combines the strengths of reverse electrodialysis (RED) and microbial electrosynthesis technology platforms, was developed to achieve efficient CO₂-to-value chemicals bioconversion by using the salinity gradient energy as driven energy sources. In the MREC, maximum acetate and ethanol concentrations of 477.5±33.2 and 46.2±8.2 mg L⁻¹ were obtained at the cathode, catalyzed by Sporomusa ovata with production rates of 165.79±11.52 and 25.11±4.46 mmol m⁻² d⁻¹, respectively. Electron balance analysis indicates that 94.4±3.9% of the electrons derived from wastewater and salinity gradient were recovered in acetate and ethanol. This work for the first time proved the potential of innovative MREC configuration has the potential as an efficient technology platform for simultaneous CO₂ capture and electrosynthesis of valuable chemicals.

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Li, X., Angelidaki, I., Zhang, Y.
Pages: 396-404
Publication date: 2018
Simultaneous biogas upgrading and biochemicals production using anaerobic bacterial mixed cultures

A novel biological process to upgrade biogas was developed and optimised during the current study. In this process, CO₂ in the biogas and externally provided H₂ were fermented under mesophilic conditions to volatile fatty acids (VFAs), which are building blocks of higher-value biofuels. Meanwhile, the biogas was upgraded to biomethane (CH₄ >95%), which can be used as a vehicle fuel or injected into the natural gas grid. To establish an efficient fermentative microbial platform, a thermal (at two different temperatures of 70°C and 90°C) and a chemical pretreatment method using 2-bromoethanesulfonate were investigated initially to inhibit methanogenesis and enrich the acetogenic bacterial inoculum. Subsequently, the effect of different H₂:CO₂ ratios on the efficiency of biogas upgrading and production of VFAs were further explored. The composition of the microbial community under different treatment methods and gas ratios has also been unravelled using 16S rRNA analysis. The chemical treatment of the inoculum had successfully blocked the activity of methanogens and enhanced the VFAs production, especially acetate. The chemical treatment led to a significantly better acetate production (291 mg HAc/L) compared to the thermal treatment. Based upon 16S rRNA gene sequencing, it was found that H₂-utilizing methanogens were the dominant species in the thermally treated inoculum, while a significantly lower abundance of methanogens was observed in the chemically treated inoculum. The highest biogas content (96% (v/v)) and acetate production were achieved for 2H₂:1CO₂ ratio (v/v), with Acetoanaerobium noterae, as the dominant homoacetogenic hydrogen scavenger. Results from the present study can pave the way towards more development with respect to microorganisms and conditions for high efficient VFAs production and biogas upgrading.

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering, Technical University of Denmark, City of Scientific Research and Technology Applications, Damietta University
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Peer-reviewed: Yes

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Journal: Water Research
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BFI (2018): BFI-level 2
Web of Science (2018): Indexed Yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 7.55 SJR 2.601 SNIP 2.358
Web of Science (2017): Impact factor 7.051
Web of Science (2017): Indexed Yes
Spatial Distribution and Diverse Metabolic Functions of Lignocellulose-Degrading Uncultured Bacteria as Revealed by Genome-Centric Metagenomics

The mechanisms by which specific anaerobic microorganisms remain firmly attached to lignocellulosic material, allowing them to efficiently decompose organic matter, have yet to be elucidated. To circumvent this issue, microbiomes collected from anaerobic digesters treating pig manure and meadow grass were fractionated to separate the planktonic microbes from those adhered to lignocellulosic substrate. Assembly of shotgun reads, followed by a binning process, recovered 151 population genomes, 80 out of which were completely new and were not previously deposited in any database. Genome coverage allowed the identification of microbial spatial distribution in the engineered ecosystem. Moreover, a composite bioinformatic analysis using multiple databases for functional annotation revealed that uncultured members of the Bacteroidetes and Firmicutes follow diverse metabolic strategies for polysaccharide degradation. The structure of cellulosome in Firmicutes species can differ depending on the number and functional roles of carbohydrate-binding modules. In contrast, members of the Bacteroidetes are able to adhere to and degrade lignocellulose due to the presence of multiple carbohydrate-binding family 6 modules in beta-xylosidase and endoglucanase proteins or S-layer homology modules in unknown proteins. This study combines the concept of variability in spatial distribution with genome-centric metagenomics, allowing a functional and taxonomical exploration of the biogas microbiome. IMPORTANCE This work contributes new knowledge about lignocellulose degradation in engineered ecosystems. Specifically, the combination of the spatial distribution of uncultured microbes with genome-centric metagenomics provides novel insights into the metabolic properties of planktonic and firmly attached to plant biomass bacteria. Moreover, the knowledge obtained in this study enabled us to understand the diverse metabolic strategies for polysaccharide degradation in different species of Bacteroidetes and Clostridiales. Even though structural elements of cellulosome were restricted to Clostridiales species, our study identified a putative mechanism in Bacteroidetes species for biomass decomposition, which is based on a gene cluster responsible for cellulose degradation, disaccharide cleavage to glucose, and transport to cytoplasm.
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 4.25 SJR 1.899 SNIP 1.414
Web of Science (2013): Impact factor 3.952
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 4.29 SJR 1.975 SNIP 1.429
Web of Science (2012): Impact factor 3.678
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 4.12 SJR 1.914 SNIP 1.455
Web of Science (2011): Impact factor 3.829
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.887 SNIP 1.436
Web of Science (2010): Impact factor 3.778
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.972 SNIP 1.528
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.156 SNIP 1.572
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 2.043 SNIP 1.647
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 2.054 SNIP 1.602
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 2.074 SNIP 1.653
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 2.108 SNIP 1.648
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 2.097 SNIP 1.821
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 2.046 SNIP 1.754
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.989 SNIP 1.736
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 1.957 SNIP 1.758
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 2.3 SNIP 1.732
Original language: English
Keywords: Archaea, Anaerobic digestion, Lignocellulose, Metagenomics, Methane, Microbial ecology, Uncultured microbes, Metabolism
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Sustainable bioenergy and biofuels innovation challenge

General information
Taxonomy of anaerobic digestion microbiome reveals biases associated with the applied high throughput sequencing strategies

In the past few years, many studies investigated the anaerobic digestion microbiome by means of 16S rRNA amplicon sequencing. Results obtained from these studies were compared to each other without taking into consideration the followed procedure for amplicons preparation and data analysis. This negligence was mainly due to the lack of knowledge regarding the biases influencing specific steps of the microbiome investigation process. In the present study, the main technical aspects of the 16S rRNA analysis were checked giving special attention to the approach used for high throughput sequencing. More specifically, the microbial compositions of three laboratory scale biogas reactors were analyzed before and after addition of sodium oleate by sequencing the microbiome with three different approaches: 16S rRNA amplicon sequencing, shotgun DNA and shotgun RNA. This comparative analysis revealed that, in amplicon sequencing, abundance of some taxa (Euryarchaeota and Spirochaetes) was biased by the inefficiency of universal primers to hybridize all the templates. Reliability of the results obtained was also influenced by the number of hypervariable regions under investigation. Finally, amplicon sequencing and shotgun DNA underestimated the Methanoculleus genus, probably due to the low 16S rRNA gene copy number encoded in this taxon.
Lignocellulosic biomass residues can be used as an interesting resource for the production of biochemicals or sustainable fuels. In this optic, lignin represents an interesting raw material for the production of chemicals, such as aromatic compounds, or fuels. This can contribute in moving away from petroleum-based industries to bio-based industries. The aim of this study was to investigate the application of a photocatalytic process using a commercial solution composed by TiO2 doped with AgCl for wheat straw valorization. The study investigated the effect of pH and catalyst concentrations for optimal phenolic compounds production. It was found that the photocatalytic treatment boosted the phenolic production from wheat straw. The efficiency of the process depended on the initial pH and catalyst concentration. Process optimization towards increased phenolic compounds production was performed. Catalyst concentration of 1 g/L and a treatment time of 1.56 hours in alkaline conditions resulted in the highest phenolics production. Use of the photocatalytic treated wheat straw for anaerobic digestion (AD) was also evaluated. Results showed that the AD microbiome is strongly inhibited by the presence of toxic compounds presented in the catalyst-straw solution and specifically, HNO3 was toxic to methanogenic communities. Hence, to succeed in an efficient biorefinery framework where total phenols and biogas production are combined, the usage of HNO3 for catalyst synthesis should be avoided.
Two-year microbial adaptation during hydrogen-mediated biogas upgrading process in a serial reactor configuration

Microbial dynamics in an upgrading biogas reactor system undergoing a more than two years-period at stable operating conditions were explored. The carbon dioxide generated during biomass degradation in the first reactor of the system was converted to methane into the secondary reactor by addition of external hydrogen. Considering the overall efficiency, the long-term operation period resulted in an improved biogas upgrading performance (99% methane content). However, a remarkable accumulation of acetate was revealed, indicating the enhancement of homoacetogenic activity. For this reason, a shift in the anaerobic digestion microbiome was expected and evaluated by 16S rRNA amplicon analysis.
Results demonstrated that the most abundant archaeal species identified in the first time point, Candidatus Methanoculleus thermohydrogenotrophicum, was replaced by Methanothermobacter thermautotrophicus, becoming dominant after the community adaptation. The most interesting taxonomic units were clustered by relative abundance and six main long-term adaptation trends were found, characterizing functionally related microbes (e.g. homoacetogens).

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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.94 SJR 2.215 SNIP 1.932
Web of Science (2016): Impact factor 5.651
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.47 SJR 2.243 SNIP 1.897
Web of Science (2015): Impact factor 4.917
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.3 SJR 2.399 SNIP 2.087
Web of Science (2014): Impact factor 4.494
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 5.97 SJR 2.405 SNIP 2.477
Web of Science (2013): Impact factor 5.039
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.25 SJR 2.334 SNIP 2.461
Web of Science (2012): Impact factor 4.75
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 5.56 SJR 2.308 SNIP 2.507
Web of Science (2011): Impact factor 4.98
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BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.089 SNIP 2.344
Web of Science (2010): Impact factor 4.365
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.915 SNIP 2.236
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.736 SNIP 2.74
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.403 SNIP 2.396
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.314 SNIP 2.003
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.278 SNIP 1.98
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.19 SNIP 1.655
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.942 SNIP 1.665
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.908 SNIP 1.294
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.537 SNIP 1.2
Scopus rating (2000): SJR 0.653 SNIP 1.023
Scopus rating (1999): SJR 0.659 SNIP 1.033
Original language: English
Keywords: Biogas upgrading, Homoacetogenic bacteria, Hydrogenotrophic methanogenesis, Long-term microbial adaptation, Syntrophic acetate-oxidizers
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Valorisation of Effluents from Anaerobic Digestion as Single Cell Protein – Focus on Safe Gas Supply

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Event: Abstract from 6th International Conference on Sustainable Solid Waste Management (NAXOS 2018), Naxos Island, Greece.
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Acclimation of ammonia tolerant methanogenic consortia using different bioreactor types

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Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Mancini, E., Fotidis, I., Tian, H., Angelidaki, I.
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Acclimation to extremely high ammonia levels during continuous biomethanation process

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Research output: Research - peer-review › Paper – Annual report year: 2017

Algal Biomass for Bioenergy and Bioproducts Production in Biorefinery Concepts
The fast population growth is increasing the demand for energy and resources. However, the reserves of oil are diminishing and greenhouse emissions associated to its combustion are affecting the global climate causing global warming. Therefore the need for alternative resources and processes is becoming impellent.
Macro- and microalgae have the ability to transform nutrients into valuable biomass. Being a good source of vitamins, minerals, lipids, proteins and pigments, they represent a promising source of various products. However these biomasses are still very little explored as biorefinery feedstocks.
Biorefinery represents an important tool towards the development of a sustainable economy. Within the biorefinery framework several bioproducts, such as food, feed and biofuels, can be produced from biomass. The specific composition of the biomass feedstock determines the potential final product that can be obtained.
In this thesis, micro- and macroalage were investigated as biorefinery feedstocks. The main aim of this work was developing different biorefinery strategies for the production of high value products, such as proteins or pigments, to be employed in the pharmaceutical or nutraceutical industry. The macroalgae used in this work were Laminaria digitata and Saccharina latissima, while the microalgae were Chlorella sorokiniana, Chlorella vulgaris and Chlorella protothecoides. Moreover, an evaluation of the effect of the harvesting season and location on the composition of high value products such as total phenolics and on the biogas potential for L. digitata and S. latissima was done. Both these factors had a significant impact on the accumulation of total phenolics in the algal biomass and on the biogas production. In particular, samples harvested in summer, because of the high content of sugars, showed to be the most promising feedstock in the development of biorefinery processes, containing 0.5 mgTPC gDM-1 and having a biomethane potential of 343.7 NmLCH4 g VS-1.
Moreover, proteins being an interesting valuable product to be used as food and feed supplement, diverse industrial methods to produce amino acids and proteins were analyzed. Innovative techniques to increase the protein content in the final biomass, such as microalgae or microorganisms to be used as single cell proteins (SCP), were also investigated. The combination of phototropic growth of C. sorokiniana with Methyllococcus capsulatus led to an innovative solution where two products rich in proteins (up to 43 %DM) were obtained.
Another strategy developed in this thesis work was based on the combination of micro- and macroalgae to enhance protein production. Indeed, the microalgae C. protothecoides was grown heterotrophically in the macroalgae L. digitata hydrolyzed. The final composition of the microalgal biomass showed that the protein content was increased from 0.07 ± 0.01 gProtein gDM-1 to 0.44 ± 0.04 gProtein DM-1. The results obtained show that this solution may represent an interesting strategy to be applied in a biorefinery approach.
Finally, a microalgae biorefinery strategy was developed. Lutein represents a very important pigment present in the macular region of the human eye. It is crucial in the protection against light-induced retinal damages and responsible for maintaining human bone health and preventing some diseases. Lutein and proteins were extracted by developing innovative methods specifically designed for microalgae species. From the initial algal biomass were extracted 0.8 ± 0.1 mg Lutein gDM-1 with a purity of 92.5 ± 1.2% and a calculated yield of 95%. Moreover, the final protein content in the fraction was 82.7 ± 3.1% w w-1with a protein yield of 55%. Finally, from the residues of this extraction processes, 372.7 ± 19.0 NmLCH4 gVS-1 of biogas were produced.
The results obtained in this thesis work show that macro- and microalgae are promising biomasses for the development of the future biorefineries.
Anaerobic granular sludge for simultaneous biomethanation of synthetic wastewater and CO with focus on the identification of CO-converting microorganisms

CO is a main component of syngas, which can be produced from the gasification of organic wastes and biomass. CO can be converted to methane by anaerobic digestion (AD), however, it is still challenging due to its toxicity to microorganisms and limited knowledge about CO converting microorganisms. In the present study, anaerobic granular sludge (AGS) was used for the simultaneous biomethanation of wastewater and CO. Batch experiments showed that AGS tolerated CO partial pressure as high as 0.5 atm without affecting its ability for synthetic wastewater degradation, which had higher tolerance of CO compared to suspended sludge (less than 0.25 atm) as previously reported. Continuous experiments in upflow anaerobic sludge blanket (UASB) reactors showed AGS could efficiently convert synthetic wastewater and CO into methane by applying gas-recirculation. The addition of CO to UASB reactor enhanced the hydrogenotrophic CO-oxidizing pathway, resulted in the increase of extracellular polymeric substances, changed the morphology of AGS and significantly altered the microbial community compositions of AGS. The microbial species relating with CO conversion and their functions were revealed by metagenomic analysis. It showed that 23 of the 70 reconstructed genome bins (GBs), most of which were not previously characterized at genomic level, were enriched and contained genes involved in CO conversion upon CO addition. CO-converting microorganisms might be taxonomically more diverse than previously known and have multi-functions in the AD process. The reductive tricarboxylic acid (TCA) cycle in combination with the oxidation of the CO was probably crucial for CO utilization by the majority of the GBs in the present study.
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 6.13 SJR 2.946 SNIP 2.702
Web of Science (2014): Impact factor 5.528
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 6.02 SJR 2.956 SNIP 2.676
Web of Science (2013): Impact factor 5.323
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.15 SJR 2.914 SNIP 2.442
Web of Science (2012): Impact factor 4.655
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 5.43 SJR 2.862 SNIP 2.355
Web of Science (2011): Impact factor 4.865
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.592 SNIP 2.192
Web of Science (2010): Impact factor 4.546
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.319 SNIP 2.224
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.073 SNIP 2.178
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.94 SNIP 2.184
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.902 SNIP 2.233
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 2.113 SNIP 2.334
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 2.209 SNIP 2.108
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.702 SNIP 1.908
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.568 SNIP 1.757
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.319 SNIP 1.69
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 1.399 SNIP 1.662
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 1.432 SNIP 1.55
Original language: English
Keywords: Anaerobic granular sludge, Wastewater treatment, CO biomethanation, Metagenomic analysis, CO-Converting microorganisms
DOIs: 10.1016/j.watres.2017.09.018
Research output: Research - peer-review › Journal article – Annual report year: 2017
A novel archaeal species belonging to Methanoculleus genus identified via de-novo assembly and metagenomic binning process in biogas reactors

Recently, a first comprehensive catalogue of microbial genomes populating biogas reactors treating manure and agro-industrial residues was determined by sequencing samples collected from 22 biogas reactors including laboratory and full scale. Among the archaeal community, one of the most abundant methanogens belongs to Methanoculleus genus and for this reason it was provisionally named Methanoculleus sp. DTU006. Its full length 16S rRNA sequence is 97% similar to Methanoculleus marisnigri JR1 and to Methanoculleus palmolei DSM 4273. Despite the high similarity of the 16S gene sequence, Average Nucleotide Identity calculation (ANI) calculated on all protein encoding genes indicated that the two most similar species, Methanoculleus bourgensis MS2T and Methanoculleus sp. MAB1, are divergent enough to define Methanoculleus sp. DTU006 as new archaeal species. Its genome (2.15 Mbp) has an estimated completeness around 93%. Analysis of the metabolic pathways using KEGG confirmed that it is a hydrogenotrophic methanogen and therefore it is proposed the Candidatus status by naming it as “Candidatus Methanoculleus thermohydrogenotrophicum”.

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BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.8 SJR 1.144 SNIP 1.204
Web of Science (2017): Impact factor 2.742
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.75 SJR 0.995 SNIP 0.948
Web of Science (2016): Impact factor 2.278
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 2.77 SJR 1.104 SNIP 0.999
Web of Science (2015): Impact factor 2.424
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 2.77 SJR 1.015 SNIP 1.16
Web of Science (2014): Impact factor 2.479
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 2.68 SJR 1.105 SNIP 1.06
Web of Science (2013): Impact factor 2.364
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 2.48 SJR 0.984 SNIP 0.937
Web of Science (2012): Impact factor 2.022
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 2.48 SJR 0.901 SNIP 0.949
Web of Science (2011): Impact factor 2.409
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.882 SNIP 1.049
An overview of electron acceptors in microbial fuel cells

Microbial fuel cells (MFC) have recently received increasing attention due to their promising potential in sustainable wastewater treatment and contaminant removal. In general, contaminants can be removed either as an electron donor via microbial catalyzed oxidization at the anode or removed at the cathode as electron acceptors through reduction. Some contaminants can also function as electron mediators at the anode or cathode. While previous studies have done a thorough assessment of electron donors, cathodic electron acceptors and mediators have not been as well described. Oxygen is widely used as an electron acceptor due to its high oxidation potential and ready availability. Recent studies, however, have begun to assess the use of different electron acceptors because of the (1) diversity of redox potential, (2) needs of alternative and more efficient cathode reaction, and (3) expanding of MFC based technologies in different areas.

The aim of this review was to evaluate the performance and applicability of various electron acceptors and mediators used in MFCs. This review also evaluated the corresponding performance, advantages and disadvantages, and future potential applications of select electron acceptors (e.g., nitrate, iron, copper, perchlorate) and mediators.
Antibiotic Resistance Genes and Correlations with Microbial Community and Metal Resistance Genes in Full-Scale Biogas Reactors As Revealed by Metagenomic Analysis

Digested residues from biogas plants are often used as biofertilizers for agricultural crops cultivation. The antibiotic resistance genes (ARGs) in digested residues pose a high risk to public health due to their potential spread to the disease-causing microorganisms and thus reduce the susceptibility of disease-causing microorganisms to antibiotics in medical treatment. A high-throughput sequencing (HTS)-based metagenomic approach was used in the present study to investigate the variations of ARGs in full-scale biogas reactors and the correlations of ARGs with microbial communities and metal resistance genes (MRGs). The total abundance of ARGs in all the samples varied from $7 \times 10^{-3}$ to $1.08 \times 10^{-1}$ copy of ARG/copy of 16S-rRNA gene, and the samples obtained from thermophilic biogas reactors had a lower total abundance of ARGs, indicating the superiority of thermophilic anaerobic digestion for ARGs removal. ARGs in all the samples were composed of 175 ARG subtypes; however, only 7 ARG subtypes were shared by all the samples. Principal component analysis and canonical correspondence analysis clustered the samples into three groups (samples from manure-based mesophilic reactors, manure-based thermophilic reactors, and sludge-based mesophilic reactors), and substrate, temperature, and hydraulic retention time (HRT) as well as volatile fatty acids (VFAs) were identified as crucial environmental variables affecting the ARGs compositions. Procrustes analysis revealed microbial community composition was the determinant of ARGs composition in biogas reactors, and there was also a significant correlation between ARGs composition and MRGs composition. Network analysis further revealed the co-occurrence of ARGs with specific microorganisms and MRGs.
A review on prospects and challenges of biological H₂S removal from biogas with focus on biotrickling filtration and microaerobic desulfurization

The production of biogas from sulfate-rich materials under anaerobic digestion results in the formation of hydrogen sulfide (H₂S). The recommended level of H₂S in the produced biogas for direct combustion purposes is in the range of 0.02 to 0.05% w/w (200 to 500 ppm), therefore, desulfurization is required to avoid damages to combustion equipment and prevent the formation of sulfur dioxide (SO₂) which is an acid rain precursor. It has been well documented that physical, thermal, and chemical desulfurization approaches suffer from high operation costs as well as waste production needing to be disposed of. Accordingly, a great deal of efforts has been put into biological methods because of being more environmentally friendly and more economically advantageous in comparison with the other techniques. Biotrickling filtration (BTF) and microaerobic desulfurization have shown a high potential for H₂S removal at pilot- and large-scale plants. Despite all the progress made and the promising aspects keeping these methods at the core of interest, there are still challenges to be addressed. The present article attempts to briefly review and discuss the challenges and future prospects of BTF and microaerobic desulfurization.

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Web of Science (2017): Indexed yes
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Web of Science (2016): Indexed yes
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Source-ID: 85036581166
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A systematic methodology to extend the applicability of a bioconversion model for the simulation of various co-digestion scenarios

Detailed simulation of anaerobic digestion (AD) requires complex mathematical models and the optimization of numerous model parameters. By performing a systematic methodology and identifying parameters with the highest impact on process variables in a well-established AD model, its applicability was extended to various co-digestion scenarios. More specifically, the application of the step-by-step methodology led to the estimation of a general and reduced set of parameters, for the simulation of scenarios where either manure or wastewater were co-digested with different organic substrates. Validation of the general parameter set involved the simulation of laboratory-scale data from three continuous co-digestion experiments, treating mixtures of different organic residues either at thermophilic or mesophilic conditions. Evaluation of the results showed that simulations using the general parameter set fitted experimental data quite well, indicating that it offers a reliable reference point for future simulations of anaerobic co-digestion scenarios.

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Web of Science (2017): Impact factor 5.807
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.94 SJR 2.215 SNIP 1.932
Web of Science (2016): Impact factor 5.651
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.47 SJR 2.243 SNIP 1.897
Web of Science (2015): Impact factor 4.917
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.3 SJR 2.399 SNIP 2.087
Web of Science (2014): Impact factor 4.494
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 5.97 SJR 2.405 SNIP 2.477
Web of Science (2013): Impact factor 5.039
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.25 SJR 2.334 SNIP 2.461
Web of Science (2012): Impact factor 4.75
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 5.56 SJR 2.308 SNIP 2.507
Web of Science (2011): Impact factor 4.98
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
Batch, fed-batch and CSTR reactors as cultivation systems to acclimate ammonia tolerant methanogenic consortia

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Contributors: Fotidis, I., Tian, H., Mancini, E., Angelidaki, I.
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Source-ID: 140589154
Research output: Research - peer-review › Poster – Annual report year: 2017

Bioaugmentation with hydrolytic microbes to improve the anaerobic biodegradability of lignocellulosic agricultural residues

Bioaugmentation with hydrolytic microbes was applied to improve the methane yield of bioreactors fed with agricultural wastes. The efficiency of Clostridium thermocellum and Melioribacter roseus to degrade lignocellulosic matter was evaluated in batch and continuously stirred tank reactors (CSTRs). Results from batch assays showed that C. thermocellum enhanced the methane yield by 34%. A similar increase was recorded in CSTR during the bioaugmentation period; however, at steady-state the effect was noticeably lower (7.5%). In contrast, the bioaugmentation with M. roseus did not promote markedly the anaerobic biodegradability, as the methane yield was increased up to 10% in batch and no effect was shown in CSTR. High-throughput 16S rRNA amplicon sequencing was used to assess the effect of bioaugmentation strategies on bacterial and archaeal populations. The microbial analysis revealed that both strains were not markedly resided into biogas microbiome. Additionally, the applied strategies did not alter significantly the microbial
communities.

**General information**
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Organisations: Department of Environmental Engineering, Residual Resource Engineering, Technical University of Denmark, University of Padova, National Technical University of Athens
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BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.94 SJR 2.215 SNIP 1.932
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Web of Science (2016): Indexed yes
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Scopus rating (2015): CiteScore 5.47 SJR 2.243 SNIP 1.897
Web of Science (2015): Impact factor 4.917
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.3 SJR 2.399 SNIP 2.087
Web of Science (2014): Impact factor 4.494
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
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Web of Science (2013): Impact factor 5.039
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.25 SJR 2.334 SNIP 2.461
Web of Science (2012): Impact factor 4.75
ISI indexed (2012): ISI indexed yes
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BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 5.56 SJR 2.308 SNIP 2.507
Web of Science (2011): Impact factor 4.98
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.089 SNIP 2.344
Web of Science (2010): Impact factor 4.365
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.915 SNIP 2.236
Bioelectricity production and microbial communities in microbial fuel cell powered by macroalgal biomass

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering, Technical University of Denmark
Contributors: Zhao, N., Jiang, Y., Alvarado-Morales, M., Treu, L., Angelidaki, I., Zhang, Y.
Number of pages: 1
Publication date: 2017

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Research output: Research - peer-review » Conference abstract in proceedings – Annual report year: 2017

Bioelectrochemical systems serve anaerobic digestion process for process monitoring and biogas upgrading
Bioelectrochemical systems (BES), which employ microbes as catalysts to convert chemical energy stored in organic matter into sustainable electricity and high-value chemicals, is an emerging and promising technology. BES have broad applications including wastewater treatment, chemical production, resource recovery and waste remediation. Recently, new concepts of been proposed. The purpose of this work was to optimize the AD process using BES in two aspects: developing a new volatile fatty acid (VFA) monitoring system which can be used as the AD process indicator, and for improving biogas quality by removing CO₂. In this thesis, a microbial desalination cell (MDC) was developed for measuring VFAs concentrations. The MDC was composed of three chambers, namely an anode, a cathode and a middle chamber. The samples were measured in the middle chamber, which was separated from the anode by an in their ionized form contained in the sample, diffused through AEM to the anode where they were microbially oxidized and produced current signals. The effect of operating parameters such as ionic strength and external resistance on the performance of the MDC-typed biosensor were assessed. High ionic strength and small external resistance were advantageous for current signal amplification. Two linear relationships between current outputs and VFA concentrations were observed. The response time was approx. 5 h and the detection range was 1 to 200 mM. The selectivity of the biosensor was demonstrated since organic matter such as protein and lipids were retained by the AEM and their interference was eliminated. The reliability was proved by real AD effluents. In order to reduce the construction cost and simplify the VFA
biosensor, a new configuration was developed. The number of chambers was reduced from three to two. The new configuration was a microbial electrolysis cell (MEC). The anode and cathode chambers were separated by an AEM and a small additional voltage was supplied to the cell. The samples were measured in the cathode. The effect of different parameters such as external voltage, ionic strength and VFA composition ratio on the MEC-typed biosensor performance was evaluated. Higher current signals were observed under larger external voltage and higher ionic strengths. The current output was mainly contributed by acetate which was always dominant in AD reactors. The current density increased linearly along with VFAs concentrations ranging from 5 to 100 mM. The response of the biosensor was now only 1 h due to the faster transfer of VFAs supported by the external voltage. The interference from other non-ionic organic matter (glucose, cellulose, lipids and protein) could be eliminated since they were retained by the membrane. During the process, hydrogen (H₂) was generated from water hydrolysis. The produced H₂ could potentially contribute to the energy needs for operating the biosensor and thereby to a self-sustaining system. Moreover, the biosensor was successfully validated both with synthetic and real AD effluents. To improve biogas quality, a microbial electrolytic capture, separation and regeneration cell (MESC) was developed. The effects of external voltage and inlet gas flow rate were elucidated. The current output increased along with the gas flow rate, while cathodic pH and upgrading performance showed opposite trends. The current output, cathodic pH and upgrading performance increased with the increasing external voltage supply. In MESC, acid and alkaline generation, CO₂ capture, biogas upgrading and COD removal were simultaneously achieved. Under the optimum condition at 1.2 V external voltage and 19.6 mL/h gas flow rate, pH in the regeneration and cathode chambers could reach 1.34±0.04 and 9.19±0.11, respectively; the maximum methane content was up to 97.0±0.2% and COD removal efficiency reached 98.2±2.6%. The energy consumption for biogas upgrading was around 0.17 kWh/m³ raw biogas. Moreover, the generated H₂ from water hydrolysis could potentially compensate for 23.4% of the energy consumption. It has been proved that the development of efficient, cheap, fast and reliable VFA monitoring with a wide detection range can be realized in BES which is sustainable and environmental friendly. The development technology could easily be installed as online monitoring system for optimizing the AD process. Moreover, BES could be a sustainable economic technology to upgrade biogas to biomethane and thereby increase the value of biogas. The proof-of-concept study in lab-scale offers ideas for expanding BES application.

Bio-electrolytic sensor for rapid monitoring of volatile fatty acids in anaerobic digestion process

This study presents an innovative biosensor that was developed on the basis of a microbial electrolysis cell for fast and reliable measurement of volatile fatty acids (VFA) during anaerobic digestion (AD) process. The bio-electrolytic sensor was first tested with synthetic wastewater containing varying concentrations of VFA. A linear correlation (R² = 0.99) between current densities (0.03 ± 0.01 to 2.43 ± 0.12 A/m²) and VFA concentrations (5–100 mM) was found. The sensor performance was then investigated under different affecting parameters such as the external voltage, VFA composition ratio, and ionic strength. Linear relationship between the current density and VFA concentrations was always observed. Furthermore, the bio-electrolytic sensor proved ability to handle interruptions such as the presence of complex organic matter, anode exposure to oxygen and low pH. Finally, the sensor was applied to monitor VFA concentrations in a lab-scale AD reactor for a month. The VFA measurements from the sensor correlated well with those from GC analysis which proved the accuracy of the system. Since hydrogen was produced in the cathode as byproduct during monitoring, the system could be energy self-sufficient. Considering the high accuracy, short response time, long-term stability and additional benefit of H₂ production, this bio-electrolytic sensor could be a simple and cost-effective method for VFA monitoring during AD and other anaerobic processes.
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<td>Journal: Water Research</td>
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<td>Volume: 111</td>
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Biological caproate production by Clostridium kluyveri from ethanol and acetate as carbon sources

Caproate is a valuable industrial product and chemical precursor. In this study, batch tests were conducted to investigate the fermentative caproate production through chain elongation from acetate and ethanol. The effect of acetate/ethanol ratio and initial ethanol concentration on caproate production was examined. When substrate concentration was controlled at 100 mM total carbon, hydrogen was used as an additional electron donor. The highest caproate concentration of 3.11 g/L was obtained at an ethanol/acetate ratio of 7:3. No additional electron donor was needed upon an ethanol/acetate ratio ≥7:3. Caproate production increased with the increase of carbon source until ethanol concentration over 700 mM, which inhibited the fermentation process. The highest caproate concentration of 8.42 g/L was achieved from high ethanol strength wastewater with an ethanol/acetate ratio of 10:1 (550 mM total carbon). Results obtained in this study can pave the way towards efficient chain elongation from ethanol-rich wastewater.
Biological systems for simultaneous methanation of CO₂ and H₂ by anaerobic microorganisms

General information
State: Published
Butanol fermentation of the brown seaweed Laminaria digitata by Clostridium beijerinckii DSM-6422

Seaweed represents an abundant, renewable, and fast-growing biomass resource for 3rd generation biofuel production. This study reports an efficient butanol fermentation process carried out by Clostridium beijerinckii DSM-6422 using enzymatic hydrolysate of the sugar-rich brown seaweed Laminaria digitata harvested from the coast of the Danish North Sea as substrate. The highest butanol yield (0.42g/g-consumed-substrates) compared to literature was achieved, with a significantly higher butanol:acetone-butanol-ethanol (ABE) molar ratio (0.85) than typical (0.6). This demonstrates the possibility of using the seaweed L. digitata as a potential biomass for butanol production. For the first time, consumption of alginate components was observed by C. beijerinckii DSM-6422. The efficient utilization of sugars and lactic acid further highlighted the potential of using this strain for future development of large-scale cost-effective butanol production based on ensiled seaweed.
Characterization of the planktonic microbiome in upflow anaerobic sludge blanket reactors during adaptation of mesophilic methanogenic granules to thermophilic operational conditions

Upflow anaerobic sludge blanket (UASB) technology refers to reactor technology where granules, i.e. self-immobilised microbial associations, are the biological catalysts involved in the anaerobic digestion process. During the start-up period, UASB reactors operate at relatively long HRT and therefore the liquid phase of the reactor becomes a favourable environment for microbial growth. The current study aimed to elucidate the dynamicity of the suspended microbial community in UASB reactors, during the transition from mesophilic to thermophilic conditions. High throughput 16S rRNA amplicon sequencing was used to characterize the taxonomic composition of the microbiome. The results showed that the
microbial community was mainly composed by hydrolytic and fermentative bacteria. Results revealed relevant shifts in the microbial community composition, which is mainly determined by the operational conditions and the reactor performance. Finally, shared OTUs between the microbial consortia of the suspended and the granular sludge showed that planktonic microbiota is significantly influencing the granule microbial community composition.

**General information**
- **State:** Published
- **Organisations:** Department of Environmental Engineering, Residual Resource Engineering, University of Padova
- **Contributors:** Zhu, X., Treu, L., Kougias, P., Campanaro, S., Angelidaki, I.
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  - **BFI (2017):** BFI-level 1
  - **Scopus rating (2017):** CiteScore 2.8 SJR 1.144 SNIP 1.204
  - **Web of Science (2017):** Impact factor 2.742
  - **Web of Science (2017):** Indexed yes
  - **BFI (2016):** BFI-level 1
  - **Scopus rating (2016):** CiteScore 2.75 SJR 0.995 SNIP 0.948
  - **Web of Science (2016):** Impact factor 2.278
  - **BFI (2015):** BFI-level 1
  - **Scopus rating (2015):** CiteScore 2.77 SJR 1.104 SNIP 0.999
  - **Web of Science (2015):** Impact factor 2.424
  - **Web of Science (2015):** Indexed yes
  - **BFI (2014):** BFI-level 1
  - **Scopus rating (2014):** CiteScore 2.77 SJR 1.015 SNIP 1.16
  - **Web of Science (2014):** Impact factor 2.479
  - **Web of Science (2014):** Indexed yes
  - **BFI (2013):** BFI-level 1
  - **Scopus rating (2013):** CiteScore 2.68 SJR 1.105 SNIP 1.06
  - **Web of Science (2013):** Impact factor 2.364
  - **ISI indexed (2013):** ISI indexed yes
  - **Web of Science (2013):** Indexed yes
  - **BFI (2012):** BFI-level 1
  - **Scopus rating (2012):** CiteScore 2.48 SJR 0.984 SNIP 0.937
  - **Web of Science (2012):** Impact factor 2.022
  - **ISI indexed (2012):** ISI indexed yes
  - **BFI (2011):** BFI-level 1
  - **Scopus rating (2011):** CiteScore 2.48 SJR 0.901 SNIP 0.949
  - **Web of Science (2011):** Impact factor 2.409
  - **ISI indexed (2011):** ISI indexed yes
  - **BFI (2010):** BFI-level 1
  - **Scopus rating (2010):** SJR 0.882 SNIP 1.049
  - **Web of Science (2010):** Impact factor 2.448
  - **Web of Science (2010):** Indexed yes
  - **BFI (2009):** BFI-level 1
  - **Scopus rating (2009):** SJR 0.679 SNIP 0.856
  - **BFI (2008):** BFI-level 1
  - **Scopus rating (2008):** SJR 0.607 SNIP 0.727

**BFI (2007):** BFI-level 1
**Scopus rating (2007):** CiteScore 2.48 SJR 0.684 SNIP 0.949
**Web of Science (2007):** Impact factor 2.424
**Web of Science (2007):** Indexed yes
**BFI (2006):** BFI-level 1
**Scopus rating (2006):** CiteScore 2.48 SJR 0.607 SNIP 0.727
Co-cultivation of Green Microalgae and Methanotrophic Bacteria for Single Cell Protein Production from Wastewater

Conventional water treatment technologies remove nutrients via resource intensive processes. However, new approaches for residual nutrient recycling are needed to provide food to the increasing world population. This work explores the use of microbial biomass – methane oxidizing bacteria and green microalgae – as a means to recover nutrients from industrial wastewater and upcycle them to feed grade single cell protein. Results demonstrated that both algae and bacteria could remove or assimilate most of the organic carbon present in the wastewater. However, their growth stopped before nutrients and substrates in the gas phase (i.e., methane and oxygen for methanotrophs and carbon dioxide for algae) were depleted. Likely, algal growth was light limited and stopped after organic carbon was consumed, whilst growth of methanotrophic bacteria could be limited by trace elements (e.g., copper). Nevertheless, the amino acid profile of both the monocultures and the algal-bacteria consortium was suitable for substitution of conventional protein sources. Further research should focus on increasing productivity of biomass grown on wastewater resources.

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Place of publication: Kgs. Lyngby, Denmark
Publisher: Technical University of Denmark (DTU)
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ABSTRACT

ABSTRACT BOOK
Source: PublicationPreSubmission
Source-ID: 140263124
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2017

Comparison of Fenton, UV-Fenton and nano-Fe3O4 catalyzed UV-Fenton in degradation of phloroglucinol under neutral and alkaline conditions: Role of complexation of Fe(III) with hydroxyl group in phloroglucinol

Phloroglucinol degradation at initial pH from 7.0 to 9.0 has been investigated in Fenton, UV-Fenton and nano-Fe3O4 catalyzed UV-Fenton (Hetero-Fenton). Within the reaction time given in this study (not more than 4 h), 150 mg/L of phloroglucinol was completely removed, while there was some difference in TOC removal efficiency: about 90% for UV-Fenton, nearly 60% for Fenton and Hetero-Fenton. Increasing initial pH from 7.0 to 9.0, there was an obvious decline in the degradation rate. The average values of H2O2 utilization efficiency were 0.65 ± 0.01 for Fenton, 0.66 ± 0.09 for UV-Fenton, and 1.35 ± 0.15 for Hetero-Fenton, suggesting Hetero-Fenton required less H2O2 consumption. Solution pH could decrease to strongly acidic conditions of pH <4.0 and the generation of organic acids including formic, acetic, oxalic, and maleic acids depended on the type of oxidation process. The spectrophotometric study showed phloroglucinol would complex with Fe(III) at pH 7.0 to form homogeneous aqueous solution which exhibited strong light absorption in the
wavelength range of 400 nm to 600 nm. Therefore, formation of Fe(III)-phloroglucinol complex and pH decrease to strongly acidic condition played important roles in Fenton degradation under neutral and alkaline pH. The result of effect of pollutant content showed phloroglucinol at lower concentrations of 20 and 50 mgÅ·L−1 could still be completely removed by all Fenton-based systems at pH 7.0, however, in Fenton with 20 mgÅ·L−1 phloroglucinol, a significantly decreased degradation rate was observed due to the slowdown of pH drop and inhibited formation of Fe(III)-phloroglucinol complex.

**General information**

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Organisations: Department of Environmental Engineering, Residual Resource Engineering, Third Institute of Oceanography
Contributors: Wang, Y., Lin, X., Shao, Z., Shan, D., Li, G., Angelidaki, I.
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BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 3.18
Web of Science (2017): Impact factor 6.735
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.16
Web of Science (2016): Impact factor 6.216
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 2.75
Web of Science (2015): Impact factor 5.31
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 2.72
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 3.03
Web of Science (2013): Impact factor 4.058
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 3.15
Web of Science (2012): Impact factor 3.473
ISI indexed (2012): ISI indexed yes
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BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 2.95
Web of Science (2011): Impact factor 3.461
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Web of Science (2010): Impact factor 3.074
Web of Science (2010): Indexed yes
In this study, a full-scale enclosed microalgae air-lift photobioreactor (PBR) module was operated using both defined and industrial wastewater (WW) media. In the effort to establish full-scale operation: a WW ultrafiltration system, two algal productions, and a harvesting microfiltration system were tested. Bioindustrial WW medium was treated with ultrafiltration and was demonstrated to be a viable microalgal growth medium at large scale; however, further treatment is needed for the removal of fecal coliform to meet drinking water standards. The fresh water mesophilic algae Chlorella sorokiniana was successfully grown on bioindustrial WW medium at suboptimal temperatures (< 25 °C) and natural lighting with peak specific growth rate (SGR) of 0.48 day−1, consistent with lab-scale results from literature. Optical densities (OD) of the algae at 665, 680, and 735 nm were found to be viable proxies for cell number of C. sorokiniana grown outdoors with daily fluctuations, despite inherent differences in chlorophyll sensitivity at each absorbance wavelength. However, OD measurements at different reactor locations shown to diverge at the onset of growth. Greenhouse temperature and solar insolation were measured, where it was observed that the SGR did not considerably improve from higher solar irradiance during periods of lower temperatures. Finally, the viability of harvested cells after microfiltration was also examined, with a negative exponential correlation between cell death and the volume of remaining filter condensate (R2 = 0.9247).

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering, Kalundborg Kommune
Contributors: Podevin, M. P. A., Fotidis, I., De Francisci, D., Møller, P., Angelidaki, I.
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Web of Science (2017): Impact factor 3.745
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.45 SJR 1.465 SNIP 1.141
Web of Science (2016): Impact factor 3.994
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BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 5.53 SJR 1.963 SNIP 1.618
Web of Science (2015): Impact factor 4.694
Different cultivation methods to acclimatise ammonia-tolerant methanogenic consortia

Bioaugmentation with ammonia tolerant-methanogenic consortia was proposed as a solution to overcome ammonia inhibition during anaerobic digestion process recently. However, appropriate technology to generate ammonia tolerant methanogenic consortia is still lacking. In this study, three basic reactors (i.e. batch, fed-batch and continuous stirred-tank reactors (CSTR)) operated at mesophilic (37°C) and thermophilic (55°C) conditions were assessed, based on methane production efficiency, incubation time, TAN/FAN (total ammonium nitrogen/free ammonia nitrogen) levels and maximum methanogenic activity. Overall, fed-batch cultivation was clearly the most efficient method compared to batch and CSTR. Specifically, by saving incubation time up to 150%, fed-batch reactors were acclimatised to nearly 2-fold higher FAN levels with a 37%-153% methanogenic activity improvement, compared to batch method. Meanwhile, CSTR reactors were inhibited at lower ammonia levels. Finally, specific methanogenic activity test showed that hydrogenotrophic methanogens were more active than aceticlastic methanogens in all FAN levels above 540 mg NH3-N L\(^{-1}\).

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering, Technical University of Denmark
Contributors: Tian, H., Fotidis, I., Mancini, E., Angelidaki, I.
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Publication date: 2017
Peer-reviewed: Yes

Publication information
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BFI (2018): BFI-level 2
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Scopus rating (2017): CiteScore 6.28 SJR 2.029 SNIP 1.799
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BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.94 SJR 2.215 SNIP 1.932
Web of Science (2016): Impact factor 5.651
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.47 SJR 2.243 SNIP 1.897
Web of Science (2015): Impact factor 4.917
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.3 SJR 2.399 SNIP 2.087
Web of Science (2014): Impact factor 4.494
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 5.97 SJR 2.405 SNIP 2.477
Effect of micro-aeration and inoculum type on the biodegradation of lignocellulosic substrate

The effect of various micro-aeration strategies on the anaerobic digestion (AD) of wheat straw was thoroughly examined using a mixture of inocula, containing compost and well digested sludge from biogas plant. The aim was to determine the most efficient oxygen load, pulse repetition and treatment duration, resulting in the highest methane production. The oxygen load had the largest impact on the biodegradability of straw, among the examined variables. More specifically, a micro-aeration intensity of 10mLO2/gVS was identified as the critical threshold above which the AD performance was more susceptible to instability. The highest enhancement in biogas production was achieved by injecting 5mLO2/gVS for a consecutive 3-day treatment period, presenting a 7.2% increase compared to the untreated wheat straw. Nevertheless, the results from optimisation case study indicated a higher increase of 9% by injecting 7.3mLO2/gVS, distributed in 2 pulses during a slightly shorter treatment period (i.e. 47h).
Effect of nitrogen source and acclimatization on specific growth rates of microalgae determined by a high throughput in vivo microplate autofluorescence method

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Efficient treatment of aniline containing wastewater in bipolar membrane microbial electrolysis cell-Fenton system
Aniline-containing wastewater can cause significant environmental problems and threaten the humans's life. However, rapid degradation of aniline with cost-efficient methods remains a challenge. In this work, a novel microbial electrolysis cell with bipolar membrane was integrated with Fenton reaction (MEC-Fenton) for efficient treatment of real wastewater containing a high concentration (4460 ± 52 mg L−1) of aniline. In this system, H2O2 was in situ electro-synthesized from O2 reduction on the graphite cathode and was simultaneously used as source of radical dotOH for the oxidation of aniline wastewater under an acidic condition maintained by the bipolar membrane. The aniline was effectively degraded following first-order kinetics at a rate constant of 0.0166 h−1 under an applied voltage of 0.5 V. Meanwhile, a total organic carbon (TOC) removal efficiency of 93.1 ± 1.2% was obtained, revealing efficient mineralization of aniline. The applicability of bipolar membrane MEC-Fenton system was successfully demonstrated with actual aniline wastewater. Moreover, energy balance showed that the system could be a promising technology for removal of biorefractory organic pollutants from wastewaters.

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Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Li, X., Jin, X., Zhao, N., Angelidaki, I., Zhang, Y.
Electricity generation and microbial community in response to short-term changes in stack connection of self-stacked submersible microbial fuel cell powered by glycerol

Stack connection (i.e., in series or parallel) of microbial fuel cell (MFC) is an efficient way to boost the power output for practical application. However, there is little information available on short-term changes in stack connection and its effect on the electricity generation and microbial community. In this study, a self-stacked submersible microbial fuel cell (SSMFC) powered by glycerol was tested to elucidate this important issue. In series connection, the maximum voltage output reached to 1.15 V, while maximum current density was 5.73 mA in parallel. In both connections, the maximum power density increased with the initial glycerol concentration. However, the glycerol degradation was even faster in parallel connection. When the SSMFC was shifted from series to parallel connection, the reactor reached to a stable power output without any lag phase. Meanwhile, the anodic microbial community compositions were nearly stable. Comparatively, after changing parallel to series connection, there was a lag period for the system to get stable again and the microbial community compositions became greatly different. This study is the first attempt to elucidate the influence of short-term changes in connection on the performance of MFC stack, and could provide insight to the practical utilization of MFC.

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Electrochemical monitoring of ammonia during anaerobic digestion

Ammonia is known as key inhibitor to methanogens in anaerobic digestion (AD) process. It’s of importance to develop efficient tool for ammonia monitoring. In this study, an electrolysis cell (EC) coupled with a complete nitrification reactor was developed as sensor for real time and online monitoring of ammonia in AD. The AD effluent was pumped into nitrification reactor first, in which ammonia was converted to nitrate. Afterwards, the nitrate-rich effluent was introduced into cathode chamber of EC. The correlation between currents and ammonia levels was first evaluated with synthetic ammonia-rich digesters. It was observed that the initial transient currents (0 min) were linearly corresponding to the ammonia levels (from 0 to 95.75 mg/L NH4+-N, R² = 0.9673). Finally, this new sensor was tested with real AD effluent and the results showed no significant difference with that measured by conventional methods. The sensor developed here has great potential for online, cost-saving, fast and accurate ammonia monitoring in AD process.

Enhancing biogas production from recalcitrant lignocellulosic residue

Lignocellulosic substrates are abundant in agricultural areas around the world and lately, are utilized for biogas production in full-scale anaerobic digesters. However, the anaerobic digestion (AD) of these substrates is associated with specific difficulties due to their recalcitrant nature which protects them from enzymatic attack. Hence, the main purpose of this work was to define diverse ways to improve the performance of AD systems using these unconventional biomasses. Thus, mechanical and thermal alkaline pretreatments, microaeration and bioaugmentation with hydrolytic microbes were examined. The studied substrates were fresh and ensiled meadow grass, regularly cultivated ensiled grass, digested manure fibers and wheat straw. AD of lignocellulosic substrates is time demanding and an extended incubation period is often needed. Initially, diverse analytical methods were used (i.e. electrical conductivity, soluble chemical oxygen demand and enzymatic hydrolysis) as a rapid way to predict the methane production. However, the precision of methane yield prediction was not high (R² < 0.68) and thus, the biochemical methane potential (BMP) test is concluded to be the most precise method to estimate the biomethanation process. Various mechanical pretreatments were examined on ensiled meadow grass biodegradability by applying shearing forces. Preliminary results showed that the methane production of ensiled meadow grass can be efficiently increased up to 25% compared to untreated samples. Hence, the most efficient method was further applied on the same substrate, focusing on different age of vegetation under mono- and co-digestion with livestock manures (i.e. poultry, mink and cattle manure). The differences on biomass’ chemical composition were also determined in order to demonstrate the effect of vegetation stage. Clear alterations were revealed due to late harvest time and specifically, the lignin content was markedly augmented (~30% of dry matter) with advancing age, implying the need of pretreatment. Mechanically pretreated biomass of increased maturity was co-digested with diverse livestock manures in order to define the optimum silage/manure ratio in the feedstock. Results showed that the ideal lignocellulose/manure contribution differs among the examined substrates and that the chemical characteristics of the feedstock mixture significantly influenced the biomethanation process. The application of shearing forces was also examined on the hardly degradable fraction of digested manure fibers. However, limited efficacy was observed on biomethanation and the remaining volatile solids (VS) were not highly utilized. Conversely, the well-studied thermal alkaline pretreatments using sodium hydroxide as a catalyst promoted the yield from approximately 42 mLCH4/gVS to 170 mLCH4/gVS. Furthermore, the positive results were validated in the co-digestion of biofibers with cattle manure under continuous mode operation. Mechanical and thermal alkaline pretreatment (6% NaOH at 55 °C for 24 h) had an effect of 7% and 26% respectively, without provoking process inhibition. Focusing on full-scale practices, the application of simple and efficient treatment methods is generally suggested. Accordingly, the reduction of supply chain steps prior to AD could eventually improve the energy budget and subsequently, process profitability. Hence, the integration of mechanical pretreatment at harvesting step was examined as a solution to scale-up the used mechanical method in real-life applications. On this topic, an innovative Disc-mower (named as Excitorator) was studied in order to simultaneously harvest and pretreat fresh meadow grass through the application of shearing forces. Kinetic studies showed that the lag phase was decreased, the methane...
production rate was increased and finally, the methane yield was significantly enhanced by up to 27% under optimal conditions. Further investigations on full-scale experiments mowing regularly cultivated grass confirmed the positive effect due to the selection of the most appropriate harvester. The modern harvester poses the ability improve the energy balance and subsequently, the sustainability of lignocellulose-based AD. The co-digestion of pig manure and lignocellulosic silage was assessed in continuous stirred tank reactors (CSTR). Addition of mechanically pretreated silage in the feedstock positively affected the methane yield (+16%) and in parallel, reduced the risk of ammonia inhibition compared to mono-digestion of pig manure. Furthermore, metagenomic analysis was performed to determine differences among the microbial communities in CSTRs operating under mono- and co-digestion. Species similar to Clostridium thermocellum, with increased cellulolytic activity, were detected to be adherent to the solid fraction of digested feedstock and concluded to be key players for lignocellulose's disintegration. Moreover, various microaeration strategies were applied in order to elucidate the effect of oxygen load (O2), pulse repeatability and treatment period on the AD of wheat straw. The results obtained from this study demonstrated a 7.2% increase in methane yield after a 3 days microaeration period, using 5 mL O2/gVS served by once. In addition, an optimisation study was conducted and the analysis indicated that the methane yield could have been increased by 9%, if 7.3 mL O2/gVS were injected. It was indicated that microaeration can be an alternative solution for augmented biomass solubilization without causing inhibition to the mandatory anaerobic methanogenic community. Based on the initial microbial analysis, the bioaugmentation with the typically abundant in AD systems C. thermocellum was examined in biogas reactors fed with wheat straw. Bioaugmentation with the hydrolytic strain had immediately a remarkable result on methane production. Nevertheless, the long term monitoring showed that routine bioaugmentation is needed to retain a positive effect of approximately 7%. Moreover, it was indicated that the bioaugmentation with C. thermocellum can be periodically applied in biogas reactors in order to extract the residual methane from the amassing materials and avoid potential accumulation. Additionally, the facultative anaerobic Melioribacter roseus was inoculated in a replicate CSTR following different bioaugmentation strategies, either strictly anaerobic or micro-aerobic conditions. Nevertheless, the novel strain did not enhance the biomethanation process and the metagenomic analysis revealed that the inoculated strain did not adapt in the biogas reactor. The results obtained confirm that lignocellulose-based AD can lead to high biogas yield. At lab-scale experiments, the bioenergy production can be further improved using micro-aeration, bioaugmentation with C. thermocellum, thermal-alkaline or mechanical pretreatments. Further insights into AD microbiome can improve and optimize the used processes. Among the examined pretreatments, only mechanical methods were evaluated in full-scale operation due to their easiness in application. On this topic, modern harvesting technology simulating the process applied in lab-scale could generate similar enhancement under full-scale trials. Machineries orientated to pretreat biomass using simplified techniques can positively affect the industrial applications.
Ex-situ biogas upgrading and enhancement in different reactor systems

Biogas upgrading is envisioned as a key process for clean energy production. The current study evaluates the efficiency of different reactor configurations for ex-situ biogas upgrading and enhancement, in which externally provided hydrogen and carbon dioxide were biologically converted to methane by the action of hydrogenotrophic methanogens. The methane content in the output gas of the most efficient configuration was >98%, allowing its exploitation as substitute to natural gas. Additionally, use of digestate from biogas plants as a cost efficient method to provide all the necessary nutrients for microbial growth was successful. High-throughput 16S rRNA sequencing revealed that the microbial community was resided by novel phylotypes belonging to the uncultured order MBA08 and to Bacteroidales. Moreover, only hydrogenotrophic methanogens were identified belonging to Methanothermobacter and Methanoculleus genera. Methanothermobacter thermautotrophicus was the predominant methanogen in the biofilm formed on top of the diffuser surface in the bubble column reactor.

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Web of Science (2016): Impact factor 5.651
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.47 SJR 2.243 SNIP 1.897
Web of Science (2015): Impact factor 4.917
High efficient ethanol and VFAs production from gas fermentation: effect of acetate, gas and inoculum microbial composition

In bioindustry, syngas fermentation is a promising technology for biofuel production without the use of plant biomass as sugar-based feedstock. The aim of this study was to identify optimal conditions for high efficient ethanol and volatile fatty acids (VFA) production from synthetic gas fermentation. Therefore, the effect of different gases (pure CO, H2, and a synthetic syngas mixture), media (acetate medium and acetate-free medium), and biocatalyst (pure and mixed culture) were studied. Acetate was the most dominant product independent on inoculum type. The maximum concentration of volatile fatty acids and ethanol was achieved by the pure culture (Clostridium ragsdalei). Depending on the headspace gas composition, VFA concentrations were up to 300% higher after fermentation with Clostridium ragsdalei compared to fermentation with mixed culture. The preferred gas composition with respect to highest VFA concentration was pure CO (100%) regardless of microbial composition of the inoculum and media composition. The addition of acetate had a negative impact on the VFA formation which was depending on the initial gas composition in head space.

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Web of Science (2016): Impact factor 3.219
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 4.03 SJR 1.51 SNIP 1.596
Web of Science (2015): Impact factor 3.249
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 4.36 SJR 1.865 SNIP 1.964
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ISI indexed (2013): ISI indexed yes
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Scopus rating (2012): CiteScore 3.66 SJR 1.516 SNIP 1.754
Web of Science (2012): Impact factor 2.975
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
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Scopus rating (2011): CiteScore 4.74 SJR 1.759 SNIP 2.296
Web of Science (2011): Impact factor 3.646
Hydrogen assisted biological biogas upgrading

Wind and biomass are promoted worldwide as sustainable forms of energy. Anaerobic digestion of biomass produces biogas with ~50–70% CH4 and 30–50% CO2. However, biogas with >90% CH4 content has higher heating value, can be injected into the natural gas grid or used as alternative to natural gas as vehicle fuel. Methods currently available for biogas upgrading mainly consists of physicochemical CO2 removal, requiring the use of chemical substances and energy input and, thus, increasing process costs. This PhD project proposes an alternative to existing biogas upgrading technologies, where H2, produced by water electrolysis, using excess of electricity from wind mills, is coupled with the CO2 contained in the biogas to convert them to CH4. This process is defined as biological biogas upgrading and is carried out by hydrogenotrophic methanogenic archaea that couples CO2 with H2 to produce biomethane, via hydrogenotrophic methanogenesis. This reaction results in an increment of the total volume of CH4 produced avoiding any loss of CH4. Moreover, the CO2 is converted rather than being released to the atmosphere providing enhanced environmental benefits of biogas technologies. Moreover, hydrogenotrophic methanogenesis can operate in moderate operating conditions, without using chemical substances, and exploiting mixed culture, rather than pure culture, markedly reducing operation costs. The combination of these characteristics makes biomethane an energy carrier with exceptional potential, which could become a key element in the future renewable-based energy system. Nevertheless, the direct injection of H2 in the reactor (in-situ biogas upgrading) can cause scientific challenges, such as pH increase due to the CO2 removal and process inhibition due to higher H2 partial pressure. Therefore, ex-situ biogas upgrading emerged as a solution aiming at the optimization of the upgrading process in dedicated external reactors. In this concept, biogas and H2 are introduced into an anaerobic reactor containing a mixed hydrogenotrophic culture where the biogas is upgraded to higher CH4 content. To overcome the issues related to in-situ biogas upgrading, a two-stage Continuous Stirred Tank Reactor (CSTR) was designed. In this configuration, the biogas and the digestate produced in the first reactor were transferred to the second one, where H2 was injected, decoupling biogas production (mainly occurring in the first reactor) and biogas upgrading (occurring in the second reactor) and providing higher process efficiency. Moreover, biogas production and upgrading performances at mesophilic and thermophilic conditions were compared. The results demonstrate the feasibility of the biogas upgrading process, at both temperature conditions with higher biomethanation and CO2 conversion.
efficiency at thermophilic. Moreover, upon H2 addition, the produced biogas was upgraded to average CH4 content of 89% in the mesophilic reactor and 85% in the thermophilic. Nevertheless, H2 is known to be poorly soluble in aqueous media and its transfer to the reactors' liquid phase represents a strong limiting factor for H2 availability for methanogens. Therefore, the optimization of H2 dispersion is crucial to ensure efficient biogas upgrading process. Gas transfer to the liquid phase is specific for given reactor configuration and operating conditions and can be modulated by adjusting on parameters such as mixing speed, gas recirculation and H2 diffusion device. This aspect has been investigated in a thermophilic granular up-flow anaerobic sludge blanket (UASB) reactor connected to a separate H2-injection chamber, for in-situ biogas upgrading. The effect of liquid and gas recirculation on gas-liquid transfer was evaluated. Moreover, the application of different packing materials in the separate chamber, as a mean to minimize gas bubble size and thus increase the gas dissolution in the liquid was discussed. Finally, the effect of gas retention time was evaluated in different reactor configurations to elucidate its role for CO2 and H2 conversion to CH4. It was observed that by distributing H2 through a stainless steel diffuser followed by a ceramic sponge in a separate chamber (having a volume of 25% of the reactor) and by applying a moderate gas recirculation, CO2 content in the biogas dropped from 42 to 10% and the final biogas was upgraded from 58 to 82% CH4 content. Based on these finding, further enhancement of the H2 gas-liquid mass transfer rate was investigated in four up-flow reactors for ex-situ biogas upgrading. The effect of different H2 distribution devices and different pore sizes on H2 uptake by methanogens was elucidated. Moreover the role of input gas flow rate and gas recirculation on H2 and CO2 conversion to CH4 was investigated. The results showed that the configurations involving diffusion devices with larger pore size presented the best kinetics and output-gas quality and at the highest recirculation rate tested, they managed to convert all the input H2 and CO2 into CH4, up to a H2 loading rate of 3.6 L/REACTOR.d. Accordingly, the CH4 content in the reactor increased from 23 to 96% and the CH4 yield reached 0.25 LCH4/LH2. Finally, to provide higher process control and efficiency, a better understanding of the biogas community composition is crucial. Previous studies have showed that in each microbial community there is a fraction of microorganisms that is always present and constitutes the core of the community and a fraction depending on operating conditions. Therefore, we hypothesized that the H2 addition would selectively stimulate the hydrogenotrophic pathway enhancing the CO2 consumption and thus the biogas upgrading. Based on this knowledge, different bioinformatics approaches, comprising the commonly utilized, 16S rRNA amplicon sequencing, but also Assembled Full-Length 16S rRNA gene sequencing and total random sequencing followed by de novo assembly and by a binning strategy, were applied to the study of biogas production and upgrading communities. Specifically, biogas core community was composed of several recurrent microbial groups, including resilient methanogenic archaea such as Methanoctullosus and Methanotermobacter and bacteria belonging to phylum Proteobacteria and genus Syntrophomonas. Moreover, upon H2 addition, the concomitant proliferation of hydrogenotrophic methanogens and syntrophic bacteria, such as Desulfovibrio, and some Thermoanaerobacteraceae and Syntrophomonadaceae, and the reduction of acetoclastic methanogens and fermentative bacteria state the role of the H2 moving biomethanation process toward the final steps stimulating CO2 consumption and therefore biogas upgrading.

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**Improving the energy balance of grass-based anaerobic digestion through combined harvesting and pretreatment**

An important challenge that has to be addressed to achieve sustainable anaerobic digestion of lignocellulosic substrates is the development of energy and cost efficient pretreatment methods. Technologies orientated to simultaneously harvest and mechanically pretreat the biomass at the field could meet these criteria as they can potentially reduce the energy losses. The objective of this study was to elucidate the effect of two full-scale harvesting machines to enhance the biogas production and subsequently, improve energy balance. The performances of Disc-mower and Excitor were assessed on meadow and cultivated grass silages. The results showed that relatively high methane production can be achieved from meadow and cultivated grass harvested in different seasons. The findings indicated that the bioenergy production can be improved based on the selection of the appropriate harvesting technology. More specifically, Excitor, which cuts and subsequently applies shearing forces on harvested biomass, enhanced the methane production up to 10% and the overall energy budget was improved proportionally to the driving speed increase.

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Insights on the activity of the anaerobic digestion microbiome by means of metatranscriptomic functional investigation

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In-situ biogas upgrading process: modeling and simulations aspects
Biogas upgrading processes by in-situ hydrogen (H2) injection are still challenging and could benefit from a mathematical model to predict system performance. Therefore, a previous model on anaerobic digestion was updated and expanded to include the effect of H2 injection into the liquid phase of a fermenter with the aim of modeling and simulating these processes. This was done by including hydrogenotrophic methanogen kinetics for H2 consumption and inhibition effect on the acetogenic steps. Special attention was paid to gas to liquid transfer of H2. The final model was successfully validated considering a set of Case Studies. Biogas composition and H2 utilization were correctly predicted, with overall deviation below 10% compared to experimental measurements. Parameter sensitivity analysis revealed that the model is highly sensitive to the H2 injection rate and mass transfer coefficient. The model developed is an effective tool for predicting process performance in scenarios with biogas upgrading.

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Web of Science (2016): Impact factor 5.651
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Web of Science (2015): Indexed yes
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Scopus rating (2014): CiteScore 5.3 SJR 2.399 SNIP 2.087
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ISI indexed (2012): ISI indexed yes
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Scopus rating (2010): SJR 2.089 SNIP 2.344
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Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.915 SNIP 2.236
Web of Science (2009): Indexed yes
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Scopus rating (2008): SJR 1.736 SNIP 2.74
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.403 SNIP 2.396
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.314 SNIP 2.003
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.278 SNIP 1.98
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.19 SNIP 1.655
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.942 SNIP 1.665
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.908 SNIP 1.294
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.537 SNIP 1.2
Scopus rating (2000): SJR 0.653 SNIP 1.023
Integrated electrochemical-biological process as an alternative mean for ammonia monitoring during anaerobic digestion of organic wastes

Ammonia monitoring is important to control anaerobic digestion (AD) process due to inhibition effect. Here, an electrolysis cell (EC) was integrated with a complete nitrification reactor as an alternative approach for online monitoring of ammonia during AD processes. The AD effluent was pumped into nitrification reactor to convert ammonia to nitrate, followed by the introduction of nitrate-rich effluent to EC cathode. It was first evaluated with synthetic ammonia-rich digesters and was observed that the current at 5min were linearly corresponding to the ammonia levels (from 0 to 7.5mM NH4+-N, R2=0.9673). The linear relationship was always observed regardless of different wastewater pH and external voltage. Pre-removal of other electron acceptors from digestate at cathode could eliminate their disturbances to sensor performance. Finally, the accuracy of biosensor was verified with real digestate test. The simple and reliable biosensor showed great promising for online ammonia monitoring of AD processes.

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Scopus rating (2015): CiteScore 4.04 SJR 1.497 SNIP 1.567
Web of Science (2015): Impact factor 3.698
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Intermittent provision of \( \text{H}_2 \) and \( \text{CO}_2 \) in up-flow reactors for ex-situ biogas upgrading

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Scopus rating (2012): CiteScore 3.5 SJR 1.794 SNIP 1.618  
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ISI indexed (2012): ISI indexed yes  
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Scopus rating (2011): CiteScore 3.61 SJR 1.962 SNIP 1.508  
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BFI (2008): BFI-level 1  
Scopus rating (2008): SJR 1.658 SNIP 1.58  
Web of Science (2008): Indexed yes  
Scopus rating (2007): SJR 1.5 SNIP 1.605  
Web of Science (2007): Indexed yes  
Scopus rating (2006): SJR 1.418 SNIP 1.673  
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Scopus rating (2005): SJR 1.479 SNIP 1.558  
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iTRAQ quantitative proteomic analysis reveals the pathways for methanation of propionate facilitated by magnetite

Methanation of propionate requires syntrophic interaction of propionate-oxidizing bacteria and hydrogenotrophic methanogens, which is referred to as interspecies electron transfer. The present study showed that 10 mg/L conductive magnetite enhanced the methane production rate from propionate by around 44% in batch experiments, and both direct interspecies electron transfer and interspecies H2 transfer were thermodynamically feasible with the addition of magnetite. The methanation of propionate facilitated by magnetite was also demonstrated in a long-term operated continuous reactor. The methane production rate from acetate by the enriched mixed culture with magnetite was higher than that without magnetite, while similar methane production rates were found from H2/CO2 by the enriched mixed culture with and without magnetite. The ability to utilize molecular H2 indicated interspecies H2 transfer played a role in the enriched culture with magnetite, and propionate-oxidizing bacteria relating with interspecies H2 transfer were also detected by metagenomic sequencing. Metagenomic sequencing analysis also showed that Thauera, possibly relating with direct interspecies electron transfer, were enriched with the addition of magnetite. iTRAQ quantitative proteomic analysis, which was used in mixed culture for the first time, showed that magnetite induced the changes of protein expression levels involved in various pathways during the methanation of propionate. The up-regulation of proteins involved in propionate metabolism were found, and they were mainly originated from propionate-oxidizing bacteria which were not reported to be capable of direct interspecies electron transfer until now. Cytochrome c oxidase was also revealed as the possible protein relating with direct interspecies electron transfer considering its up-regulation with the addition of magnetite. The up-regulated proteins in methane metabolism were originated from Methanosarcina, while most of the enzymes with down-regulated proteins were originated from Methanosaeta. However, the up-regulated proteins relating with hydrogenotrophic methanogenesis were originated from either Methanosaeta or Methanosarcina, indicating they were not involved in direct interspecies electron transfer. The hydrogenotrophic methanogens, e.g. Methanospirillum, Methanosphaerula et al., might be involved in direct interspecies electron transfer. Overall, the present study showed that both direct interspecies electron transfer and interspecies H2 transfer were present during methanation of propionate facilitated by magnetite.

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Scopus rating (2015): CiteScore 6.63 SJR 2.665 SNIP 2.482
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BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 6.02 SJR 2.956 SNIP 2.676
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ISI indexed (2013): ISI indexed yes
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BFI (2012): BFI-level 2
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Scopus rating (2008): SJR 2.073 SNIP 2.178
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Web of Science (2004): Indexed yes
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Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.568 SNIP 1.757
Web of Science (2002): Indexed yes
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Laminaria digitata as potential carbon source in heterotrophic microalgae cultivation for the production of fish feed supplement

A novel concept using the macroalgae Laminaria digitata as substrate to grow heterotrophically microalgae species to be used as fish feed supplement is investigated in the present study. Enzymatic hydrolysis of the macroalgae was performed to release the sugars present in the biomass. The hydrolysate was then used as culture medium and nutrient source to grow heterotrophically three different microalgae species, namely Chlorella protothecoides, Chlorella vulgaris and Chlorella sorokiniana, identified as valuable sources of proteins. Due to its faster growth rates, C. protothecoides was selected for further cultivation in batch reactors and its protein content and amino acid composition were measured. At the end of the process the biomass production reached 10.68 ± 1.33 g L−1 with a total protein accumulation of 41.77 ± 1.82% (dry weight basis) and a protein yield of 0.17 ± 0.06. Moreover, the essential amino acids score at the end of the experiment was 6 times greater than for the original content of the macroalgae hydrolysate which was used as substrate for the microalgae cultivation. Therefore, this study reveals the potential of macroalgae hydrolysate as culture medium for microalgae cultivation and it opens possibilities for the development of future strategies to optimize the microalgae production processes.

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Web of Science (2017): Indexed yes
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Scopus rating (2013): CiteScore 4.17 SJR 1.424 SNIP 1.119
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Macroalgae Laminaria digitata and Saccharina latissima as Potential Biomasses for Biogas and Total Phenolics Production: Focusing on Seasonal and Spatial Variations of the Algae

Laminaria digitata (L. digitata) and Saccharina latissima (S. latissima) are the most common species of macroalgae in the north Atlantic and north Pacific. Because of their interesting composition, they have recently attracted attention as useful biomass for various purposes such as for biochemicals and bioenergy production. Nevertheless their composition varies according to the season and to the local environmental conditions. Therefore, in this study different samples harvested throughout a year and in different locations in Denmark were analyzed. The aim of the study was identifying the best
period of the year and location to cultivate macroalgae for biofuels and biochemical production. Therefore, the biogas potential and the total phenolics profile for L. digitata and S. latissima were determined. The total phenolics were determined as they may represent an interesting bioactive compound, due to their significant health benefits. The highest methane yield (358.9 ± 5.1 and 285.0 ± 19.1 N mL of CH4 g^-1 of volatile solids for L. digitata and S. latissima, respectively) and total phenolic content (TPC) content (47.4 ± 0.0 mg of TPC g^-1 of dry matter for L. digitata) were recorded in summer when the sugar level and the light intensity reached their maximum.

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Scopus rating (2014): CiteScore 3.3
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Scopus rating (2012): CiteScore 3.25
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Mechanical pretreatment at harvesting increases the bioenergy output from marginal land grasses

Meadow grass has recently gained increased attention as a substrate for full-scale biogas reactors. However, to increase its biodegradability, pretreatment is needed. In the present work, different harvesting machines were compared in order to assess their effect on biogas production. Specifically, a Disc-mower, an Excoriator and a Chopper were used to define the most appropriate machinery in order to improve the energy output per hectare for full-scale biogas plants. Among the harvesters, Excoriator, a novel simultaneous harvest and mechanical treatment, was found to significantly increase the methane yield of meadow grass by 20% compared to a classical Disc-mower. The positive effect was also validated by three kinetic model equations. The modified Gompertz model was the most capable of determining the kinetics of anaerobic digestion process, pointing out also the superiority of Excoriator. The usage of the novel harvester was associated with increased energy output, either for electrical/thermal energy generation or for transport fuel production, compared to the alternative machineries. Moreover, it was shown that the co-digestion of harvested biomass with different types of manure can enhance the bioenergy output of a full-scale biogas plant in a range of 12%-23%. (C) 2017 Elsevier Ltd. All rights reserved.
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Microalgae biorefinery symbiosis: screening, production, and process analytical technology

Microalgae treatment of municipal wastewater (WW) has been the focal point of microalgal biotechnology research for several decades. However, this technology did not have a competitive advantage over other WW treatment technologies, which could be implemented in smaller areal footprints. In the past few decades, microalgal WW treatment has made a resurgence with the idea of using biomass from microalgal WW treatment, as a source of lipids for conversion into biodiesel. However, the savings from the treatment of nutrients and organic matter, as well as biodiesel production, are still not competitive with the price of crude oil. In recent years, microalgal research continued with the prospect of a microalgae biorefinery, where microalgal byproducts and coproducts are extracted to valorize the entire microalgal production, in which the sum of the parts of the microalgae is greater than the whole microalgae. However, in large part, the microalgae biorefinery does not comply with the treatment of nutrient-rich municipal WWs, due to regulatory concerns. Only recently, it was realized that biob industrious WWs are viable and conceivably regulatory compliant nutrient rich waste streams, capable of sustaining microalgae growth, as much as municipal WWs. The concept of an “industrial symbiosis” has also emerged in the past several decades, in which networks of industries cooperate to use waste sources from neighboring industries, in industrial parks, to create added value. The intersection of the microalgae biorefinery and industrial symbiosis, in a microalgae biorefinery symbiosis (MBS), may be the next generation scheme to valorize the microalgal production and promote industrial and global sustainability. Moreover, technological advances in screening, outdoor photobioreactor (PBR) design, macromolecular monitoring and process automation must all be addressed to execute the complex bioprocesses needed to valorize an MBS successfully.

In order to properly identify viable MBS partnerships with industry, microalgal species capable of producing an array of valuable products must first be screened on these potential biob industrious WW streams for their growth potential. During screening, microalgae may have a preference or aversion for a given biob industrious WW media, based on the types and ratios of nitrogen (ammonium, nitrate, or urea) in the WW. Furthermore, identifying algae capable of withstanding fluctuations between these nitrogen forms in dynamic WWs, is an important criterion for productivity. However, when screening microalgae on WWs containing different nitrogen sources and concentrations, assimilation of different nitrogen sources can result in starkly different physiochemical changes, specifically pH changes. In many microalgae, ammonium is the preferred nitrogen source, because it can passively transport into the cell and is directly assimilated into amino acids, without relying on light-mediated enzymatic processes to be reduced. However, when microalgae assimilate ammonium, the pH of the system can drop sharply, inhibiting growth after that; however, these pH changes do not directly reflect the microalgae’s affinity to grow on ammonium. By growing batch cultivations of microalgae in 24-well microplates, a microplate reader can be used to measure relative fluorescence of chlorophyll in vivo, during balanced growth, before these pH changes occur. This technique can be used to preempt the effects of pH changes on growth and reflects the true preference or aversion of microalgae to a particular nitrogen source or a WW media. Additionally, along with being spatially high-throughput in a 24-well microplate—where 24 batch reactions can be conducted simultaneously in a small footprint—the early and low detection of growth rates is also more temporally high-throughput than any other screening method. This method can also be used to quickly screen for robust and adaptable microalgae, capable of acclimatizing to different nitrogen sources and fluctuating media as well as to screen for the upper and lower tolerances of the microalgae to various concentrations of the WW. The latter must also be addressed when screening dynamic WW capable of large fluctuations.

Over the years, there have been very few demonstrations of outdoor microalgal growth in enclosed PBRs; demonstrations, which is essential for understanding the feasibility of an MBS as a whole. From microplate scales to large-scales—six orders of magnitude larger—the industrially important screened microalgal Chlorella sorokniana was grown on biob industrious WW, inside a novel, solar tracking, 4000 L, airlift PBR. Despite cold temperatures and low irradiance, the microalgal reached a growth rate of 0.48 day^-1, in the four-day period immediately following inoculation of biob industrious WW containing ammonium, as a primary nitrogen source. After that, after ammonium was depleted and the media was augmented with nitrate, a long lag phase persisted, before undergoing the predominant production phase with a specific growth rate (SGR) of 0.15 day^-1 over an 18-day period. It was evident that the transition from ammonium to nitrate metabolism can severely stunt microalgal growth in the outdoor PBR under low temperature and irradiance. More importantly, the delay in growth did not appear to be due to deleterious effects of the contents of biob industrious WW media, since rapid growth was observed early in the experiment on the unaugmented WW. Moreover, it was demonstrated that microalgae could continue to grow in adverse environmental conditions at large-scales.

The success of the in vivo fluorescence microplate assay and the complexity of these outdoor reactions demonstrate the value of pursuing real-time data of microalgae in vivo at large-scales. The complex and dynamic nature of large-scale outdoor microalgal reactions, when grown on dynamic WW media, encourages the need for on-line, real-time monitoring to improve automation models of PBRs. In outdoor conditions with fluctuating light and temperature, there are several factors that can change the growth of microalgae, at time-scales less than a minute and as low as microseconds, which may not be accounted for in microalgal productivity models. Similarly, fluctuations of WW media are not accounted for in these models, especially in outdoor conditions. However, recent advances in hardware and software can significantly improve microalgal bioprocess models and automation, by manipulating large, time-resolute data sets, so-called “big data,” which can be acquired through high-selectivity vibrational spectroscopy, such as mid-infrared (MIR), near-infrared (NIR), or Raman vibrational spectroscopies. These large, real-time data sets can now be used to create adaptive models from artificial intelligence/machine learning tools or “black-box” models, to automate large-scale, outdoor PBRs treating WW.

With microalgae, now entering into a new paradigm of food, feed, pharmaceuticals and functional products, on top of biofuels in a biorefinery, there will be a growing need to maintain product quality, regulate, and mitigate contamination, especially in a symbiosis with WW. Vibrational spectroscopies can be used to monitor several microalgal components.
simultaneously, which can be used to aid fractionation of microalgal compounds in a biorefinery, while improving model building for automation and control of product quality and contamination, where quality can be built into the system. The results and research summarized in this thesis demonstrate that the modernization of microalgal research is becoming increasingly necessary and beneficial to microalgae production in an MBS. The focus of this thesis is to bring together lab-scale demonstrations, scaled up knowledge, and a critical outlook of modern technologies capable of making the MBS a reality.

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Microbial community changes in methanogenic granules during the transition from mesophilic to thermophilic conditions
Upflow anaerobic sludge blanket (UASB) reactor is one of the most applied technologies for various high-strength wastewater treatments. The present study analysed the microbial community changes in UASB granules during the transition from mesophilic to thermophilic conditions. Dynamicity of microbial community in granules was analysed using high-throughput sequencing of 16S ribosomal RNA gene amplicons, and the results showed that the temperature strictly determines the diversity of the microbial consortium. It was demonstrated that most of the microbes which were present in the initial mesophilic community were not found in the granules after the transition to thermophilic conditions. More specifically, only members from family Anaerolinaceae managed to tolerate the temperature change and contributed in maintaining the physical integrity of granular structure. On the contrary, new hydrolytic and fermentative bacteria were quickly replacing the old members in the community. A direct result from this abrupt change in the microbial diversity was the accumulation of volatile fatty acids and the concomitant pH drop in the reactor inhibiting the overall anaerobic digestion process. Nevertheless, by maintaining deliberately the pH levels at values higher than 6.5, a methanogen belonging to Methanoculleus genus emerged in the community enhancing the methane production.

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Web of Science (2016): Impact factor 3.42
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Scopus rating (2015): CiteScore 3.43 SJR 1.256 SNIP 1.221
Web of Science (2015): Impact factor 3.376
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BFI (2014): BFI-level 1
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Web of Science (2014): Impact factor 3.337
Web of Science (2014): Indexed yes
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Web of Science (2013): Impact factor 3.811
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BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 4 SJR 1.488 SNIP 1.29
Web of Science (2012): Impact factor 3.689
ISI indexed (2012): ISI indexed yes
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BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 3.72 SJR 1.437 SNIP 1.229
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ISI indexed (2011): ISI indexed yes
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BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.389 SNIP 1.233
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Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.363 SNIP 1.068
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BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.249 SNIP 0.99
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.037 SNIP 1.017
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.138 SNIP 1.066
Web of Science (2006): Indexed yes
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Scopus rating (2003): SJR 0.977 SNIP 1.237
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.057 SNIP 1.011
Web of Science (2002): Indexed yes
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Scopus rating (2000): SJR 1.16 SNIP 1.047
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Microbial community dynamics during a successful acclimation process to extremely high ammonia levels in continuous anaerobic digester

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Microbial electrochemical sensor for online ammonia monitoring of waste streams

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Microbial electrolytic capture, separation and regeneration of CO2 for biogas upgrading

Biogas upgrading to natural gas quality is essential for the efficient use of biogas in various applications. Carbon dioxide (CO2) which constitutes a major part of the biogas is generally removed by physicochemical methods. However, most of the methods are expensive and often present environmental challenges. In this study, an innovative microbial electrolytic system was developed to capture, separate and regenerate CO2 for biogas upgrading without external supply of chemicals, and potentially to treat wastewater. The new system was operated at varied biogas flow rates and external applied voltages. CO2 was effectively separated from the raw biogas and the CH4 content in the outlet reached as high as 97.0±0.2% at the external voltage of 1.2 V and gas flow rate of 19.6 mL/h. Regeneration of CO2 was also achieved in the regeneration chamber with low pH (1.34±0.04). The relatively low electric energy consumption (≤0.15 kWh/m3) along with the H2 production which can contribute to the energy input makes the overall energy need of the system low, and thereby makes the technology promising. This work provides the first attempt for development of a sustainable biogas upgrading technology and potentially expands the application of microbial electrochemical technologies.

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Peer-reviewed: Yes
Microbial population dynamics in urban organic waste anaerobic co-digestion with mixed sludge during a change in feedstock composition and different hydraulic retention times

Microbial communities play an essential role in the biochemical pathways of anaerobic digestion processes. The correlations between microorganisms’ relative abundance and anaerobic digestion process parameters were investigated, by considering the effect of different feedstock compositions and hydraulic retention times (HRTs). Shifts in microbial diversity and changes in microbial community richness were observed by changing feedstock composition from mono-digestion of mixed sludge to co-digestion of food waste, grass clippings and garden waste with mixed sludge at HRT of 30, 20, 15 and 10 days. Syntrophic acetate oxidation along with hydrogenotrophic methanogenesis, mediated by Methanothermobacter, was found to be the most prevalent methane formation pathway, with the only exception of 10 days’ HRT, in which Methanosarcina was the most dominant archaea. Significantly, the degradation of complex organic polymers was found to be the most active process, performed by members of S1 (Thermotogales), Thermonema and Lactobacillus in a reactor fed with a high share of food waste. Conversely, Thermacetogenium, Anaerobaculum, Ruminococcaceae, Porphyromonadaceae and the lignocellulosic-degrading Clostridium were the significantly more abundant bacteria in the reactor fed with an increased share of lignocellulosic biomass in the form of grass clippings and garden waste. Finally, microbes belonging to Coprothermobacter, Syntrophomonas and Clostridium were correlated significantly with the specific methane yield obtained in both reactors.

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Web of Science (2017): Impact factor 7.051
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BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 7.49 SJR 2.663 SNIP 2.563
Web of Science (2016): Impact factor 6.942
Novel bio-electro-Fenton technology for azo dye wastewater treatment using microbial reverse-electrodialysis electrolysis cell

Development of sustainable technologies for treatment of azo dyes containing wastewaters has long been of great interest. In this study, we proposed an innovative concept of using microbial reverse-electrodialysis electrolysis cell (MREC) based Fenton process to treat azo dye wastewater. In such MREC-Fenton integrated process, the production of H₂O₂ which is the key reactant of fenton-reaction was driven by the electrons harvested from the exoelectrogens and salinity-gradient between sea water and fresh water in MREC. Complete decolorization and mineralization of 400 mg L⁻¹ Orange G was achieved with apparent first order rate constants of 1.15 ± 0.06 and 0.26 ± 0.03 h⁻¹, respectively. Furthermore, the initial concentration of orange G, initial solution pH, catholyte concentration, high and low concentration salt water flow rate and air flow rate were all found to significantly affect the dye degradation. This study provides an efficient and cost-effective system for the degradation of non-biodegradable pollutants.
Novel protocol for lutein extraction from microalgae *Chlorella vulgaris*

Lutein is a pigment generally extracted from marigold flowers. However, lutein is also found in considerable amounts in microalgae. In this study a novel method was developed to improve the extraction efficiency of lutein from microalgae *C. vulgaris*. Differently from conventional methods, ethanol was used instead of water in the saponification step, which was conducted simultaneously to the solvent extraction, performed using dichloromethane. The amount of lutein extracted from *C. vulgaris* dried biomass increased more than threefold, from 0.20 ± 0.00 mg Lutein/g DM to 0.69 ± 0.08 mg Lutein/g DM. Lutein purity was increased from 73.6% to 93.7% by decreasing the ethanol-water ratio from 85% to 50% in the resolubilization step. The novel method was also tested with tetrahydrofuran. The extraction proved to be again more effective than the conventional one; however dichloromethane outperformed tetrahydrofuran in terms of quantity and purity of the recovered lutein.

**General information**

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Organisations: Department of Environmental Engineering, Residual Resource Engineering

Contributors: D’Este, M., De Francisci, D., Angelidaki, I.

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BFI (2016): BFI-level 1
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Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 3.03
Web of Science (2013): Impact factor 4.058
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
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Scopus rating (2012): CiteScore 3.15
Web of Science (2012): Impact factor 3.473
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
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Web of Science (2011): Indexed yes
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Web of Science (2010): Impact factor 3.074
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Optimization of hydrogen dispersion in thermophilic up-flow reactors for ex situ biogas upgrading

This study evaluates the efficiency of four novel up-flow reactors for ex situ biogas upgrading converting externally provided CO2 and H2 to CH4, via hydrogenotrophic methanogenesis. The gases were injected through stainless steel diffusers combined with alumina ceramic sponge or through alumina ceramic membranes. Pore size, input gas loading and gas recirculation flow rate were modulated to optimize gas-liquid mass transfer, and thus methanation efficiency. Results showed that larger pore size diffusion devices achieved the best kinetics and output-gas quality converting all the injected H2 and CO2, up to 3.6L/REACTOR·d H2 loading rate. Specifically, reactors' CH4 content increased from 23 to 96% and the CH4 yield reached 0.25LCH4/LH2. High throughput 16S rRNA gene sequencing revealed predominance of bacteria belonging to Anaerobaculum genus and to uncultured order MBA08. Additionally, the massive increase of hydrogenotrophic methanogens, such as Methanothermobacter thermautotrophicus, and syntrophic bacteria demonstrates the selection-effect of H2 on community composition.

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Scopus rating (2011): CiteScore 5.56 SJR 2.308 SNIP 2.507
Process performance and comparative metagenomic analysis during co-digestion of manure and lignocellulosic biomass for biogas production

Mechanical pretreatment is considered to be a fast and easily applicable method to prepare the biomass for anaerobic digestion. In the present study, the effect of mechanical pretreatment on lignocellulosic silages biodegradability was elucidated in batch reactors. Moreover, co-digestion of the silages with pig manure in continuously fed biogas reactors was examined. Metagenomic analysis for determining the microbial communities in the pig manure digestion system was performed by analysing unassembled shotgun genomic sequences. A comparative analysis allowed to identify the microbial species firmly attached to the digested grass particles and to distinguish them from the planktonic microbes floating in the liquid medium. It was shown that the methane yield of ensiled grass was significantly increased by 12.3% due to mechanical pretreatment in batch experiments. Similarly, the increment of the methane yield in the co-digestion system reached 6.4%. Regarding the metagenomic study, species similar to Coprothermobacter proteolyticus and to Clostridium thermocellum, known for high proteolytic and cellulolytic activity respectively, were found firmly attached to the solid fraction of digested feedstock. Results from liquid samples revealed clear differences in microbial community composition, mainly dominated by Proteobacteria. The archaeal community was found in higher relative abundance in the liquid fraction of co-digestion experiment compared to the solid fraction. Finally, an unclassified Alkaliphilus sp. was found in high relative abundance in all samples.

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Organisations: Department of Environmental Engineering, Residual Resource Engineering, University of Padova
Contributors: Tsapekos, P., Kougias, P., Treu, L., Campanaro, S., Angelidaki, I.
Hydrogen peroxide (H$_2$O$_2$) as a strong oxidant, is widely used in various chemical industries and environmental remediation processes. In this study, we developed an innovative method for cost-effective production of H$_2$O$_2$ by using a microbial reverse-electrodialysis electrolysis cell (MREC). In the MREC, electrical potential generated by the exoelectrogens and the salinity-gradient between salt and fresh water were utilized to drive the high-rate H$_2$O$_2$ production. Operational parameters such as air flow rate, pH, cathodic potential, flow rate of salt and fresh water were investigated. The optimal H$_2$O$_2$ production was observed at salt and fresh water flow rate of 0.5 mL min$^{-1}$, air flow rate of 12–20 mL min$^{-1}$, cathode potential of $-0.485 \pm 0.025$ V (vs Ag/AgCl). The maximum H$_2$O$_2$ accumulated concentration of $778 \pm 11$ mg L$^{-1}$ was obtained at corresponding production rate of $11.5 \pm 0.5$ mg L$^{-1}$ h$^{-1}$. The overall energy input for the synthesis process was $0.45 \pm 0.03$ kWh kg$^{-1}$ H$_2$O$_2$. Cathode potential was the key factor for H$_2$O$_2$ production, which was mainly affected by the air flow rate. This work for the first time proved the potential of MREC as an efficient platform technology for simultaneous electrosynthesis of valuable chemicals and utilization of salinity-gradient energy.
Seaweed as innovative feedstock for energy and feed – Evaluating the impacts through a Life Cycle Assessment

Offshore cultivation of seaweed provides an innovative feedstock for biobased products supporting blue growth in northern Europe. This paper analyzes two alternative exploitation pathways: energy and protein production. The first pathway is based on anaerobic digestion of seaweed which is converted into biogas, for production of electricity and heat, and digestate, used as fertilizer; the second pathway uses seaweed hydrolysate as a substrate for cultivation of heterotrophic microalgae. As a result the seaweed sugars are consumed while new proteins are produced enhancing the total output. We performed a comparative Life Cycle Assessment of five scenarios identifying the critical features affecting resource efficiency and environmental performance of the systems with the aim of providing decision support for the design of future industrial scale production processes. The results show that all scenarios provide environmental benefits in terms of mitigation of climate change, with biogas production from dried Laminaria digitata being the most favorable scenario, quantified as $-18.7 \times 10^2$ kg CO2 eq./ha. This scenario presents also the lowest consumption of total cumulative energy demand, $1.7 \times 10^4$ MJ/ha, and even resulting in a net reduction of the fossil energy fraction, $-1.9 \times 10^4$ MJ/ha compared to a situation without seaweed cultivation. All scenarios provide mitigation of marine eutrophication thanks to bioextraction of nitrogen and phosphorus during seaweed growth. The material consumption for seeded lines has 2–20 times higher impact on human toxicity (cancer) than the reduction achieved by energy and protein substitution. However, minor changes in cultivation design, i.e. use of stones instead of iron as ballast to weight the seeded lines, dramatically reduces human toxicity (cancer). Externalities from the use of digestate as fertilizer affect human toxicity (non-cancer) due to transfer of arsenic from aquatic environment to agricultural soil. However concentration of heavy metals in digestate does not exceed the limit established by Danish regulation. The assessment identifies seaweed productivity as the key parameter to further improve the performance of the production systems which are a promising service provider of environmental restoration and climate change mitigation.

General information

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Organisations: Department of Environmental Engineering, Residual Resource Engineering, Aarhus University, University of Siena
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Scopus rating (2014): CiteScore 4.6 SJR 1.665 SNIP 2.481
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Web of Science (2014): Indexed yes
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ISI indexed (2013): ISI indexed yes
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The impact of anode acclimation strategy on microbial electrolysis cell treating hydrogen fermentation effluent

The impact of different anode acclimation methods for enhancing hydrogen production in microbial electrolysis cell (MEC) was investigated in this study. The anodes were first acclimated in microbial fuel cells using acetate, butyrate and corn stalk fermentation effluent (CSFE) as substrate before moving into MECs, respectively. Subsequently, CSFE was used as feedstock in all the three MECs. The maximum hydrogen yield with the anode pre-acclimated with butyrate (5.21 ± 0.24 L H2/L CSFE) was higher than that pre-acclimated with acetate (4.22 ± 0.19 L H2/L CSFE) and CSFE (4.55 ± 0.14 L H2/L CSFE). The current density (480 ± 11 A/m3) and hydrogen production rate (4.52 ± 0.13 m3/m3/d) with the anode pre-acclimated with butyrate were also higher that another two reactors. These results demonstrated that the anode biofilm pre-acclimated with butyrate has significant advantages in CSFE treatment and could improve the performance of hydrogen production in MEC.

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Organisations: Department of Environmental Engineering, Residual Resource Engineering, Zhengzhou University, Nankai University
Contributors: Li, X., Zhang, R., Qian, Y., Angelidaki, I., Zhang, Y.
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TiO$_2$/UV based photocatalytic pretreatment of wheat straw for biogas production

The present study deals with the application of an advanced oxidation process combining UV irradiation in the presence of the photocatalyst titanium dioxide (TiO$_2$), as an effective pretreatment method of wheat straw as means for increasing its biodegradability for increased biogas production by anaerobic digestion (AD). Especially attention was paid in oxidation of the lignin in straw, besides release the sugars from the lignocellulosic structure of straw. Specifically, four different TiO$_2$ concentrations (0.0, 0.5, 1.0, 1.5, and 2.0% (w/w) TiO$_2$) were tested at three different irradiation times (0, 1, 2, and 3 h). Products of lignin-fraction oxidation, namely, vanillic acid, ferullic acid and acetic acid were quantified for each set of pretreatment conditions. Subsequently, biochemical methane potentials (BMPs) assays were conducted under thermophilic conditions from differentially pretreated samples and the pretreatment with the best performance was further tested in continuous mode operation. From BMP assays, 1.5% (w/w) TiO$_2$/straw at 3 h of UV light exposure pretreatment resulted in 37% (p < 0.05) increase in methane yield and 25% in CSTRs. It was concluded that the presence of TiO$_2$ and the products of lignin oxidation did not inhibit the AD process. Finally, a simplified energy assessment showed that all pretreatment conditions become feasible when amounts of substrate to be treated are greater than the threshold value of 1.15 g.
Wirelessly powered submerged-light illuminated photobioreactors for efficient microalgae cultivation

A novel submerged-light photobioreactor (SL-PBR) with free-floating, wireless internal light sources powered by near-field resonant inductive coupling was investigated using a quick (Chlorella vulgaris) and a slow (Haematococcus pluvialis) growing microalgal species. During testing of the SL-PBR, the yield on photons was 1.18 and 1.15 g biomass mol⁻¹ photons for C. vulgaris and H. pluvialis, respectively. At the same time, a conventional, externally illuminated PBR with the same internal light intensity produced yields of 0.78 and 0.05 g biomass mol⁻¹ photons for C. vulgaris and H. pluvialis, respectively. Thus, the wireless internal light source was proven to be up to fivefold more effective light delivery system compared to the conventional illumination system. Meanwhile, it was discovered that some of the internal light sources had ceased to function, which might have caused underestimation of the true yield. Interestingly, the SL-PBR provided more uniform light to the culture and had the ability to reduce the presence of dark zones and the effect of self-shading. Thus, the SL-PBR showed potential, if subsequent prototype designs address the technical challenges identified during this study.
System and method to control H2O2 level in advanced oxidation processes

The present invention relates to a bio-electrochemical system (BES) and a method of in-situ production and removal of H2O2 using such a bio-electrochemical system (BES). Further, the invention relates to a method for in-situ control of H2O2 content in an aqueous system of advanced oxidation processes (AOPs) involving in-situ generation of hydroxyl radical (OH) by using such a bio-electrochemical system (BES) and to a method for treatment of wastewater and water disinfection. The bio-electrochemical system (BES) according to the invention comprises: - an aqueous cathode compartment comprising a first cathode and a second cathode, - an aqueous anode compartment comprising an anode at least partly covered in biofilm, wherein the first cathode is connected to a first circuit and the second cathode is connected to a second circuit, wherein the first and the second circuit are connected to the system by an external switch.
Acclimation of continuous biomethanation process to extremely high ammonia levels

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Alternate switching between MFC and MEC for H2O2 synthesis and residual removal in Bioelectro-Fenton system

Sustainable H2O2 supply and elimination of residual H2O2 are two key challenges to the Fenton processes treating recalcitrant contaminants. In this study, an innovative Bioelectro-Fenton system capable of alternate switching between microbial electrolysis cell (MEC) and microbial fuel cell (MFC) mode of operation was developed to meet the challenges. In the MEC mode, H2O2 was electrochemically produced which reacts with Fenton’s reagent (Fe II) to form hydroxyl radical. The residual H2O2 (unused H2O2) is removed as electron acceptor by switching the system to MFC mode. Complete decolorization and mineralization of 50 mg L-1 methylene blue (MB) was achieved in the MEC mode with apparent first order rate constants of 0.43 and 0.22 h-1, respectively. After switching to the MFC mode, residual H2O2 of 180 mg L-1 was removed at a removal rate of 4.61 mg L-1 h-1 while generating a maximum current density of 0.49 A m-2. The MB degradation and residual H2O2 removal were affected by external resistance, cathode pH and initial MB concentration. Furthermore, the system performance was enhanced under stack operation. This study provides a proof-in-concept new system for efficient and cost-effective H2O2 control and recalcitrant pollutants removal.

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Alternative co-digestion scenarios for efficient fixed-dome reactor biomethanation processes

Many of the existing low-tech biogas reactors in the remote rural areas of developing countries have been abandoned due to the lack of substrates. This study investigated if unutilized biomasses are able to support an efficient biomethanation process with low carbon footprint, in these rural areas where low-tech reactors have been abandoned. Thus, the aims of this study were: a) to identify and evaluate alternative biomasses as anaerobic digestion substrates at a remote rural area site in India; b) to propose an efficient continuous biomethanation scenario for low-tech reactors; c) to assess the influence of the operational parameters on the stability of the anaerobic digestion process. The highest methane yield (137–159
NmL CH4 L−1) and co-digestion synergy (>20% more CH4 than expected) were achieved by co-digestion of wastewater, cow manure, banana and rice by-products at 79.3/4.2/16.3/0.2 ww−1 VS ratio, respectively. Three fixed-dome reactors, R30, R45 and R60, fed with all substrates, operated with hydraulic retention times of 30, 45, and 60 days and organic loading rates of 2.18, 1.46, and 1.09 g VS L−1 d−1, respectively (different co-digestion scenarios). R60 was the best continuous co-digestion scenario with 45% and 13% higher energy recovery from biomasses' utilization and 69% and 25% less greenhouse gas (GHG) emissions, compared to R30 and R45, respectively. These results indicate that it is possible to operate efficiently low-tech biogas reactors with utilized biomasses as anaerobic digestion substrates.
Ammonia inhibition on hydrogen enriched anaerobic digestion of manure under mesophilic and thermophilic conditions

Capturing of carbon dioxide by hydrogen derived from excess renewable energy (e.g., wind mills) to methane in a microbially catalyzed process offers an attractive technology for biogas production and upgrading. This bioconversion process is catalyzed by hydrogenotrophic methanogens, which are known to be sensitive to ammonia. In this study, the tolerance of the biogas process under supply of hydrogen, to ammonia toxicity was studied under mesophilic and thermophilic conditions. When the initial hydrogen partial pressure was 0.5 atm, the methane yield at high ammonia load (7 g NH₄⁺-N L⁻¹) was 41.0% and 22.3% lower than that at low ammonia load (1 g NH₄⁺-N L⁻¹) in mesophilic and thermophilic condition, respectively. Meanwhile no significant effect on the biogas composition was observed. Moreover, we found that hydrogenotrophic methanogens were more tolerant to the ammonia toxicity than acetoclastic methanogens in the hydrogen enriched biogas production and upgrading processes. The highest methane production yield was achieved under 0.5 atm hydrogen partial pressure in batch reactors at all the tested ammonia levels. Furthermore, the thermophilic methanogens at 0.5 atm of hydrogen partial pressure were more tolerant to high ammonia levels (≥5 g NH₄⁺-N L⁻¹), compared with mesophilic methanogens. The present study offers insight in developing resistant hydrogen enriched biogas production and upgrading processes treating ammonia-rich waste streams.
Ammonia - LCFA synergetic co-inhibition effect in manure-based continuous biomethanation process

In the current study it has been hypothesized that, when organic loading of an anaerobic reactor is increased, the additional cell biomass biosynthesis would capture more ammonia nitrogen and thereby reduce the ammonia toxicity. Therefore, the alleviation of the toxicity of high ammonia levels using lipids (glycerol trioleate-GTO) or carbohydrates (glucose-GLU) as co-substrates in manure-based thermophilic continuous stirred-tank reactors (RGTO and RGLU, respectively) was tested. At 5 g NH4+-N L−1, relative methane production of RGTO and RGLU, was 10.5% and 41% compared to the expected uninhibited production, respectively. At the same time control reactor (RCTL), only fed with manure, reached 32.7% compared to the uninhibited basis production. Therefore, it seems that using lipids to counteract the ammonia effect in CSTR reactors creates an “ammonia–LCFA (long chain fatty acids) synergetic co-inhibition” effect. Moreover, co-digestion with glucose in RGLU was more robust to ammonia toxicity compared to RCTL.

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Scopus rating (2015): CiteScore 5.47 SJR 2.243 SNIP 1.897
Web of Science (2015): Impact factor 4.917
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BFI (2014): BFI-level 2
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Web of Science (2014): Impact factor 4.494
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Biogas production is becoming increasingly important in the environmental area because, besides treating wastewaters, it also generates energy. Co-digestion has become more and more powerful since it is possible, with the use of abundant and cheap substrates, to dilute the inhibitory effects of various other substrates, making the process of anaerobic digestion more efficient and stable. Biogas process modelling describes the kinetics and stoichiometry of different steps in the anaerobic digestion process. This mathematical modelling provides an understanding of the processes and interactions occurring inside the biogas system. The present work investigated the interactions between different simple co-substrates...
(carbohydrate, lipid and protein) and real co-substrates (corn silage, fodder beet, grass and wheat straw) under co-digestion with manure, in order to verify synergetic effects. Subsequently, some experiments were reproduced, in order to evaluate the synergy obtained in the previous simulation and validate the model.

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BFI (2015): BFI-level 1
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Web of Science (2015): Impact factor 1.061
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Scopus rating (2014): CiteScore 1.3 SJR 0.41 SNIP 0.849
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ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
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ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.387 SNIP 0.717
Web of Science (2010): Impact factor 0.811
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.342 SNIP 0.627
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.327 SNIP 0.674
Scopus rating (2007): SJR 0.326 SNIP 0.636
An innovative process for biogas upgrading by the microbial electrolysis cell

Biogas as an alternative energy source is getting more attention which can facilitate to reduce fossil fuel utilization and greenhouse gas emissions. However, biogas is a mixture of gases and typically composed of 60-70% v/v methane (CH₄) and 30-40% v/v carbon dioxide (CO₂), small amounts of hydrogen sulfide (H₂S) and other gases. Rude biogas exhibits a significantly low Wobbe index, heating value and energy efficiency which hinder its application. Therefore, CH₄ enrichment prior to use is crucial to improve the quality of biogas. In this work, a novel bipolar membrane-microbial electrolysis cell (BPMEC) was proposed to realize biogas upgrading. The system was composed of the anode, middle and cathode chamber which were separated by a bipolar membrane (BM) and an anion exchange membrane (AEM), respectively. With an external potential, water dissociation occurred and acid was produced in the middle chamber while electrolysis happened and alkali was generated in the cathode chamber. When rude biogas was injected into the cathode chamber, CO₂ was absorbed chemically into the solution and migrated via AEM as the form of CO₃²⁻ and HCO₃⁻ into the middle chamber where they reacted with H⁺ and CO₂ was regenerated and released from the solution. The gas flow rates were varied, as well as the external voltage. Results revealed the highest cathodic pH was 10.03±0.21 and the lowest pH in the middle chamber was 1.34±0.21. The highest CO₂ removal efficiency can be reached at 98.76±1.32% and the maximum CH₄ content can be 98.13±1.12% with 19.64 ml/h gas flow rate and 1.2 V external potential. Organic matter was removed remarkably and COD of the last day was below 60 mg/l. Hydrogen (H₂) was produced and collected in the enriched gas which is another benefit of the system. This study provides a simple, efficient and sustainable way to extend the application of electrochemical technology.

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Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Jin, X., Li, X., Zhao, N., Angelidaki, I., Zhang, Y.
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Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2016

Bioflocculation of green microalgae using activated sludge and potential for biogas production

General information
State: Published
Organisations: Department of Environmental Engineering, Water Technologies, Residual Resource Engineering, Technical University of Denmark
Contributors: Radovici, M., Wágner, D. S., Angelidaki, I., Valverde Pérez, B., Plósz, B. G.
Number of pages: 1
**Bioremediation capacity, nutritional value and biorefining of macroalga Saccharina latissima**

Macroalgae have the ability to assimilate and convert waste nutrients (N and P) into valuable biomass. In this context, they have been extensively studied for their bioremediation potential for integrated multi-trophic aquaculture (IMTA). With a global aquaculture production of 23.8 million tonnes in 2012, macroalgae are a valuable source of vitamins, minerals, lipids, protein, and dietary fibres. Macroalgae have been used as food since ancient times in Asian countries, while in Europe they have lately been introduced as healthy food. Moreover, recently macroalgae have been receiving increasing attention as sustainable feedstock for biorefinery. Nevertheless, macroalgae resources are still very little explored in western countries. The aim of this study was fulfilled by the investigation of the bioremediation potential of the macroalga Saccharina latissima cultivated at a reference site (control) and at an IMTA site during 12 months (May 2013-May 2014), and assessing the effect of cultivation site and harvest time. Moreover, a comprehensive chemical and nutritional characterization of the produced biomass was made, and its potential as food and/or feed discussed. Finally, S. latissima biomass was tested as feedstock for fermentation-based succinic acid production in a biorefinery approach. Maximum biomass yield over one growing season was achieved in August (1.08-1.51 kg fresh weight (FW) m-1 of cultivation line) and September (0.92-1.49 kg FW m-1). Biomass yield directly correlated with the nutrient removal which similarly peaked in August (5.02-7.02 g N m-1 and 0.86-1.23 g P m-1) and September (4.73-7.24 g N m-1 and 0.83-0.96 g P m-1).

Moreover, both biomass yield and nutrient removal were higher in the IMTA site compared to the reference site in August (p<0.05). Additionally, macroalgal cultivation over two growing seasons enhanced the biomass yield and thus value, but not the bioremediation capacity. Harvest time had a significant impact in overall chemical composition, while cultivation site did not generally result in marked differences. The growth of epiphytic organisms from July to November makes the biomass unsuitable for human consumption, thus biomass meant to be used as food should be harvested in May. Protein content increased significantly from 1.3% dry matter (DM) in May to 10.8% DM in November. Similarly, the maximum essential amino acid (EAA) score was found in November (68.9%). Thus, results suggest an apparent mismatch between harvest time for human consumption (May) and the highest nutritional value of the protein in the biomass (November). The growth of epiphytes did not change the amino acid content or EAA score. However, the protein content and composition did not comply with the requirements for standard protein ingredients for fish feed (i.e. fishmeal, soymeal). The lipid concentration varied from 0.62%–0.88% DM in July to 3.33%–3.35% DM in November (p<0.05). Polyunsaturated fatty acids (PUFA’s) made up more than half of the fatty acids with a maximum in July (52.3%–54.0% fatty acid methyl esters). This including the most appreciated health beneficial PUFA’s, eicosapentaenoic (EPA; 20:5n-3) and docosahexaenoic acid (DHA; 22:6n-3), but also arachidonic (ARA) and stearidonic acid (SDA). Season of harvest is important for the choice of lipid quantity and quality, but the macroalga provides better sources of EPA, DHA and long-chain (LC)-PUFA’s in general compared to traditional vegetables. Regarding safety regulations, however, the main conclusions on the mineral analyses showed that high concentrations of iodine (up to 5,001 mg kg-1 DM) in the biomass may be of concern for human consumption, while the concentrations of total arsenic (up to 63.3 mg kg-1 DM) may restrict utilization as ingredient for feed. Seasonal variations in the content of carbohydrates, and fermentable sugars, had a significant impact on the succinic acid yield and titer. A maximum succinic acid yield of 91.9% (g g-1 of total sugars) corresponding to 70.5% of the theoretical maximum yield was achieved; while succinic acid titer amounted up to 36.8 g L-1 with maximum productivity of 3.9 g L-1 h-1. The high content of total phenolic compounds in the macroalga (July-August: 5-1% DM), and high concentration of inorganic nutrients in the solid residue recovered after enzymatic hydrolysis, makes co-production of antioxidants (i.e. phenols) and fertilizer very attractive. This was demonstrated to have the potential to increase the cost-effectiveness of the biorefinery facility. This study gives comprehensive information of the bioremediation potential of S. latissima cultivated commercially in the inner Danish waters. Year-round data show that harvest time can be effectively used to optimize the bioremediation capacity, and the biomass yield and application/value. The macroalga can be a source of valuable proteins, specific amino acids and food; however, high concentrations of iodine and total arsenic may be of concern regarding food and feed safety regulations, respectively. On the other hand, S. latissima is a promising feedstock for fermentation-based succinic acid production with co-production of phenols, and fertilizers.
Co-digestion of food and garden waste with mixed sludge from wastewater treatment in continuously stirred tank reactors

Co-digestions of urban organic waste were conducted to investigate the effect of the mixing ratio between sludge, food waste, grass clippings and green waste at different hydraulic retention times (HRTs). Compared to the digestion of 100% sludge, the methane yield increased by 48% and 35%, when co-digesting sludge with food waste, grass clippings and garden waste with a corresponding % VS of 10:67.5:15.75:6.75 (R1) and 10:45:31.5:13.5 (R2), respectively. The methane yield remained constant at around 425 and 385 NmL CH4/g VS in R1 and R2, respectively, when the reactors were operated at HRTs of 15, 20 and 30 days. However, the methane yield dropped significantly to 356 (R1) and 315 (R2) NmL CH4/g VS when reducing the HRT to 10 days, indicating that the process was stressed. Since the methane production rate improved significantly with decreasing HRT, the trade-off between yield and productivity was obtained at 15 days HRT.

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Web of Science (2017): Impact factor 5.807
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.94 SJR 2.215 SNIP 1.932
Web of Science (2016): Impact factor 5.651
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Scopus rating (2015): CiteScore 5.47 SJR 2.243 SNIP 1.897
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Web of Science (2014): Impact factor 4.494
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BFI (2013): BFI-level 2
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Web of Science (2013): Impact factor 5.039
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Web of Science (2013): Indexed yes
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Web of Science (2012): Impact factor 4.75
ISI indexed (2012): ISI indexed yes
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Keywords: Anaerobic digestion, Urban organic waste, Sewage sludge, Hydraulic retention time, Biochemical methane potential

Co-digestion of microalgae and activated sludge following a novel bioflocculation method

General information
- State: Published
- Organisations: Department of Environmental Engineering, Water Technologies, Residual Resource Engineering, Technical University of Denmark
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- Electronic versions: poster_YAS_final.pdf
Comparative analysis of taxonomic, functional, and metabolic patterns of microbiomes from 14 full-scale biogas reactors by metagenomic sequencing and radioisotopic analysis

Background
Biogas production is a very complex process due to the high complexity in diversity and interactions of the microorganisms mediating it, and only limited and diffuse knowledge exists about the variation of taxonomic and functional patterns of microbiomes across different biogas reactors, and their relationships with the metabolic patterns. The present study used metagenomic sequencing and radioisotopic analysis to assess the taxonomic, functional, and metabolic patterns of microbiomes from 14 full-scale biogas reactors operated under various conditions treating either sludge or manure.

Results
The results from metagenomic analysis showed that the dominant methanogenic pathway revealed by radioisotopic analysis was not always correlated with the taxonomic and functional compositions. It was found by radioisotopic experiments that the acetoclastic methanogenic pathway was dominant, while metagenomics analysis showed higher relative abundance of hydrogenotrophic methanogens. Principal coordinates analysis showed the sludge-based samples were clearly distinct from the manure-based samples for both taxonomic and functional patterns, and canonical correspondence analysis showed that the both temperature and free ammonia were crucial environmental variables shaping the taxonomic and functional patterns. The study further the overall patterns of functional genes were strongly correlated with overall patterns of taxonomic composition across different biogas reactors.

Conclusions
The discrepancy between the metabolic patterns determined by metagenomic analysis and metabolic pathways determined by radioisotopic analysis was found. Besides, a clear correlation between taxonomic and functional patterns was demonstrated for biogas reactors, and also the environmental factors that shaping both taxonomic and functional genes patterns were identified.

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Contributors: Luo, G., Fotidis, I., Angelidaki, I.
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Scopus rating (2016): CiteScore 5.89 SJR 2.119 SNIP 1.737
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Scopus rating (2015): CiteScore 6.79 SJR 2.487 SNIP 1.916
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.86 SJR 2.49 SNIP 1.792
Web of Science (2014): Impact factor 6.044
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Cultivation of microalgae in industrial wastewaters

Microalgae production for the purpose of clearing wastewater has been researched for at least half a century. Such systems have a dual benefit: first, they prevent nutrients from entering water bodies and causing eutrophication; second, they transform sunlight and carbon dioxide into a biomass that has many potential uses. Unfortunately, the current high costs of cultivation have limited the development and exploitation of such systems, resulting in only a few full-scale algae wastewater treatment installations and a small industry based mostly around food and pigments. This thesis contributes to a growing body of knowledge with the aim to make algae cultivation viable for the production of sustainable products. Specific contributions include: improvement in the methods of screening the growth potential of different microalgae species; identification of an industrial wastewater that allows good algae growth; knowledge about the mixotrophic utilization of chemical energy present in organic waste; demonstration of a method to optimize efficiency of culture growth and nutrient removal; and biochemical characterization of the produced biomass.

When designing algae cultivation, one challenge is that there are many potential combinations which must empirically screened. Tens of thousands of microalgae species have been identified so far and there are numerous waste-streams that potentially could be of interest. A screening system was developed using the microplate as cultivation vessel and measurement cuvette. Fluorescence was demonstrated to be an order of magnitude more sensitive than optical density for detecting biomass growth, which increased the length of time in which exponential growth was observable from hours to days. This enabled growth rate-light intensity (µ-I) curves to be measured in microplates which were found to be equivalent to those obtained in typical lab-scale photobioreactors. As µ-I curves are the key biological input to an already existing model, it was validated that low density microplate cultivations can be used to make predictions about industrially relevant autotrophic cultivation.

When algae are grown within a wastewater treatment plant, the use of the chemical energy stored in the organic carbon dissolved in the wastewater could also be a useful option. Conventional aerobic sewage treatment expends much energy in breaking down the biomass to CO2. However, various anaerobic treatment methods would result in effluent containing dissolved organic molecules suitable for algae species that have the ability to grow as mixo- or heterotrophs. Chlorella sorokiniana was cultivated in a lab scale photobioreactor under daily light dark cycles and various timing strategies were tested for adding acetate at concentrations that can be obtained in waste streams of 1 – 2 g L⁻¹. The results showed that the fastest growth occurred when adding the acetate at night (cyclic autotrophy/heterotrophy). However adding the acetate during the day (mixotrophy) also improved growth compared to autotrophic controls.

Industrial wastewater was used as cultivation medium of Chlorella sorokiniana. The culture was able to grow at high rates up to a density of 4 g L⁻¹. The deceleration-stat technique was used to create a series of pseudo-steady states to give information about the expected results of continuous cultivation of microalgae in the selected wastewater. At light intensities of 2100 and 200 µmol photon m⁻² s⁻¹ the algae grew at a rate of over 5 and 1.67 g L⁻¹day⁻¹, respectively. The
corresponding removal rates of nitrogen were 238 and 93 mg L-1day-1 and 40 and 19 mg L-1day-1 for phosphorous. Ammonium removal varied from below 40% to 99%, while phosphate removal was always nearly total. When the biomass was characterized, it was found that fertilizer value N and P content increased with growth rate. For animal feed, the amino acid content was about 40% of biomass. The content of the nutritionally important α-Linoleic fatty acid increased when light intensity and dilution rate were higher. Valuable pigments lutein, carotene and other carotenoids were higher in low-light conditions.

The results from this thesis demonstrate that industrial wastewater can be a suitable replacement for algae cultivation medium. The screening method developed will reduce the cost of identifying the best conditions to test at lab scale. The D-stat method offers a way to identify the best conditions for biomass production and nutrient removal. Various options for heterotrophic and mixotrophic utilization of waste organic carbon in effluents are identified. Further advances in microalgae cultivation and processing will be needed for the production of sustainable products from wastewater in the future.

**General information**

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*Organisations:* Department of Environmental Engineering, Residual Resource Engineering, National Food Institute, Research Group for Bioactives – Analysis and Application  
*Contributors:* van Wagenen, J. M., Angelidaki, I., De Francisci, D., Holdt, S. L.  
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Deeper insight into the structure of the anaerobic digestion microbial community; the biogas microbiome database is expanded with 157 new genomes

This research aimed to better characterize the biogas microbiome by means of high throughput metagenomic sequencing and to elucidate the core microbial consortium existing in biogas reactors independently from the operational conditions. Assembly of shotgun reads followed by an established binning strategy resulted in the highest, up to now, extraction of microbial genomes involved in biogas producing systems. From the 236 extracted genome bins, it was remarkably found that the vast majority of them could only be characterized at high taxonomic levels. This result confirms that the biogas microbiome is comprised by a consortium of unknown species. A comparative analysis between the genome bins of the current study and those extracted from a previous metagenomic assembly demonstrated a similar phylogenetic distribution of the main taxa. Finally, this analysis led to the identification of a subset of common microbes that could be considered as the core essential group in biogas production.

**General information**

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*Organisations:* Department of Environmental Engineering, Residual Resource Engineering, University of Padova  
*Contributors:* Treu, L., Kougias, P., Campanaro, S., Bassani, I., Angelidaki, I.  
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  *Scopus rating (2017):* CiteScore 6.28 SJR 2.029 SNIP 1.799  
  *Web of Science (2017):* Impact factor 5.807  
  *Web of Science (2017):* Indexed yes  
  *BFI (2016):* BFI-level 2  
  *Scopus rating (2016):* CiteScore 5.94 SJR 2.215 SNIP 1.932  
  *Web of Science (2016):* Impact factor 5.651
**Dynamic bioconversion mathematical modelling and simulation of urban organic waste co-digestion in continuously stirred tank reactor**

The application of anaerobic digestion (AD) as process technology is increasing worldwide: the production of biogas, a versatile form of renewable energy, from biomass and organic waste materials allows mitigating greenhouse gas emission from the energy and transportation sectors while treating waste. However, the successful operation of AD processes is challenged by economic and technological issues. To overcome these barriers, mathematical modelling of the bioconversion process can provide support to develop strategies for controlling and optimizing the AD process. The objective of this study was to apply a dynamic mathematical model to simulate the co-digestion of different urban organic wastes (UOW). The modelling was based on experimental activities, during which two reactors (R1, R2) were operated at hydraulic retention times (HRT) of 30, 20, 15, 10 days, in thermophilic conditions (55°C). Sludge, food waste, grass clippings, garden waste were co-digested with VS-based mixing ratios of 10:67.5:15.75:6.75 and 10:45:31.5:13.5 in R1 and R2 respectively. The BioModel (Angelidaki et al., 1999) was then employed with minor modifications of model parameters. The model outputs were validated with experimental results using AD of mixed sludge as single substrate and UOW as co-substrate. The process parameters values were reasonably predicted by the model, showing good correlation with the measured data. Identification of optimal scenarios for co-digestion of UOW, with changing HRT and feedstock compositions, was performed with multi-parameter pareto optimization. The results of the optimization demonstrated that tradeoff between productivity, methane yield and stable process operation should be taken into consideration.

**General information**

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Electronic versions:
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Source-ID: 127769521
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2016

**Dynamic functional characterization and phylogenetic changes due to Long Chain Fatty Acids pulses in biogas reactors**

The process stability of biogas plants is often deteriorated by the accumulation of Long Chain Fatty Acids (LCFA). The microbial community shifts due to LCFA disturbances have been poorly understood as the molecular techniques used were not able to identify the genome characteristics of uncultured microorganisms, and additionally, the presence of limited number of reference genomes in public databases prevented the comprehension of specific functional roles characterizing these microorganisms. The present study is the first research which deciphers by means of high throughput shotgun sequencing the dynamics of the microbial community during an inhibitory shock load induced by single pulses of unsaturated LCFA at two different concentrations (i.e. 2g/L-reactor and 3g/L-reactor). The metagenomic analysis showed that only the microbes associated with LCFA degradation could encode proteins related to "chemotaxis" and "flagellar assembly", which promoted the ability to move towards the LCFA sources so as to degrade them. Moreover, the syntrophic interactions found between Syntrophomonas sp. together with Methanosarcina sp. were possibly assigned to the menaquinone-electron transfer. Finally, it was proven that a previously exposed to LCFA inoculum is more efficient in the degradation process of LCFA due to the specialization of the microbial consortium.

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Evaluation of minerals and vitamins in the Danish cultivated sugar kelp

Seaweeds are known for their nutraceutical applications, but also the ability to accumulate e.g. very high iodine concentrations and toxic heavy metals. In this study, cultivated Saccharina latissima (sugar kelp) harvested year-round was analysed for minerals (incl. heavy metals) and vitamins (vit A and E) to evaluate the nutritional value, possible risks and harvest time for optimized value and application. Rope cultivated sugar kelp was sampled both in close proximity to a blue mussel and fish farm (IMTA) and in a reference/control site, both outside Horsens fjord in Denmark, and freeze dried and stored frozen for further analyses. Sugar kelp biomass was sampled (n=3) at 2 m depth in 2013-2014. Surprisingly high concentrations of K and Ca (up to more than 100 and 150 g/kg DW, respectively) were found, along with other trace metals: Cr, Fe, Mn, Co, Cu, Na, Zn, and Se. Undesirable elements such as Pb, Hg, and inorganic As were below legislative threshold values for edible seaweed in France and food supplements in EU, whereas Cd concentrations in some seasons were above the French limits. However, a 70 kg person would need an intake of 0.77-2.0 kg DW of sugar kelp to reach the provisional tolerable weekly intake limit set for Cd. The iodine was found in so high levels (up to 5 g/kg) that this will be the limiting element for intake of sugar kelp. Moreover, the concentrations of total As found from September to March were above the EU regulatory levels for feed ingredients (40 mg/kg DW. Pb and Cd concentrations were below threshold values. The vitamin E (alpha-tocopherol) concentrations (6-25 mg/kg DW) were similar to what is
found in broccoli. Generally the year-round variations were due season, and not between the two locations (reference and IMTA), so harvest time is important for optimized use, and may be conflicting with highest yields of sugar kelp. High concentrations of iodine and total As may be of concern regarding food and feed regulations, respectively.

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*Organisations:* National Food Institute, Research Group for Bioactives – Analysis and Application, Research Group for Nano-Bio Science, Department of Environmental Engineering, Residual Resource Engineering, Technical University of Denmark  
*Number of pages:* 1  
*Publication date:* 2016  
*Peer-reviewed:* Yes  
*Event:* Abstract from 22nd International Seaweed Symposium, Copenhagen, Denmark.

**Bibliographical note**
*OR-26-03*

**Extraction of alginate from Sargassum muticum: process optimization and study of its functional activities**
In the present study, alginate extraction from the brown seaweed Sargassum muticum was studied using single factor analysis. Response Surface Methodology-Central Composite Rotatary design (RSM-CCRD) was performed to reduce and optimize extraction temperature, alkali concentration, and consumption of solvent. Different interaction effect of three extraction factors of temperature (60–100 °C), alkali (1–5 %), and aqueous ethanol (70–100 %) were studied to reduce residual waste. The result showed that the optimum extraction yield (13.57 %) was obtained with 86 °C temperature, 3 % alkali, and 93 % ethanol. A second order polynomial equation using multiple regression analysis was developed, and the predicted extraction yield showed a high coefficient of determination (R² = 0.98) with the experimental alginate yield. The functionality of extracted alginate and residual supernatant left over after extraction were evaluated for total polyphenols and its antioxidant capacity. The extracted alginate was further characterized using fluorescence spectrophotometer and nuclear magnetic resonance spectroscopy. The 1H NMR data revealed that extracted alginate has an M/G ratio of 1.08 and η<1.

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*Organisations:* National Food Institute, Research Group for Bioactives – Analysis and Application, Department of Environmental Engineering, Residual Resource Engineering, Indian Institute of Technology, Kharagpur  
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*Ratings:*  
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**Web of Science (2018):** Indexed yes  
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**Scopus rating (2017):** CiteScore 2.59  
**Web of Science (2017):** Impact factor 2.401  
**Web of Science (2017):** Indexed yes  
**BFI (2016):** BFI-level 1  
**Scopus rating (2016):** CiteScore 2.46  
**Web of Science (2016):** Impact factor 2.616  
**Web of Science (2016):** Indexed yes  
**BFI (2015):** BFI-level 1  
**Scopus rating (2015):** CiteScore 2.32  
**Web of Science (2015):** Impact factor 2.372  
**Web of Science (2015):** Indexed yes  
**BFI (2014):** BFI-level 1
Forward osmosis treatment of effluents from anaerobic digestion: correlation between membrane performance and biogas potential

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Contributors: Schneider, C., Sathyadev Rajmohana, R., Tsapekos, P., Angelidaki, I., Zarebska, A., Hélix-Nielsen, C.
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Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2016

Harvesting microalgae using activated sludge can decrease polymer dosing and enhance methane production via co-digestion in a bacterial-microalgal process

Third generation biofuels, e.g. biofuels production from algal biomass, have gained attention due to increased interest on global renewable energy. However, crop-based biofuels compete with food production and should be avoided. Microalgal cultivation for biofuel production offers an alternative to crops and can become economically viable when combined with the use of used water resources. Besides nutrients and water, harvesting microalgal biomass represents one of the major costs related to biofuel production and thus efficient and cheap solutions are needed. In bacterial-algal systems, there is
the potential to produce energy by co-digesting the two types of biomass. We present an innovative approach to recover microalgal biomass via a two-step flocculation using bacterial biomass after the destabilisation of microalgae with conventional cationic polymer. A short solids retention time (SRT) enhanced biological phosphorus removal (EBPR) system was combined with microalgal cultivation. Two different bacterial biomass removal strategies were assessed whereby bacterial biomass was collected from the solid-liquid separation after the anaerobic phase and after the aerobic phase. Microalgal recovery was tested by jar tests where three different chemical coagulants in coagulation-flocculation tests (AlCl₃, PDADMAC and Greenfloc 120) were assessed. Furthermore, jar tests were conducted to assess the microalgal biomass recovery by a two-step flocculation method, involving chemical coagulants in the first step and bacterial biomass used in the second step to enhance the flocculation. Up to 97% of the microalgal biomass was recovered using 16 mg polymer/g algae and 0.1 g algae/g bacterial biomass. Moreover, the energy recovery by the short-SRT EBPR system combined with microalgal cultivation was assessed via biomethane potential tests. Up to 560 ± 24 mL CH₄/gVS methane yield was obtained by co-digesting bacterial biomass collected after the anaerobic phase and microalgal biomass. The energy recovery in terms of methane production obtained in the short-SRT EBPR system is about 40% of the influent chemical energy.

General information
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Contributors: Wágner, D. S., Radovici, M., Smets, B. F., Angelidaki, I., Valverde Pérez, B., Plósz, B. G.
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Scopus rating (2014): CiteScore 4.96 SJR 1.902 SNIP 1.598
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Improving methane production from digested manure biofibers by mechanical and thermal alkaline pretreatment
Animal manure digestion is associated with limited methane production, due to the high content in fibers, which are hardly degradable lignocellulosic compounds. In this study, different mechanical and thermal alkaline pretreatment methods were applied to partially degradable fibers, separated from the effluent stream of biogas reactors. Batch and continuous experiments were conducted to evaluate the efficiency of these pretreatments. In batch experiments, the mechanical
pretreatment improved the degradability up to 45%. Even higher efficiency was shown by applying thermal alkaline pretreatments, enhancing fibers degradability by more than 4-fold. In continuous experiments, the thermal alkaline pretreatment, using 6% NaOH at 55 °C was proven to be the most efficient pretreatment method as the methane production was increased by 26%. The findings demonstrated that the methane production of the biogas plants can be increased by further exploiting the fraction of the digested manure fibers which are discarded in the post-storage tank.
Improving the energy balance of grass-based anaerobic digestion through harvesting optimization

Meadows, marginal and environmentally sensitive areas are often considered as the source to find the needed organic feedstock for the proliferated full-scale biogas plant. However, the anaerobic digestion (AD) of biomass from these areas is connected with specific challenges, originated from their complex lignocellulosic structure. Thus, pretreatment methods are typically applied in order to disrupt their rigid matrix and improve the digestibility.

Despite the fact that a lot of research has already focused on various pretreatment methods for lignocellulosic substrates, their overall process efficiency is still doubted and thus, they are not widely used in full-scale biogas plants. In addition, these methods are typically associated with increased costs or energy demands. Hence, there is a need to find effective and cost-efficient solutions that boost biomass decomposition. In this concept, one way to improve the overall process efficiency is to minimize the number of individual process steps prior to feeding the biomass to the reactor.

The present study examined the effect of full-scale harvesting machines (i.e. a simple front mounted disc mower and a disc mower equipped additionally with a number of coarse barbs) to simultaneously mow and mechanically pretreat two different lignocellulosic substrates. Thus, ensiled meadow grass was initially examined at the first experimental set up. Regarding the second field test, an area sowed with regularly cultivated grass was harvested. In order to determine the treatment with the best energy balance, the energy demand during harvesting was compared to the practical methane yield. The biomethanation process was evaluated using triplicate batch assays under thermophilic conditions following the guidelines of the biochemical methane potential (BMP) protocol.

The findings showed that methane production can efficiently be enhanced by mechanical pretreatment applied at the harvesting step. More specifically, the most effective treatment yielded more than 10% increase in the bioenergy production from both examined grass silages. Our study demonstrates that the appropriate harvester can improve the energy output by approximately 2.4 GJ/ha under optimal conditions and subsequently, the overall sustainability of grass-based AD.
Innovative microbial electrochemical process for \( \text{H}_2\text{O}_2 \) synthesis and residual \( \text{H}_2\text{O}_2 \) removal for wastewater treatment

Sustainable \( \text{H}_2\text{O}_2 \) synthesis and residual \( \text{H}_2\text{O}_2 \) removal are key challenges to the treatment of recalcitrant wastewater using Fenton processes. In this study, an innovative bioelectrochemical system was developed to meet the challenges by alternate switching between microbial electrolysis cell (MEC) and microbial fuel cell (MFC) mode of operation. In the MEC mode, \( \text{H}_2\text{O}_2 \) was produced and then reacted with Fenton’s reagent (Fe II) to form hydroxyl radical. When the system was switched to MFC mode, the unused \( \text{H}_2\text{O}_2 \) as residual is removed at the cathode as electron acceptor. For wastewater containing 50 mg L\(^{-1}\) methylene blue (MB), complete decolorization and mineralization was achieved in the MEC mode with apparent first order rate constants of 0.43 and 0.22 h\(^{-1}\), respectively. After switching the system to the MFC mode, unused \( \text{H}_2\text{O}_2 \) at concentration of 180 mg L\(^{-1}\) was removed. The removal rate was 4.61 mg L\(^{-1}\) h\(^{-1}\) while maximum current density of 0.49 A m\(^{-2}\) was generated. The MB degradation and removal of unused \( \text{H}_2\text{O}_2 \) were affected by different operational parameters such as external resistance, cathode pH and initial MB concentration. Furthermore, stack operation greatly improved the system performance. This study for the first time demonstrated an efficient and cost-effective bioelectrochemical system for \( \text{H}_2\text{O}_2 \) generation, residual removal and treatment of recalcitrant pollutants.

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Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2016

In-situ biogas upgrading in thermophilic granular UASB reactor; key factors affecting the hydrogen mass transfer rate

Biological biogas upgrading coupling \( \text{CO}_2 \) with external \( \text{H}_2 \) to form biomethane opens new avenues for sustainable biofuel production. For developing this technology, efficient \( \text{H}_2 \) to liquid transfer is fundamental. This study proposes an innovative setup for in-situ biogas upgrading converting the \( \text{CO}_2 \) in the biogas into \( \text{CH}_4 \), via hydrogenotrophic methanogenesis. The setup consisted of a granular reactor connected to a separate chamber, where \( \text{H}_2 \) was injected. Different packing materials (rashig rings and alumina ceramic sponge) were tested to increase gas-liquid mass transfer. This aspect was optimized by liquid and gas recirculation and chamber configuration. It was shown that by distributing \( \text{H}_2 \) through a metallic diffuser followed by ceramic sponge in a separate chamber, having a volume of 25% of the reactor, and by applying a mild gas recirculation, \( \text{CO}_2 \) content in the biogas dropped from 42 to 10% and the final biogas was upgraded from 58 to 82% \( \text{CH}_4 \) content.

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BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.94 SJR 2.215 SNIP 1.932
Web of Science (2016): Impact factor 5.651
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.47 SJR 2.243 SNIP 1.897
Web of Science (2015): Impact factor 4.917
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.3 SJR 2.399 SNIP 2.087
Web of Science (2014): Impact factor 4.494
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BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 5.97 SJR 2.405 SNIP 2.477
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ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.25 SJR 2.334 SNIP 2.461
Web of Science (2012): Impact factor 4.75
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 5.56 SJR 2.308 SNIP 2.507
Web of Science (2011): Impact factor 4.98
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.089 SNIP 2.344
Web of Science (2010): Impact factor 4.365
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.915 SNIP 2.236
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.736 SNIP 2.74
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.403 SNIP 2.396
Web of Science (2007): Indexed yes
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Scopus rating (2005): SJR 1.278 SNIP 1.98
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.19 SNIP 1.655
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.942 SNIP 1.665
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.908 SNIP 1.294
Integrated production of cellulose bioethanol and succinic acid from industrial hemp in a biorefinery concept

The aim of this study was to develop integrated biofuel (cellulosic bioethanol) and biochemical (succinic acid) production from industrial hemp (Cannabis sativa L.) in a biorefinery concept. Two types of pretreatments were studied (dilute-acid and alkaline oxidative method). High cellulose recovery (> 95%) as well as significant hemicelluloses solubilization (49-59%) after acid-based method and lignin solubilization (35-41%) after alkaline H2O2 method were registered. Alkaline pretreatment showed to be superior over the acid-based method with respect to the rate of enzymatic hydrolysis and ethanol productivity. With respect to succinic acid production, the highest productivity was obtained after liquid fraction fermentation originated from steam treatment with 1.5% of acid. The mass balance calculations clearly showed that 149 kg of EtOH and 115 kg of succinic acid can be obtained per 1 ton of dry hemp. Results obtained in this study clearly document the potential of industrial hemp for a biorefinery.
Low-sludge age EBPR process for resource recovery – microbial and biochemical process characterization

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Organisations: Department of Environmental Engineering, Water Technologies, Residual Resource Engineering, Technical University of Denmark
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Mesophilic and thermophilic alkaline fermentation of waste activated sludge for hydrogen production: Focusing on homoacetogenesis

The present study compared the mesophilic and thermophilic alkaline fermentation of waste activated sludge (WAS) for hydrogen production with focus on homoacetogenesis, which mediated the consumption of H2 and CO2 for acetate production. Batch experiments showed that hydrogen yield of WAS increased from 19.2 mL H2/gVSS at 37 °C and pH 10–80.1 mL H2/gVSS at 55 °C and pH 10. However, the production of volatile fatty acids (mainly acetate) was higher at 37 °C and pH 10 by comparison with 55 °C and pH 10. Hydrogen consumption due to homoacetogenesis was observed at 37 °C and pH 10 but not 55 °C and pH 10. Higher expression levels of genes relating with homoacetogenesis and lower expression levels of genes relating with hydrogen production were found at 37 °C and pH 10 compared to 55 °C and pH 10. The continuous experiment demonstrated the steady-state hydrogen yield of WAS was comparable to that obtained from batch experiments at 55 °C and pH 10, and homoacetogenesis was still inhibited. However, the steady-state hydrogen yield of WAS (6.5 mL H2/gVSS) was much lower than that (19.2 mL H2/gVSS) obtained from batch experiments at 37 °C and pH 10 due to the gradual enrichment of homoacetogens as demonstrated by qPCR analysis. The high-throughput sequencing analysis of 16S rRNA genes showed that the abundance of genus Clostridium, containing several homoacetogens, was 5 times higher at 37 °C and pH 10 than 55 °C and pH 10.

General information

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Organisations: Department of Environmental Engineering, Residual Resource Engineering, Fudan University
Contributors: Wan, J., Jing, Y., Zhang, S., Angelidaki, I., Luo, G.
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Web of Science (2017): Impact factor 7.051
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 7.49 SJR 2.663 SNIP 2.563
Web of Science (2016): Impact factor 6.942
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 6.63 SJR 2.665 SNIP 2.482
Web of Science (2015): Impact factor 5.991
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 6.13 SJR 2.946 SNIP 2.702
Web of Science (2014): Impact factor 5.528
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 6.02 SJR 2.956 SNIP 2.676
Web of Science (2013): Impact factor 5.323
ISI indexed (2013): ISI indexed yes
Metagenomic analysis and functional characterization of the biogas microbiome using high throughput shotgun sequencing and a novel binning strategy

Biogas production is an economically attractive technology that has gained momentum worldwide over the past years. Biogas is produced by a biologically mediated process, widely known as "anaerobic digestion." This process is performed by a specialized and complex microbial community, in which different members have distinct roles in the establishment of a collective organization. Deciphering the complex microbial community engaged in this process is interesting both for unraveling the network of bacterial interactions and for applicability potential to the derived knowledge. In this study, we dissect the bioma involved in anaerobic digestion by means of high throughput Illumina sequencing (~51 gigabases of...
sequence data), disclosing nearly one million genes and extracting 106 microbial genomes by a novel strategy combining two binning processes. Microbial phylogeny and putative taxonomy performed using >400 proteins revealed that the biogas community is a trove of new species. A new approach based on functional properties as per network representation was developed to assign roles to the microbial species. The organization of the anaerobic digestion microbiome is resembled by a funnel concept, in which the microbial consortium presents a progressive functional specialization while reaching the final step of the process (i.e., methanogenesis). Key microbial genomes encoding enzymes involved in specific metabolic pathways, such as carbohydrates utilization, fatty acids degradation, amino acids fermentation, and syntrophic acetate oxidation, were identified. Additionally, the analysis identified a new uncultured archaean that was putatively related to Methanomassiliicoccales but surprisingly having a methylotrophic methanogenic pathway. This study is a pioneer research on the phylogenetic and functional characterization of the microbial community populating biogas reactors. By applying for the first time high-throughput sequencing and a novel binning strategy, the identified genes were anchored to single genomes providing a clear understanding of their metabolic pathways and highlighting their involvement in anaerobic digestion. The overall research established a reference catalog of biogas microbial genomes that will greatly simplify future genomic studies.

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Web of Science (2017): Impact factor 5.497
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.89 SJR 2.119 SNIP 1.737
Web of Science (2016): Impact factor 5.203
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 6.79 SJR 2.487 SNIP 1.916
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.86 SJR 2.49 SNIP 1.792
Web of Science (2014): Impact factor 6.044
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 6.21 SJR 2.257 SNIP 1.932
Web of Science (2013): Impact factor 6.221
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.7 SJR 2.118 SNIP 1.942
Web of Science (2012): Impact factor 5.552
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Methane Production and Kinetic Modeling for Co-digestion of Manure with Lignocellulosic Residues

Anaerobic digestion (AD) of animal manure and lignocellulosic residues is gaining increased interest as a result of their wide availability, optimum physicochemical characteristics, high methane potential, and absence of conflict with the human food chain compared to energy crops. The aim of this study was to assess the biomethanation process of two lignocellulosic substrates, wheat straw (WS) and meadow grass (MG), with cattle manure (CM) under thermophilic (53°C) conditions, focusing on nutrient availability in the reaction mixtures, along with C/N ratios. Results showed that, with the use of 50% WS on an organic matter basis in the feedstock and substitution of the rest of the volatile solids (VS) component share between CM and MG (25:75, 50:50, and 75:25), the methane yield can be increased by 20-24% compared to WS mono-digestion, with a methane production rate of 27, 23, and 22 N mL of CH4 g-1 of VS day-1, respectively. Moreover, the positive effects of coupled biological reactions in the reaction mixture of co-digestion were explained using the synergistic effect value (η). The η value was calculated using estimated and experimental methane yields. Furthermore, in MG co-digestion, where 75% VS originated from MG and the rest was distributed as a 25:75 mixture of CM and WS, a 14% enhancement in the methane yield was shown in comparison to MG mono-digestion, with the maximum methane production rate of 25 N mL of CH4 g-1 of VS day-1 in batch experiments. Finally, the best co-digestion results with the highest methane yield (up to 25%) and lowest lag phase (6-7 days) were achieved when 75% organic matter originated from CM. The combination presenting the above-mentioned increase in the methane yield also showed a methane production rate of 22 N mL of CH4 g-1 of VS day-1. It was concluded that increasing the MG share in co-digestion improves the feedstock digestibility and also gives the higher methane production rate. In contrast, a high WS share increases the lag phase and is a detriment to the biodegradability. Finally, through co-digestion of two lignocellulosic substrates of different physiochemical characteristics with CM, the overall biodegradability compared to single-substrate digestion is improved and the methane yield is enhanced.
Web of Science (2017): Impact factor 3.024
Web of Science (2017): Indexed yes
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Scopus rating (2016): CiteScore 3.49
Web of Science (2016): Impact factor 3.091
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3.34
Web of Science (2015): Impact factor 2.835
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.3
Web of Science (2014): Impact factor 2.79
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 3.52
Web of Science (2013): Impact factor 2.733
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 3.25
Web of Science (2012): Impact factor 2.853
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 3.05
Web of Science (2011): Impact factor 2.721
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Web of Science (2010): Impact factor 2.444
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Web of Science (2008): Indexed yes
Web of Science (2007): Indexed yes
Web of Science (2006): Indexed yes
Web of Science (2005): Indexed yes
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Research output: Research - peer-review ; Journal article – Annual report year: 2016
Methane production from formate, acetate and H₂/CO₂: focusing on kinetics and microbial characterization

For evaluating the methanogenesis from typical methanogenic precursors (formate, acetate and H₂/CO₂), CH₄ production kinetics were investigated at 37 +/- 1 degrees C in batch anaerobic digestion tests and stimulated by modified Gompertz model. The results showed that maximum methanation rate from formate, acetate and H₂/CO₂ were 19.58 +/- 0.49, 42.65 +/- 1.17 and 314.64 +/- 3.58 N mL/gVS/d in digested manure system and 6.53 +/- 0.31, 132.04 +/- 3.96 and 640.16 +/- 19.92 N mL/gVS/d in sewage sludge system during second generation incubation. Meanwhile the model could not fit well in granular sludge system, while the rate of formate methanation was faster than from H₂/CO₂ and acetate. Considering both the kinetic results and microbial assay we could conclude that H₂/CO₂ methanation was the fastest methanogenic step in digested manure and sewage sludge system with Methanomicrobiales as dominant methanogens, while granular sludge with Methanobacteria as dominant methanogens contributed to the fastest formate methanation.

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Microbial and biochemical process characterization of a low-sludge age EBPR process for resource recovery

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Microbial electrochemical monitoring of volatile fatty acids during anaerobic digestion
Volatile fatty acid (VFA) concentration is known as an important indicator to control and optimize anaerobic digestion (AD) process. In this study, an innovative VFA biosensor was developed based on the principle of a microbial desalination cell. The correlation between current densities and VFA concentrations was firstly evaluated with synthetic digestate. Two linear relationships were observed between current densities and VFA levels from 1 to 30 mM (0.04 to 8.50 mA/m²,
R2=0.97) and then from 30 to 200 mM (8.50 to 10.80 mA/m², R2=0.95). The detection range was much broader than that of other existing VFA biosensors. The biosensor had no response to protein and lipid which are frequently found along with VFAs in organic waste streams from AD, suggesting the selective detection of VFAs. The current displayed different responses to VFA levels when different ionic strengths and external resistances were applied, though linear relationships were always observed. Finally, the biosensor was further explored with real AD effluents and the results did not show significance differences with those measured by GC. The simple and efficient biosensor showed promising potential for online, inexpensive and reliable measurement of VFA levels during AD and other anaerobic processes.

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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 6.26 SJR 2.559 SNIP 1.902
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.61 SJR 2.546 SNIP 1.838
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.5 SJR 2.777 SNIP 2.003
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 5.52 SJR 2.952 SNIP 2.102
Web of Science (2013): Indexed yes
ISI indexed (2013): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.17 SJR 3.115 SNIP 2.043
Web of Science (2012): Indexed yes
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Web of Science (2011): Indexed yes
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Scopus rating (2011): CiteScore 5.16 SJR 3.18 SNIP 1.945
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Microbial Electrochemical Systems and Technologies: It Is Time To Report the Capital Costs

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Scopus rating (2017): CiteScore 6.58 SJR 2.535 SNIP 1.941
Web of Science (2017): Impact factor 6.653
Microbial electro-synthesis of hydrogen peroxide in microbial reverse-electrodialysis electrolysis cell

Microbial reverse-electrodialysis electrolysis cell (MREC) as a novel type of microbial electrochemical technologies has been proposed to produce H₂ and CH₄. In this study, we developed MREC to produce the strong oxidant H₂O₂. In the MREC, electrical potential generated by the exoelectrogens and the salinity-gradient between sea water and river water were utilized to drive the high-rate H₂O₂ production without external power supply. Operational parameters such as air flow rate, pH, cathodic potential, flow rate of high and low concentration solution were investigated. The optimal H₂O₂ production were observed at high and low concentration solution flow rate of 0.5 mL/min, air flow rate of 8-20 mL/min, cathode potential of -0.485 ± 0.025 V (vs Ag/AgCl). Under the optimal conditions, the maximum H₂O₂ yield of 778 ± 11 mg/L could be obtained. Cathode potential was found as the key factor for H₂O₂ production, which can be controlled through adjusting the air flow rate without power supply and potentiostat. This study shows for the first time high yield synthesis of H₂O₂ from oxygen reduction in a microbial electrochemical system without external power supply.

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Contributors: Li, X., Angelidaki, I., Zhang, Y.
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Source-ID: 126283368
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2016

Monitoring of volatile fatty acids during anaerobic digestion using a microbial electrochemical sensor

Volatile fatty acid (VFA) concentration is known as an important indicator to control and optimize anaerobic digestion (AD) process. In this study, an innovative VFA biosensor was developed based on the principle of a microbial desalination cell. The bulk substrate was dosed into the middle chamber innovatively which was separated from the anode chamber by an anion exchange membrane. The detection range can be broadened as only part of the ionized VFAs can transport through the membrane and the biofilm can be protected from inhibitors and toxicants.

The correlation between current densities and VFA concentrations was firstly evaluated with synthetic digestate. Two linear relationships were observed between current densities and VFA levels from 1 to 30 mM (0.04±0.01 to 8.50±0.32 mA/m², R²=0.97) and then from 30 to 200 mM (8.50±0.32 to 10.80±1.26 mA/m², R²=0.95). The detection range was much broader than that of other existing VFA biosensors. The biosensor had no response to protein and lipid which are frequently found along with VFAs in organic waste streams from AD, suggesting the selective detection of VFAs. The current displayed different responses to VFA levels when different ionic strengths and external resistances were applied, though linear relationships were always observed. Finally, the biosensor was further explored with real AD effluents and the results did not show significant differences with those measured by GC. The simple and efficient biosensor showed promising potential for online, inexpensive and reliable measurement of VFA levels during AD and other anaerobic processes. The outcomes will expand the application of bio-electrochemical system application.

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Jin, X., Angelidaki, I., Zhang, Y.
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Host publication information
Optimising the anaerobic co-digestion of urban organic waste using dynamic bioconversion mathematical modelling

Mathematical anaerobic bioconversion models are often used as a convenient way to simulate the conversion of organic materials to biogas. The aim of the study was to apply a mathematical model for simulating the anaerobic co-digestion of various types of urban organic waste, in order to develop strategies for controlling and optimising the co-digestion process. The model parameters were maintained in the same way as the original dynamic bioconversion model, albeit with minor adjustments, to simulate the co-digestion of food and garden waste with mixed sludge from a wastewater treatment plant in a continuously stirred tank reactor. The model's outputs were validated with experimental results obtained in thermophilic conditions, with mixed sludge as a single substrate and urban organic waste as a co-substrate at hydraulic retention times of 30, 20, 15 and 10 days. The predicted performance parameter (methane productivity and yield) and operational parameter (concentration of ammonia and volatile fatty acid) values were reasonable and displayed good correlation and accuracy. The model was later applied to identify optimal scenarios for an urban organic waste co-digestion process. The simulation scenario analysis demonstrated that increasing the amount of mixed sludge in the co-substrate had a marginal effect on the reactor performance. In contrast, increasing the amount of food waste and garden waste resulted in improved performance.
Optimization of biomethanation focusing on high ammonia loaded processes

The toxicity effect of high ammonia is one of the most common problems, which cause imbalance and low biogas production rate in biogas plants. When protein-rich substrates (e.g. pig manure and mink manure, food waste, etc.) are used in biogas plants, lead to suboptimal utilization of the biogas potential and unstable biogas process. However, up to now, the solutions for alleviating ammonia toxicity effect have been proven either too expensive or time consuming for the full-scale biogas plants. Thus, sustainable and practical solutions to overcome the problem of ammonia inhibition efficiently are urgently required. In order to alleviate the toxicity effect of high ammonia levels, some new ideas-hypotheses were presented and evaluated in this thesis.

Firstly, preliminary modelling results from a previous study, have demonstrated that the increase of lipids' concentration in ammonia-rich substrates, could theoretically mitigate the ammonia inhibition problem (Angelidaki et al., 1999). Therefore, the effect of co-digestion of cattle manure with lipids (i.e. glycerol trioleate (GTO)) under high ammonia levels (5 g NH4+-
N·L\(^{-1}\)) in anaerobic continuous stirred tank (CSTR) reactors (RGTO) was assessed. Additionally, for comparison purposes, a soluble carbohydrate (i.e. glucose) was also used as a co-substrate in an identical CSTR reactor (RGLU). At 5 g NH\(_4^+\)-N·L\(^{-1}\), relative methane production of RGTO and RGLU, was 10.5% and 41% compared to the expected uninhibited production, respectively. At the same time control reactor (RCTL), only fed with manure, reached 32.7% compared to the uninhibited basis production. Therefore, the hypothesis that the co-digestion of manure with lipids could alleviate the ammonia inhibition was not supported by the results. However, an “ammonia-LCFA synergetic inhibitory effect” was observed, which caused a deterioration of the inhibition effect in anaerobic digestion process. On contrary, the reactor where glucose was co-digested demonstrated higher tolerance to ammonia toxicity compared with the reactor where GTO was used.

Secondly, the problem of ammonia inhibition during biomethanation process could also be solved by microbiological methods. It is possible to promote the syntrophic acetate oxidation pathway during biomethanation process for countering ammonia inhibition. Therefore, the effects of different ammonia levels on pure strains of syntrophic acetate oxidation bacteria (SAOB) and hydrogenotrophic methanogens were evaluated. Furthermore, the effect of different ammonia levels on the syntrophic cultivation of SAOB and hydrogenotrophic methanogens was also assessed. The results showed that some hydrogenotrophic methanogens (79.1% of the theoretical methane production) were equally, or more resistant to ammonia toxicity compared to SAOB (11.1% of the theoretical methane production). In addition, the thermophilic hydrogenotrophic methanogens tested in the current study were more robust to high ammonia concentrations compared to the mesophilic hydrogenotrophic methanogens, which was contradictory to the results of some previous studies. Moreover, for SAOB, the resistance to ammonia toxicity could be improved by syntrophic cultivation with hydrogenotrophic methanogens, which indicated that at high ammonia levels, hydrogenotrophic methanogens seem to be the key players in the SAO pathway.

Thirdly, based on the same idea (promoting the syntrophic acetate oxidation pathway to alleviate ammonia inhibition), the hypothesis of bioaugmentation with high ammonia tolerant methanogenic archaea could be a new practical solution for fast recovery from ammonia inhibition. The results derived from this study clearly demonstrated a 31.3% increase in methane production yield in the CSTR reactor, at steady-state, after bioaugmentation. It indicated that this new solution to counteract ammonia inhibition was more practical and effective compared with other methods applied today in continuous reactors. Furthermore, bioaugmentation with an ammonia tolerant methanogen to alleviate ammonia toxicity could be applied for improving the efficiency of biomethanation process in full-scale continuous reactors.

Finally, an innovative method, where hydrogen is injected in the anaerobic reactor and subsequently been converted together with carbon dioxide to methane by hydrogenotrophic methanogens, could potentially be more tolerant to ammonia toxicity. Therefore, the effect of different ammonia levels on this hydrogen assisted biogas upgrading process under different hydrogen partial pressure (0, 0.25, 0.5 and 1 atm) in anaerobic reactors at both mesophilic and thermophilic temperature was evaluated. When the initial hydrogen partial pressure was 0.5 atm, the methane yield at high ammonia load (7 g NH\(_4^+\)-N·L\(^{-1}\)) was 41.0% and 22.3% lower than at low ammonia load (1 g NH\(_4^+\)-N·L\(^{-1}\)) in mesophilic and thermophilic condition, respectively. For the reactors without adding hydrogen, the methane yield decreased 65.0% (mesophilic) and 44.2% (thermophilic) when ammonia level increased to 7 g NH\(_4^+\)-N·L\(^{-1}\). The results demonstrated that the hydrogen assisted biogas production and upgrading processes were inhibited by high ammonia levels. Nevertheless, the hydrogen assisted biogas upgrading process was still more robust to the increasing ammonia concentrations compared to the conventional anaerobic digestion processes. Under all the different ammonia concentrations tested in the current study, the optimal hydrogen partial pressure in batch reactors was 0.5 atm. Furthermore, at 0.5 atm of hydrogen partial pressure, the thermophilic methanogens seemed to be more robust to high ammonia concentrations (5 and 7 g NH\(_4^+\)-N·L\(^{-1}\)) compared with mesophilic methanogens.

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**Recent developments on biofuels production from microalgae and macroalgae**

Biofuels from algae are considered as promising alternatives of conventional fossil fuels, as they can eliminate most of the environmental problems. The present study focuses on all the possible avenues of biofuels production through biochemical and thermochemical conversion methods in one place, bringing together both microalgae and macroalgae on the same platform. It provides a brief overview on the mechanism of different biofuel production from algae. Factors affecting the biofuel process and the associated challenges have been highlighted along with analysis of techno-economic study available in literature. Undoubtedly, biodiesel is the center of attraction among other biofuels. However, their routes and process need to be optimized in order to bring the minimum fuel selling price (MFSP) of biodiesel competitive.
Technological challenges have not been overcome to make biofuel production process energetically and commercially viable. Macrolalgeae are low in lipid content. Therefore, the use of macrolalgeae is restricted for gaseous fuels or fermentative methods of liquid biofuels production. Anaerobic digestion of algal biomass is easy and seems promising as the process is simple in terms of engineering and infrastructure requirement. Hydrogen production by microalgeae through biophotolysis seems interesting as it directly converts the solar energy into hydrogen. However, the process has not been scaled-up till today. Hydrothermal liquefaction (HTL) is more promising due to handling of wet biomass at moderate temperature and pressure and conversion of whole biomass into high quality oil. However, HTL process is energy intensive.

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- BFI (2017): BFI-level 2
- Scopus rating (2017): CiteScore 10.54 SJR 3.036 SNIP 3.594
- Web of Science (2017): Impact factor 9.184
- Web of Science (2017): Indexed yes
- BFI (2016): BFI-level 2
- Scopus rating (2016): CiteScore 9.52 SJR 2.998 SNIP 3.501
- Web of Science (2016): Impact factor 8.05
- Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 2
- Scopus rating (2015): CiteScore 8.35 SJR 2.921 SNIP 3.368
- Web of Science (2015): Indexed yes
- BFI (2014): BFI-level 2
- Scopus rating (2014): CiteScore 7.79 SJR 3.03 SNIP 3.72
- Web of Science (2014): Impact factor 5.901
- Web of Science (2014): Indexed yes
- BFI (2013): BFI-level 1
- Scopus rating (2013): CiteScore 7.88 SJR 2.98 SNIP 3.893
- Web of Science (2013): Impact factor 5.51
- ISI indexed (2013): ISI indexed yes
- Web of Science (2013): Indexed yes
- BFI (2012): BFI-level 1
- Scopus rating (2012): CiteScore 7.24 SJR 2.734 SNIP 3.861
- Web of Science (2012): Impact factor 5.627
- ISI indexed (2012): ISI indexed yes
- Web of Science (2012): Indexed yes
- BFI (2011): BFI-level 1
- Scopus rating (2011): CiteScore 7.39 SJR 2.717 SNIP 3.911
- Web of Science (2011): Impact factor 6.018
- ISI indexed (2011): ISI indexed yes
- Web of Science (2011): Indexed yes
- BFI (2010): BFI-level 1
- Scopus rating (2010): SJR 2.338 SNIP 3.092
Taxonomy and functional roles of biogas microbiota binned from multiple metagenomes of anaerobic digestion systems

Anaerobic digestion, a biologically mediated process, is a worldwide spread technology for biogas production. This work represents the first comprehensive catalogue of microbial genomes populating mesophilic and thermophilic biogas reactors treating manure, agro-industrial organic residues. High throughput Illumina sequencing was performed on samples collected from 22 biogas reactors (laboratory and full scale) operating under different conditions. Using a binning strategy, 575 high quality microbial genome bins were extracted and abundance-weighted community composition was determined. Average nucleotide identity grouped the genomes in 373 different species. Phylogeny and taxonomy assignment at species/genus level was possible only for 12% of the community members demonstrating a high degree of novelty in this microbiome. Moreover, 21 highly abundant genomes were found to be present in all digesters and constitute the community core group. Interestingly, 42% of them were classified as belonging to the Syntrophomonadaceae family. A correlation between the community composition resilience and the microbial functional specialization was also established. The core functional properties were found to cover all the steps of the anaerobic digestion process, from hydrolysis to methanogenesis. On contrary, 4 groups of genomes were identified only in specific bioreactors and therefore were found to be dependent on the operational parameters. Despite specific, some of these genomes are crucial for a properly functioning microbiome since they operate in peculiar conditions, determined by lipids and polysaccharides overload or in the presence of ammonia inhibition. Remarkably, by combining community composition and functional properties we provided a clear understanding of the anaerobic digestion process.

General information
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Contributors: Angelidaki, I., Treu, L., Campanaro, S., Luo, G., Kougias, P.
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Event: Abstract from 16th International Symposium on Microbial Ecology, Montreal, Canada.
Electronic versions:
abstract_ISME_Angelidaki.pdf
Source: PublicationPreSubmission
Source-ID: 141911590
Research output: Research - peer-review » Conference abstract for conference – Annual report year: 2017
The microbiome of biogas reactors treating lignocellulosic substrates revealed different mechanisms for carbohydrates utilization

The present study dissected the microbiome of biogas reactors treating lignocellulosic substrate and swine manure by means of high throughput Illumina sequencing. A comparative metagenomic analysis allowed to identify the microbial species firmly attached to the digested lignocellulosic particles and to distinguish them from the planktonic microbes floating in the liquid medium. Proteobacteria and Firmicutes were the most abundant phyla identified respectively in the liquid samples and firmly attached to the grass, and accounted approximately 17 and 22% of the total microbial counts. Additionally, Actinobacteria were also presented in both samples but in lower relative abundance. Assembly of the shotgun reads followed by a binning process led to the extraction of 151 genome bins, out of which 80 microbial species were completely new and not previously deposited in any database. Moreover, it was shown that 25 microbial genomes were more enriched (>2 fold) in the firmly attached grass samples compared to the liquid phase. A bioinformatic approach based on multiple databases for functional annotation (KEGG, COG, SEED and dbCAN) demonstrated that these microbial species encode enzymes related to carbohydrate utilisation and present numerous carbohydrate binding modules. Finally, it was found that apart from the cellulosome multi-enzyme complex, specific microbes, such as Bacteroidetes, present different mechanisms for binding and degrading the lignocellulose due to the presence of multiple CBM6 modules in beta-xylosidase and endoglucanase proteins or SLH modules in unknown proteins.

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TiO₂ assisted photo-oxidative pretreatment of wheat straw for biogas production

Photo-catalytic oxidation is an advanced oxidation process in which a catalyst is used to absorb light energy and oxidize the target substrates such as organic polymers. A number of metal oxides and metal ions can efficiently increase substrate's depolymerisation during the process of photo-catalytic oxidation. Titanium oxide (TiO₂) is a photo-catalyst that in its rutile and anatase forms presents the property to enhance the photo-oxidation of lignin-containing substrates. Due to lignin is one of the major obstacles in methane production from lignocellulosic biomass, its destruction is a necessary step to enhance biomass biodegradability in anaerobic digestion (AD) process. Thus, the present study elucidated the photo-catalytic oxidation of highly lignified wheat straw using TiO₂at the presence of UV light in the region of 300-360nm. Specifically, the combinations of four different concentrations of TiO₂ (i.e. 0.5, 1, 1.5 and 2 wt%) with four different exposure time periods (i.e. 0, 60, 120 and 180 min) were investigated under 700W medium pressure UV lamp radiations. Subsequently, biochemical methane potentials (BMPs) assays were conducted under thermophilic conditions for the different pretreated samples, based on the guidelines of the BMP protocol. The results showed that the methane yield was increased by 27% (p < 0.05) when compared to untreated wheat straw, due to the action of pretreatment with 1.5 wt% TiO₂ at 180min of exposure time. The findings were in accordance with the scanning electron microscopy (SEM) images of the pretreated wheat straw that showed augmented damaged areas and development of pits after the pretreatment. In addition, the products of oxidation were also measured, as it was expected the lignin to be oxidized into phenolic acids. For instance, vanillic acid was found to be markedly higher in the pretreated samples that were exposed for 180min with 1.5 wt% and 2 wt% of TiO₂ compared to the untreated wheat straw. Moreover, it was concluded that the products of lignin oxidation and also, the presence of TiO₂ did not inhibit the AD process. Finally, UV treatment or TiO₂ alone did not enhance the decomposition of wheat straw and the methane production from these samples did not differ significantly compared to untreated biomass (p > 0.05).

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Abstract_Biogas_Science_2016_MUH.pdf
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Source-ID: 125914982
Towards a standardization of biomethane potential tests

Production of biogas from different organic materials is a most interesting source of renewable energy. The biomethane potential (BMP) of these materials has to be determined to get insight in design parameters for anaerobic digesters. Although several norms and guidelines for BMP tests exist, interlaboratory tests regularly still show high variability of BMPs for the same substrate. A workshop was held in June 2015, in Leysin, Switzerland, with over 40 attendees from 30 laboratories around the world, to agree on common solutions to the conundrum of inconsistent BMP test results. This paper presents the consensus of the intense roundtable discussions and cross-comparison of methodologies used in respective laboratories. Compulsory elements for the validation of BMP results were defined. They include the minimal number of replicates, the request to carry out blank and positive control assays, a criterion for the test duration, details on BMP calculation, and last but not least criteria for rejection of the BMP tests. Finally, recommendations on items that strongly influence the outcome of BMP tests such as inoculum characteristics, substrate preparation, test setup, and data analysis are presented to increase the probability of obtaining validated and reproducible results.

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BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.34 SJR 0.429 SNIP 0.574
Web of Science (2017): Impact factor 1.247
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.3 SJR 0.404 SNIP 0.637
Web of Science (2016): Impact factor 1.197
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.19 SJR 0.464 SNIP 0.594
Web of Science (2015): Impact factor 1.064
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.14 SJR 0.585 SNIP 0.683
Web of Science (2014): Impact factor 1.106
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 1.3 SJR 0.571 SNIP 0.701
Web of Science (2013): Impact factor 1.212
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 1.13 SJR 0.597 SNIP 0.659
Untangling the Effect of Fatty Acid Addition at Species Level Revealed Different Transcriptional Responses of the Biogas Microbial Community Members

In the present study, RNA-sequencing was used to elucidate the change of anaerobic digestion metatranscriptome after long chain fatty acids (oleate) exposure. To explore the general transcriptional behavior of the microbiome, the analysis was first performed on shotgun reads without considering a reference metagenome. As a second step, RNA reads were aligned on the genes encoded by the microbial community, revealing the expression of more than 51 000 different transcripts. The present study is the first research which was able to dissect the transcriptional behavior at a single species level by considering the 106 microbial genomes previously identified. The exploration of the metabolic pathways confirmed the importance of Syntrophomonas species in fatty acids degradation, and also highlighted the presence of protective mechanisms toward the long chain fatty acid effects in bacteria belonging to Clostridiales, Rykennellaceae, and in species of the genera Halothermothrix and Anaerobaculum. Additionally, an interesting transcriptional activation of the chemotaxis genes was evidenced in seven species belonging to Clostridia, Halothermothrix, and Tepidanaerobacter.
Surprisingly, methanogens revealed a very versatile behavior different from each other, even among similar species of the Methanoculleus genus, while a strong increase of the expression level in Methanosarcina sp. was evidenced after oleate addition.

**General information**

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Organisations: Department of Environmental Engineering, Residual Resource Engineering, University of Padova


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Web of Science (2017): Impact factor 6.653

Web of Science (2017): Indexed yes

BFI (2016): BFI-level 2

Scopus rating (2016): CiteScore 6.26 SJR 2.559 SNIP 1.902

Web of Science (2016): Impact factor 6.198

Web of Science (2016): Indexed yes

BFI (2015): BFI-level 2

Scopus rating (2015): CiteScore 5.61 SJR 2.546 SNIP 1.838

Web of Science (2015): Impact factor 5.393

Web of Science (2015): Indexed yes

BFI (2014): BFI-level 2

Scopus rating (2014): CiteScore 5.5 SJR 2.777 SNIP 2.003

Web of Science (2014): Impact factor 5.33

Web of Science (2014): Indexed yes

BFI (2013): BFI-level 2

Scopus rating (2013): CiteScore 5.52 SJR 2.952 SNIP 2.102

Web of Science (2013): Impact factor 5.481

ISI indexed (2013): ISI indexed yes

Web of Science (2013): Indexed yes

BFI (2012): BFI-level 2

Scopus rating (2012): CiteScore 5.17 SJR 3.115 SNIP 2.043

Web of Science (2012): Impact factor 5.257

ISI indexed (2012): ISI indexed yes

Web of Science (2012): Indexed yes

BFI (2011): BFI-level 2

Scopus rating (2011): CiteScore 5.16 SJR 3.18 SNIP 1.945

Web of Science (2011): Impact factor 5.228

ISI indexed (2011): ISI indexed yes

Web of Science (2011): Indexed yes

BFI (2010): BFI-level 2

Scopus rating (2010): SJR 2.979 SNIP 1.726

Web of Science (2010): Impact factor 4.827

Web of Science (2010): Indexed yes

BFI (2009): BFI-level 2
Using a combination of binning strategies and taxonomic approaches to unravel the anaerobic digestion microbiome

Metagenomic sequencing is a fundamental tool to identify the functional potential of the prokaryotic species present in microbial communities, particularly for the unculturable microbes. Recent advances in software dedicated to metagenomic assembly allow nowadays to generate collections of scaffolds comprehensive of thousands genome sequences, but the binning of these scaffolds into OTUs representative of microbial genomes is still challenging. In the attempt to obtain a deep characterization of the anaerobic digestion microbiome, different metagenomic binning approaches were integrated into a new tool. To facilitate the binning process, this tool integrates two strategies; the taxonomic assignment of scaffolds and the clustering based on coverage values. By applying this procedure, 373 high quality genomes involved in the anaerobic digestion process have been extracted and annotated using COG, KEGG, SEED and Pfam. These high throughput approaches pose nowadays other basic challenges related to the computational effort needed for the taxonomic assignment of hundreds new microbial genomes. It is also mandatory to verify if other DNA sequences deriving from the same species are already present in public databases. Metagenomics raise new fundamental questions regarding the definition of what a microbial species is and how it can be defined solely considering its genome. In order to address these issues we have developed a collection of scripts to check the presence of the same genome sequence not only in different assemblies, but also in public databases and, finally, to simplify its functional annotation.

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Using_a_combination_of_binning_strategies_and_taxonomic_approaches_to_unravel_the_anaerobic_digestion_microbiome.pdf
Valorization of macroalga Saccharina latissima as novel feedstock for fermentation-based succinic acid production in a biorefinery approach and economic aspects

This study aimed to evaluate the potential of the macroalga Saccharina latissima as feedstock for fermentation-based succinic acid production in a biorefinery approach. Seasonal variations in the content of carbohydrates, and fermentable sugars, had a significant impact on the succinic acid yield and titer. A maximum succinic acid yield of 91.9% (g g⁻¹ of total sugars) corresponding to 70.5% of the theoretical maximum yield was achieved when a blend of macroalgal biomass cultivated over two growing seasons and harvested in July and August was used as feedstock. A succinic acid titer of 36.8 g L⁻¹ with a maximum productivity of 3.9 g L⁻¹ h⁻¹ was achieved. The high content of total phenolic compounds (TPCs) in the macroalgal biomass (July-August: 5-1% DM), and high concentration of macro- (Ca, K, Na, Mg, P, N and Fe) and micronutrients in the solid residue recovered after enzymatic hydrolysis (PHSR), makes co-production of antioxidants (i.e. phenolics) and fertilizer very attractive. Finally, a simplified economic assessment showed that for the analyzed scenarios the main product's selling price (succinic acid) can be lowered significantly by coproducing added value products (fertilizers) and high added value-lower volume products (antioxidants).
Variation in biochemical composition of Saccharina latissima and Laminaria digitata along an estuarine salinity gradient in inner Danish waters

In European kelp cultivation, knowledge on the spatial variation in biomass productivity and quality needs to be established. The present study provides a detailed overview of the biochemical composition and biomass production potential of Saccharina latissima and Laminaria digitata along a salinity gradient (16–31 PSU) in inner Danish waters. We discuss the results in a cultivation perspective, and evaluate the potential use of Laminariales as an energy feedstock, a feed additive and a bioremediation tool for mitigating eutrophication. We found the highest biomass production potential, the highest protein content (7.5% of dry matter), and the highest capacity for bio-remediation of nitrogen (1.88% N of dry matter) at high salinities, as opposed to the highest concentrations of fermentable sugars (90% of dry matter) and pigments at low salinities. Thus, areas suitable for high biomass production are not necessarily optimal for producing a specific biomass quality such as high carbohydrate concentration for bioenergy conversion, and this challenges the cultivation practice. Furthermore, concentrations of arsenic in the biomass were generally higher (up to 88 ppm) than allowed for animal diet (40 ppm) and could therefore impose challenges for utilizing S. latissima and L. digitata as animal feed additives.

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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.45 SJR 1.465 SNIP 1.141
Web of Science (2016): Impact factor 3.994
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 5.53 SJR 1.963 SNIP 1.618
Web of Science (2015): Impact factor 4.694
Scopus rating (2014): CiteScore 4.96 SJR 1.902 SNIP 1.598
Web of Science (2014): Impact factor 5.014
Scopus rating (2013): CiteScore 4.17 SJR 1.424 SNIP 1.119
Web of Science (2013): Impact factor 4.095
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Original language: English
Keywords: Amino acids, Metals, Monosaccharides, Nitrogen, Pigments, Protein
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Research output: Research - peer-review › Journal article – Annual report year: 2016

Recovery of ammonia and sulfate from waste streams and bioenergy production via bipolar bioelectrodialysis

Ammonia and sulfate, which are prevalent pollutants in agricultural and industrial wastewaters, can cause serious inhibition in several biological treatment processes, such as anaerobic digestion. In this study, a novel bioelectrochemical approach termed bipolar bioelectrodialysis was developed to recover ammonia and sulfate from waste streams and thereby counteracting their toxicity during anaerobic digestion. Furthermore, hydrogen production and wastewater treatment were also accomplished. At an applied voltage of 1.2 V, nitrogen and sulfate fluxes of 5.1 g View the MathML
source NH4+-N/m2/d and 18.9 g View the MathML source SO42−/m2/d were obtained, resulting in a Coulombic and current efficiencies of 23.6% and 77.4%, respectively. Meanwhile, H2 production of 0.29 L/L/d was achieved. Gas recirculation at the cathode increased the nitrogen and sulfate fluxes by 2.3 times. The applied voltage, initial (NH4)2SO4 concentrations and coexistence of other ions were affecting the system performance. The energy balance revealed that net energy (≥16.8 kWh/kg-N recovered or ≥4.8 kWh/kg-H2SO4 recovered) was produced at all the applied voltages (0.8-1.4 V). Furthermore, the applicability of bipolar bioelectrodialysis was successfully demonstrated with cattle manure. The results provide new possibilities for development of cost-effective technologies, capable of waste resources recovery and renewable energy production.
Alternate switching between microbial fuel cell and microbial electrolysis cell operation as a new method to control $\text{H}_2\text{O}_2$ level in Bioelectro-Fenton system

Sustainable $\text{H}_2\text{O}_2$ supply and cost-effective elimination of residual $\text{H}_2\text{O}_2$ are two key challenges associated with the successful application of Fenton reaction for contaminant removal. In this study, an innovative Bioelectro-Fenton system capable of alternate switching between microbial electrolysis cell (MEC) and microbial fuel cell (MFC) mode of operation was developed to meet the challenges. In the MEC mode, a bioelectrochemical system (BES) produces $\text{H}_2\text{O}_2$ which reacts with Fenton's reagent (Fe II) to form hydroxyl radical. The unused $\text{H}_2\text{O}_2$ (residual $\text{H}_2\text{O}_2$) is removed as electron acceptor by switching the system to MFC mode of operation. Complete decolorization and mineralization of 50 mg L$^{-1}$ methylene blue (MB) was achieved in the MEC mode with apparent first order rate constants of 0.43 and 0.22 h$^{-1}$, respectively. After switching to the MFC mode, residual $\text{H}_2\text{O}_2$ of 180 mg L$^{-1}$ was removed at a removal rate of 4.61 mg L$^{-1}$ h$^{-1}$ while generating a maximum current density of 0.49 A m$^{-2}$. The MB degradation and residual $\text{H}_2\text{O}_2$ removal were affected by external resistance, cathode pH and initial MB concentration. Furthermore, the system performance was enhanced under stack operation. This study provides a proof-in-concept new system for efficient and cost-effective $\text{H}_2\text{O}_2$ control and recalcitrant pollutants removal.

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering, Third Institute of Oceanography
Contributors: Zhang, Y., Wang, Y., Angelidaki, I.
Pages: 108-116
Publication date: 2015
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Ammonia effect on hydrogenotrophic methanogens and syntrophic acetate oxidizing bacteria

Substrates that contain high ammonia levels can cause inhibition on anaerobic digestion process and unstable biogas production. The aim of the current study was to assess the effects of different ammonia levels on pure strains of (syntrophic acetate oxidizing) SAO bacteria and hydrogenotrophic methanogens. Two pure strains of hydrogenotrophic methanogens (i.e: Methanoculleus bourgensis and Methanoculleus thermophiles) and two pure strains of SAO bacteria (i.e: Tepidanaerobacter acetatoxydans and Thermacetogenium phaeum) were inoculated under four different ammonia (0.26, 3, 5, and 7g NH4+-N/L) and free ammonia levels (Mesophilic: 3.31, 38.2, 63.68 and 89.15 g NH3-N/L. Thermophilic: 8.48, 97.82, 163.03 and 228.24 g NH3-N/L). The results indicated that both T. acetatoxydans and T. phaeum were more sensitive to high ammonia levels compared to the hydrogenotrophic methanogens tested. Additionally, the total incubation periods of hydrogenotrophic methanogens were significantly shorter compared to the SAO bacteria incubation periods. Thus, it seems that hydrogenotrophic methanogens could be equally, if not more, tolerant to high ammonia levels compared to SAO bacteria.
Ammonia effect on hydrogenotrophic methanogens and syntrophic acetate oxidizing bacteria

Ammonia-rich substrates can cause inhibition on anaerobic digestion process. Syntrophic acetate oxidizing bacteria (SAOB) and hydrogenotrophic methanogens are important for the ammonia inhibitory mechanism on anaerobic digestion. The roles and interactions of SAOB and hydrogenotrophic methanogens to ammonia inhibition effect are still unclear. The aim of the current study was to determine the ammonia toxicity levels of various pure strains of SAOB and hydrogenotrophic methanogens was tested. Thus, four hydrogenotrophic methanogens (i.e. Methanoculleus bourgensis, Methanobacterium congolense, Methanoculleus thermophilus and Methanothermobacter thermautotrophicus), two SAOB (i.e. Tepidanaerobacter acetatoxydans and Thermacetogenium phaeum) and their syntrophic cultivation, were assessed under 0.26, 3, 5 and 7 g NH₄⁺-N L⁻¹. The results showed that some hydrogenotrophic methanogens were equally, or in some cases, more tolerant to high ammonia levels compared to SAOB. Furthermore, a mesophilic hydrogenotrophic methanogen was more sensitive to ammonia toxicity compared to thermophilic methanogens tested in the study; which is contradicting to the general belief that thermophilic methanogens are more vulnerable to high ammonia loads compared to mesophilic. This unexpected finding underlines the fact that the complete knowledge of ammonia inhibition effect on hydrogenotrophic methanogens is still absent.
Ammonia tolerant enriched methanogenic cultures as bioaugmentation inocula to alleviate ammonia inhibition in continuous anaerobic reactors

Ammonia is the most common inhibitor of anaerobic digestion (AD) process, resulting in suboptimal exploitation of the biogas potential of the feedstocks, causing significant economic losses to the biogas plants. Ammonia is mainly inhibiting the acetoclastic methanogens, while the hydrogenotrophic methanogens are more robust to ammonia toxicity effect. It has been shown that bioaugmentation of a pure strain of a hydrogenotrophic methanogen (i.e. Methanoculleus bourgensis) in an ammonia inhibited continuous anaerobic reactor can improve methane production more than 30%. Nevertheless, cultivation of a pure culture, to be used as bioaugmentation inoculum, poses technical difficulties due to the required sterile conditions and the special growing media. On the contrary acclimatized enrichment methanogenic cultures have lower requirements to sterility. In the present study, we used an enriched ammonia tolerant methanogenic culture as potential bioaugmentation inoculum in a continuous stirred tank reactor (CSTR) operating under “inhibited steady-state”, triggered by high ammonia levels (5 g NH4+-N L-1). The results of the current study established for the first time that bioaugmentation of an enriched ammonia tolerant methanogen in a CSTR reactor could completely alleviate the ammonia inhibitory effect. Furthermore, it was found that bioaugmentation with the enriched culture resulted in 25% higher methane production compared to when the bioaugmentation was achieved with pure methanogenic strains. The bioaugmentation was performed without pausing the continuous operation of the CSTR reactor and without excluding the ammonia-rich substrate from the feedstock. Thus, bioaugmentation with mixed methanogenic cultures could potentially support the development of an efficient and cost-effective biomethanation process of ammonia-rich organic waste in full-scale continuous reactors.

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Fotidis, I., Wang, H., Angelidaki, I.
Ammonia tolerant enriched methanogenic cultures as bioaugmentation inocula to alleviate ammonia inhibition in continuous anaerobic reactors

Ammonia is the most common inhibitor of anaerobic digestion (AD) process, resulting in suboptimal exploitation of the biogas potential of the feedstocks, causing significant economic losses to the biogas plants. Ammonia is mainly inhibiting the acetoclastic methanogens, while the hydrogenotrophic methanogens are more robust to ammonia toxicity effect. It has been shown that bioaugmentation of a pure strain of a hydrogenotrophic methanogen (i.e. Methanoculleus bourgensis) in an ammonia inhibited continuous anaerobic reactor can improve methane production more than 30%. Nevertheless, cultivation of a pure culture, to be used as bioaugmentation inoculum, poses technical difficulties due to the required sterile conditions and the special growing media. On the contrary acclimatized enrichment methanogenic cultures have lower requirements to sterility. In the present study, we used an enriched ammonia tolerant methanogenic culture as potential bioaugmentation inoculum in a continuous stirred tank reactor (CSTR) operating under "inhibited steady-state", triggered by high ammonia levels (5 g NH4+-N L-1). The results of the current study established for the first time that bioaugmentation of an enriched ammonia tolerant methanogen in a CSTR reactor could completely alleviate the ammonia inhibitory effect. Furthermore, it was found that bioaugmentation with the enriched culture resulted in 25% higher methane production compared to when the bioaugmentation was achieved with pure methanogenic strains. The bioaugmentation was performed without pausing the continuous operation of the CSTR reactor and without excluding the ammonia-rich substrate from the feedstock. Thus, bioaugmentation with mixed methanogenic cultures could potentially support the development of an efficient and cost-effective biomethanation process of ammonia-rich organic waste in full-scale continuous reactors.

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Organisations: Department of Environmental Engineering, Residual Resource Engineering
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Peer-reviewed: Yes
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Research output: Research - peer-review › Poster – Annual report year: 2015

Anaerobic co-digestion of agricultural by-products with manure, for enhanced biogas production

Biogas is extensively promoted as a promising renewable energy. Therefore, the search of appropriate co-substrates has come into focus. In this study, we examined the potential of using agricultural byproducts as alternative co-substrates for increased biogas production. The biochemical methane potential (BMP) of six agricultural organic byproducts were tested. Consecutively, the byproduct with the highest BMP was used as a co-digestion substrate with manure, in a continuous stirred tank reactor (CSTR). Meadow grass had the highest BMP value [388 ± 30 NmL of CH4 g–1 of volatile solids (VS)] among all mono-substrates tested. On the basis of BMP, the substrates ranked as follows: meadow grass > spring barley, winter wheat, winter barley, ryegrass > rapeseed > manure. Co-digestion of manure with byproducts resulted in only an additive and not synergistic methane production. Continuous co-digestion of 34 g L–1 raw meadow grass with manure increased the methane production rate of the CSTR reactor by 114% compared to the manure alone.

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering, Technical University of Denmark
Contributors: Søndergaard, M. M., Fotidis, I., Kovalovszki, A., Angelidaki, I.
Pages: 8088-8094
Publication date: 2015
Anaerobic Mono- and Co-digestion of Mechanically Pretreated Meadow Grass for Biogas Production

Biomass from permanent grasslands and meadows can be exploited for biogas production, because this substrate is abundant and does not compete with food production. In the present study, the biogas productivity of meadow grass silage, harvested in two different seasons (early and late cut), was investigated. The grass silage was mechanically pretreated with different methods to increase its biodegradability. It was found that the early cut of non-treated meadow grass silage led to higher methane production [294 mL of CH4/g of volatile solids (VS)] compared to the corresponding non-treated meadow grass silage from the late cut (282 mL of CH4/g of VS). Moreover, it was found that the application of two mesh grating plates, as the pretreatment method, greatly enhanced the methane production in early and late cut silage in a range of 15 and 17%, respectively, compared to the non-treated grass silage. The methane productivity from pretreated meadow grass silage, harvested at fall (late cut), was further examined in a co-digestion process with three different types of livestock manure (mink, poultry, and cattle). The silage was co-digested with manure in five different manure/silage mixing ratios in terms of organic matter. The results showed that the optimum silage concentration in the co-digestion mixture with manure, for the highest methane yield, was strongly dependent upon the chemical composition of the manure. More specifically, the ammonia concentration of manure and the C/N ratio of the co-digestion mixture were found to be the key parameters for an improved biomethanation process.
Application of comminution machines to enhance the anaerobic biodegradability of ensiled meadow grass

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Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Tsapekos, P., Kougias, P., Angelidaki, I.
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Publication date: 2015

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Place of publication: Lyngby
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Tsapekos_et_al_Sustain_DTU_2015.pdf
Source: PublicationPreSubmission
Source-ID: 118954678
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2015

Bioelectrochemical recovery of waste-derived volatile fatty acids and production of hydrogen and alkali

Volatile fatty acids (VFA) are organic compounds of great importance for various industries and environmental processes. Fermentation and anaerobic digestion of organic wastes are promising alternative technologies for VFA production.
However, one of the major challenges is development of sustainable downstream technologies for VFA recovery. In this study, an innovative microbial bipolar electrodialysis cell (MBEDC) was developed to meet the challenge of waste-derived VFA recovery, produce hydrogen and alkali, and potentially treat wastewater. The MBEDC was operated in fed-batch mode. At an applied voltage of 1.2 V, a VFA recovery efficiency of 98.3%, H2 of 18.4 mL and alkali production presented as pH of 12.64 were obtained using synthetic fermentation broth. The applied voltage, initial VFA concentrations and composition were affecting the VFA recovery. The energy balance revealed that net energy (5.20 e6.86 kWh/kg-VFA recovered) was produced at all the applied voltages (0.8e1.4 V). The coexistence of other anionic species had no negative effect on VFA transportation. The VFA concentration was increased 2.96 times after three consecutive batches. Furthermore, the applicability of MBEDC was successfully verified with digestate. These results demonstrate for the first time the possibility of a new method for waste-derived VFA recovery and valuable products production that uses wastewater as fuel and bacteria as catalyst. © 2015 Elsevier Ltd. All rights reserved.
Biogas production from ensiled meadow grass; effect of mechanical pretreatments and rapid determination of substrate biodegradability via physicochemical methods

As the biogas sector is rapidly expanding, there is an increasing need in finding new alternative feedstock to biogas plants. Meadow grass can be a suitable co-substrate and if ensiled it can be supplied to biogas plants continuously throughout the year. Nevertheless, this substrate is quite recalcitrant and therefore efficient pretreatment is needed to permit easy access of microbes to the degradable components. In this study, different mechanical pretreatment methods were applied on ensiled meadow grass to investigate their effect on biomass biodegradability. All the tested pretreatments increased the methane productivity and the increase ranged from 8% to 25%. The best mechanical pretreatment was the usage of two coarse mesh grating plates. Additionally, simple analytical methods were conducted to investigate the possibility of rapidly determining the methane yield of meadow grass. Among the methods, electrical conductivity test showed the most promising calibration statistics (R² = 0.68).

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State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Tsapekos, P., Kougias, P., Angelidaki, I.
Pages: 329-335
Publication date: 2015
Peer-reviewed: Yes
Biogas upgrading by injection of hydrogen in a two-stage Continuous Stirred-Tank Reactor system

An innovative method for biogas upgrading (i.e. CH4 content more than 90%) combines the coupling of H2, which could be produced by water electrolysis using surplus renewable electricity produced from wind mills, with the CO2 of the biogas. CO2 is biologically converted to CH4 by hydrogenotrophic methanogens. In this study, a novel serial biogas reactor system is presented, in which the produced biogas from the first stage reactor was introduced in the second stage, where also H2 was injected. The effects of the H2 addition on the process performance and on the microbial community were investigated. It was shown that after the H2 addition, the CH4 rate increased by 45%, resulting in an average CH4 content of approximately 85%, with a maximum of 93.9%. The increase of the pH to 8.5, due to the CO2 conversion, was not an inhibitory factor, demonstrating the adaptation of microorganisms to these pH levels. The profiles of the microbial communities prior and after the H2 addition showed distinct differences. Changes in the archaeal community and more specifically increase in the relative abundance of Methanobrevibacter sp. and Methanoculleus sp. indicated that the methanogenic pathway was clearly shifted from aceticlastic to hydrogenotrophic.

**General information**

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Organisations: Department of Environmental Engineering, Residual Resource Engineering
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Publication date: 2015
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Electronic versions:
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Source: PublicationPreSubmission
Source-ID: 123767000
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2016

Biogas Upgrading via Hydrogenotrophic Methanogenesis in Two-Stage Continuous Stirred Tank Reactors at Mesophilic and Thermophilic Conditions

This study proposes an innovative setup composed by two stage reactors to achieve biogas upgrading coupling the CO2 in the biogas with external H2 and subsequent conversion into CH4 by hydrogenotrophic methanogenesis. In this configuration, the biogas produced in the first reactor was transferred to the second one, where H2 was injected. This configuration was tested at both mesophilic and thermophilic conditions. After H2 addition, the produced biogas was upgraded to average CH4 content of 89% in the mesophilic reactor and 85% in the thermophilic. At thermophilic conditions, a higher efficiency of CH4 production and CO2 conversion was recorded. The consequent increase of pH did not inhibit the process indicating adaptation of microorganisms to higher pH levels. The effects of H2 on the microbial community were studied using high-throughput Illumina random sequences and full-length 16S rRNA genes extracted from the total sequences. The relative abundance of archaeal community markedly increased upon H2 addition with Methanoculleus as dominant genus. The increase of hydrogenotrophic methanogens and syntrophic Desulfovibrio and the decrease of aceticlastic methanogens indicate a H2-mediated shift toward the hydrogenotrophic pathway enhancing biogas upgrading. Moreover, Thermoanaerobacteraceae were likely involved in syntrophic acetate oxidation with hydrogenotrophic methanogens in absence of aceticlastic methanogenesis.

**General information**

State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Bassani, I., Kougias, P., Treu, L., Angelidaki, I.
Bioremediation Potential of Sugarkelp, Saccharina Latissima, Cultivated in a Commercial Off-Shore Integrated Multi-Trophic Aquaculture

Characterization of nutrient removal and microalgal biomass production on an industrial waste-stream by application of the deceleration-stat technique

Industrial wastewaters can serve as a nutrient and water source for microalgal production. In this study the effluent of an internal circulation (IC) reactor anaerobically treating the wastes of a biotechnology production facility were chosen as the cultivation medium for Chlorella sorokiniana in batch and continuous cultures. The aim was to evaluate the rates of nutrient removal and biomass production possible at various dilution rates. The results demonstrate that the industrial wastewater served as a highly effective microalgal culture medium and that dilution rate strongly influenced algae productivity in a short light-path photobioreactor. Batch culture on undiluted wastewater showed biomass productivity of 1.33gL-1day-1, while removing over 99% of the ammonia and phosphate from the wastewater. Deceleration-stat (D-stat) experiments performed at high and low intensities of 2100 and 200 (μmol photon m2s-1) established the optimal dilution rates to reach volumetric productivity of 5.87 and 1.67gL-1day-1 respectively. The corresponding removal rates of nitrogen were 238 and 93mg L-1day-1 and 40 and 19mg L-1day-1 for phosphorous. The yield on photons at low light intensity was as high as had been observed in any previous report indicating that the waste stream allowed the algae to grow at its full potential.
Scopus rating (2004): SJR 2.209 SNIP 2.108
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.702 SNIP 1.908
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.568 SNIP 1.757
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.319 SNIP 1.69
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 1.399 SNIP 1.662
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 1.432 SNIP 1.55

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Keywords: Chlorella sorokiniana, Deceleration-stat, IC reactor, Microalgae productivity, Nutrient removal, Short light-path photobioreactor, Algae, Batch cell culture, Biomass, Light, Microorganisms, Nitrogen removal, Nutrients, Photobioreactors, Photons, Productivity, Ic reactors, Micro-algae, Effluents

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Co-Digestion of Food Waste and Garden Waste With WTTP Mixed Sludge in CSTR

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Fitamo, T. M., Boldrin, A., Boe, K., Angelidaki, I., Scheutz, C.
Number of pages: 1
Publication date: 2015
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Event: Poster session presented at 14th World Congress on Anaerobic Digestion, Viña del Mar, Chile.
Electronic versions:
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Combined anaerobic digestion of green waste with wastewater treatment plant mixed sludge in continuous stirred tank reactor (CSTR)

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Contributors: Fitamo, T. M., Boldrin, A., Angelidaki, I., Boe, K., Scheutz, C.
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Electronic versions:
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Source: PublicationPreSubmission
Source-ID: 127769544
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Commercial cultivation and bioremediation potential of sugar kelp, Saccharina latissima, in Danish waters

Several seaweed species have been successfully tested for their biofilter potential for integrated multi-trophic aquaculture (IMTA). In this study, Saccharina latissima bioremediation potential was assessed over 12 months with respect to the yield, phosphorous (P), nitrogen (N) content and N removal. The experiment took place at two commercial cultivation areas; in close proximity to a blue mussel and fish farm (IMTA) and at a reference site, both situated outside Horsens fjord in Denmark. The maximum biomass yield over the first growing season was achieved in August (1.08±0.09 and 1.51±0.13 kg FW m−1) and September (0.92±0.18 and 1.49±0.16 kg FW m−1). Yield was significantly higher at the IMTA compared to
the reference site in August (P<0.05). A second growing season did not improve biofiltration efficiency. The highest N and P removal was achieved in August and September. Again the IMTA location showed better N and P removal compared with the reference site in August; 5.02-7.02 g N and 0.86-1.23 g P m⁻¹ of cultivation line (P<0.05). S. latissima shows potential for assimilation and removal of nutrients, particularly nitrogen. Seasonal variations of biofilter efficiency, conditions and potential applications should be taken into account when evaluating the best suited harvest time. For Horsens fjord, our results showed that the harvest time should take place in August-September in order to achieve maximum biofiltration efficiency (including N and P in epiphytes). However, for human consumption, it is better to harvest in May where the seaweed is free of epiphytes.

General information
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Scopus rating (2016): CiteScore 2.46
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Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 2.32
Web of Science (2015): Impact factor 2.372
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
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Web of Science (2014): Impact factor 2.559
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Scopus rating (2013): CiteScore 2.78
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ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 2.68
Web of Science (2012): Impact factor 2.326
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 2.29
Web of Science (2011): Impact factor 2.411
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
Comparison of mixotrophic to cyclic autotrophic/heterotrophic growth strategies to optimize productivity of Chlorella sorokiniana

In addition to providing cheap or free mineral nutrients, wastewaters may contain organic carbon compounds that could increase productivity of algal cultures. This study defined a strategy for the addition of organic carbon to photobioreactors in order to improve their productivity compared to autotrophic growth. Chlorella sorokiniana was cultivated in medium supplemented with sodium acetate in concentrations equivalent to the volatile fatty acid concentration found in anaerobic digester effluent. Flat-panel photobioreactors were operated using 16:8 light:dark cycles, with different strategies for acetate addition. Acetate was added during the light period for the mixotrophic strategy and during the dark one for the cyclic autotrophic/heterotrophic strategy. Autotrophic productivity of up to 0.99 g L⁻¹ day⁻¹ was obtained using the optimal tested dilution rate of 0.031 h⁻¹. The highest mixotrophic productivity was 1.04 g L⁻¹ day⁻¹. When a constant dilution rate was applied throughout the day, cyclic heterotrophy/autotrophy (1.2 g L⁻¹ day⁻¹) showed higher productivity than during mixotrophic growth, while using only half as much acetate. By diluting and adding acetate only during the eight dark hours, a maximal productivity of 1.6 g L⁻¹ day⁻¹ was obtained. Whenever acetate was added, lutein and chlorophyll content decreased, but overall lutein productivity increased. Carotene also increased during the cyclic treatment. These results show that dilution and carbon addition during the dark period resulted in an increased efficiency of the photobioreactor.

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Contributors: van Wagener, J. M., De Francisci, D., Angelidaki, I.
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Web of Science (2017): Indexed yes
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Scopus rating (2016): CiteScore 2.46
Web of Science (2016): Impact factor 2.616
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Counteracting ammonia inhibition during anaerobic digestion by recovery using submersible microbial desalination cell

Ammonia inhibition is one of the most frequent and serious problems in biogas plants. In this study, a novel hybrid system consisting of a submersible microbial desalination cell (SMDC) and a continuous stirred tank reactor (CSTR) was developed for counteracting ammonia inhibition during anaerobic digestion (AD) with simultaneous in situ ammonia recovery and electricity production. The SMDC was powered by acetate in a buffer solution, while synthetic ammonia-rich wastewater was used as the feeding of the CSTR. Under continuous operation, ammonia recovery rate of 86 g-N/m²/day and current density of 4.33 A/m² were achieved at steady-state condition. As a result, 112% extra biogas was produced due to ammonia recovery by the SMDC. High-throughput sequencing showed that ammonia recovery had an impact on the microbial community structures in the SMDC and CSTR. Considering the additional economic benefits of biogas enhancement and possible wastewater treatment, the SMDC may represent a cost-effective and environmentally friendly method for waste resources recovery and biomethanation of ammonia-rich residues. Biotechnol. Bioeng. 2015;9999: 1-5. © 2015 Wiley Periodicals, Inc.
Counteracting foaming caused by lipids or proteins in biogas reactors using rapeseed oil or oleic acid as antifoaming agents

Foaming is one of the major operational problems in biogas plants, and dealing with foaming incidents is still based on empirical practices. Various types of antifoams are used arbitrarily to combat foaming in biogas plants, but without any scientific support this action can lead to serious deterioration of the methanogenic process. Many commercial antifoams are derivatives of fatty acids or oils. However, it is well known that lipids can induce foaming in manure based biogas plants. This study aimed to elucidate the effect of rapeseed oil and oleic acid on foam reduction and process performance in biogas reactors fed with protein or lipid rich substrates. The results showed that both antifoams efficiently suppressed foaming. Moreover rapeseed oil resulted in stimulation of the biogas production. Finally, it was reckoned that the chemical structure of lipids, and more specifically their carboxylic ends, is responsible for their foam promoting or foam counteracting behaviour. Thus, it was concluded that the fatty acids and oils could suppress foaming, while salt of fatty acids could generate foam.

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering, Technical University of Denmark
Contributors: Kougias, P., Boe, K., Einarsdottir, E. S., Angelidaki, I.
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Scopus rating (2016): CiteScore 7.49 SJR 2.663 SNIP 2.563
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Scopus rating (2015): CiteScore 6.63 SJR 2.665 SNIP 2.482
Web of Science (2015): Impact factor 5.991
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Scopus rating (2014): CiteScore 6.13 SJR 2.946 SNIP 2.702
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BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 6.02 SJR 2.956 SNIP 2.676
Web of Science (2013): Impact factor 5.323
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.15 SJR 2.914 SNIP 2.442
Web of Science (2012): Impact factor 4.655
ISI indexed (2012): ISI indexed yes
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BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 5.43 SJR 2.862 SNIP 2.355
Web of Science (2011): Impact factor 4.865
ISI indexed (2011): ISI indexed yes
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Scopus rating (2010): SJR 2.592 SNIP 2.192
Web of Science (2010): Impact factor 4.546
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.319 SNIP 2.224
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.073 SNIP 2.178
Web of Science (2008): Indexed yes
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Web of Science (2007): Indexed yes
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Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 2.113 SNIP 2.334
Web of Science (2005): Indexed yes
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Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.319 SNIP 1.69
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 1.399 SNIP 1.662
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 1.432 SNIP 1.55
Economically Viable Components from Jerusalem Artichoke (Helianthus tuberosus L.) in a Biorefinery Concept

Biorefinery applications are receiving growing interest due to climatic and waste disposal issues and lack of petroleum resources. Jerusalem artichoke (Helianthus tuberosus L.) is suitable for biorefinery applications due to high biomass production and limited cultivation requirements. This paper focuses on the potential of Jerusalem artichoke as a biorefinery crop and the most viable products in such a case. The carbohydrates in the tubers were found to have potential for production of platform chemicals, e.g., succinic acid. However, economic analysis showed that production of platform chemicals as a single product was too expensive to be competitive with petrochemically produced sugars. Therefore, production of several products from the same crop is a must. Additional products are protein based ones from tubers and leaves and biogas from residues, although both are of low value and amount. High bioactive activity was found in the young leaves of the crop, and the sesquiterpene lactones are of specific interest, as other compounds from this group have shown inhibitory effects on several human diseases. Thus, future focus should be on understanding the usefulness of small molecules, to develop methods for their extraction and purification and to further develop sustainable and viable methods for the production of platform chemicals.

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Organisations: Department of Environmental Engineering, Residual Resource Engineering, Swedish University of Agricultural Sciences, Lund University
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BFI (2017): BFI-level 1
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Web of Science (2017): Impact factor 3.687
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.73 SJR 1.235 SNIP 1.15
Web of Science (2016): Impact factor 3.226
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 3.37 SJR 1.157 SNIP 1.118
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 3.06 SJR 0.991 SNIP 1.143
Web of Science (2014): Impact factor 2.862
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 2.83 SJR 0.769 SNIP 1.103
Web of Science (2013): Impact factor 2.339
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
Effect of ammonia on hydrogenotrophic methanogens and syntrophic acetate oxidizing bacteria

Substrates that contain high ammonia levels can cause inhibition on anaerobic digestion process and unstable biogas production. The aim of the current study was to assess the effects of different ammonia levels on pure strains of (syntrophic acetate oxidizing) SAO bacteria and hydrogenotrophic methanogens. Two pure strains of hydrogenotrophic methanogens (i.e: Methanoculleus bourgensis and Methanoculleus thermophiles) and two pure strains of SAO bacteria (i.e: Tepidanaerobacter acetatoxydans and Thermacetogenium phaeum) were inoculated under four different ammonia (0.26, 3, 5 and 7g NH4+-N/L) and free ammonia levels (Mesophilic: 3.31, 38.2, 63.68 and 89.15 g NH3-N/L. Thermophilic: 8.48, 97.82,163.03 and 228.24 g NH3-N/L) (Westerholm, et al., 2011; Satoshi, et al., 2000; Jacob, et al., 1997). The results indicated that both T. acetatoxydans and T. phaeum were more sensitive to high ammonia levels compared to the hydrogenotrophic methanogens tested. Thus, it seems that hydrogenotrophic methanogens could be equally, if not more, tolerant to high ammonia levels compared to SAO bacteria.
Effect of nitrogen source and acclimatization on specific growth rates of microalgae determined by a high-throughput in vivo microplate autofluorescence method

Specific growth rates (SGR) of freshwater algae species (Chlorella vulgaris, Auxenochlorella protothecoides, and Chlorella sorokiniana) and the marine species Nannochloropsis oculata on various nitrogen sources (ammonium carbonate, ammonium chloride, sodium nitrate, and urea) could be determined by in vivo chlorophyll-a autofluorescence. These preferences could be determined before large pH changes occurred in the media, with no significant difference (P>0.05) between buffered and non-buffered media. In all algal species, acclimatization was observed with no significant difference (P>0.05) between SGRs of the second and third cultivations. ANOVA of SGRs in the acclimatized second and third cultivations revealed preferences for nitrogen sources among most of the algae; C. vulgaris preferred sodium nitrate over other nitrogen sources, A. protothecoides adapted to urea after no growth in the first cultivation, and the SGRs of N. oculata showed an aversion for sodium nitrate over other nitrogen sources (P<0.05).

General information
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Organisations: Department of Environmental Engineering, Residual Resource Engineering, National Food Institute, Division of Industrial Food Research
Contributors: Podevin, M., De Francisci, D., Holdt, S. L., Angelidaki, I.
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BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.59
Web of Science (2017): Impact factor 2.401
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
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Web of Science (2016): Impact factor 2.616
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 2.32
Web of Science (2015): Impact factor 2.372
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 2.88
Web of Science (2014): Impact factor 2.559
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 2.78
Web of Science (2013): Impact factor 2.492
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 2.68
Effect of pulse and continuous addition of oleate on microbial communities involved in anaerobic digestion process

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Baserba, M. G., Karakashev, D., Angelidaki, I.
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Research output: Research - peer-review » Conference abstract in proceedings – Annual report year: 2015

Effects of Benzalkonium Chloride, Proxel LV, P3 Hypochloran, Triton X-100 and DOWFAX 63N10 on anaerobic digestion processes
In this study, the individual and synergistic toxicity of the following xenobiotics: Benzalkonium Chloride (BKC), Proxel LV (PRX), P3 Hypochloran (HPC), Triton X-100 (TRX), and DOWFAX 63N10 (DWF), on anaerobic digestion (AD) process, was assessed. The experiments were performed in batch and continuous (up-flow anaerobic sludge blanket, UASB) reactors with biochemical-industrial wastewater, as substrate. In batch experiments, half-maximal inhibitory concentrations (IC50) for the tested xenobiotics were found to be 13.1, 1003, 311.5 and 24.3 mg L1 for BKC, PRX, DWF and TRX, respectively while HPC did not affect the AD process. Furthermore, the xenobiotics mixture tested did not present any synergistic inhibitory effect on the AD process. In continuous experiments, BKC and xenobiotics' mixture induced even stronger (more than 85%) of inhibition, expressed as IC50, compared to the levels observed from the batch reactors. Oppositely, TRX showed no inhibition in continuous mode, while inhibition was detected at batch mode.

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering, Technical University of Denmark, Novozyymes A/S
Effects of triclosan, diclofenac, and nonylphenol on mesophilic and thermophilic methanogenic activity and on the methanogenic communities

In this study, a toxicity assay using a mesophilic wastewater treatment plant sludge-based (SI) and a thermophilic manure-based inoculum (MI), under different biomass concentrations was performed to define the effects of diclofenac (DCF), triclosan (TCS), and nonylphenol (NP) on anaerobic digestion (AD) process. Additionally, the influence of DCF, TCS, and NP on the relative abundance of the methanogenic populations was investigated. Results obtained demonstrated that, in terms of methane production, SI inoculum was more resistant to the toxicity effect of DCF, TCS, and NP, compared to the MI inoculum. The IC50 values were 546, 35, and 363mgL-1 for SI inoculum and 481, 32, and 74mgL-1 for MI inoculum for DCF, TCS, and NP, respectively. For both inocula, higher biomass concentrations reduced the toxic effect of TCS (higher methane production up to 64%), contrary to DCF, where higher biomass loads decreased methane yield up to 31%. Fluorescence in situ hybridization analysis showed that hydrogenotrophic methanogens were more resistant to the inhibitory effect of DCF, TCS, and NP compared to aceticlastic methanogens.

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering, University of the Aegean
Contributors: Symarsis, E. C., Fotidis, I., Stasinakis, A. S., Angelidaki, I.
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BFI (2017): BFI-level 1
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Web of Science (2017): Impact factor 6.434
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 6.31 SJR 1.742 SNIP 2.061
Web of Science (2016): Impact factor 6.065
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Ethanol production from steam exploded rapeseed straw and the process simulation using artificial neural networks

Rapeseed straw was utilized as a cheap raw material for ethanol production. Effects of steam explosion on chemical composition, enzymatic hydrolysis (EH) and simultaneous saccharification and fermentation (SSF) were studied. Changes in the pretreatment conditions showed strong effects on digestibility of the resulting straw. The optimum results were obtained at 180°C, 10% solid fraction, 1% H2SO4, and 10 min retention time. Under optimal condition, glucose hydrolysis yields of 93 and 89% were obtained for 5 and 10% solid fractions, respectively. The corresponding ethanol yields were 63 and 67% of maximum theoretical value. Next, data of the experimental runs were exploited for modeling the processes by artificial neural networks (ANNs) and performance of the developed models was evaluated. The ANN-based models showed a great potential for time-course prediction of the studied processes. Efficiency of the joint network for simulating the whole process was also determined and promising results were obtained.

General information
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Organisations: Department of Environmental Engineering, Residual Resource Engineering, Babol Noshirvani University of Technology
Contributors: Talebnia, F., Mighani, M., Rahimnejad, M., Angelidaki, I.
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Web of Science (2017): Impact factor 1.226
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.23 SJR 0.405 SNIP 0.545
Web of Science (2016): Impact factor 1.16
Web of Science (2016): Indexed yes
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Scopus rating (2015): CiteScore 1.3 SJR 0.446 SNIP 0.572
Web of Science (2015): Impact factor 1.211
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.26 SJR 0.486 SNIP 0.629
Web of Science (2014): Impact factor 1.113
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 1.51 SJR 0.601 SNIP 0.721
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BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 1.41 SJR 0.589 SNIP 0.771
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Scopus rating (2011): CiteScore 1.31 SJR 0.531 SNIP 0.647
Web of Science (2011): Impact factor 1.278
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.45 SNIP 0.583
Web of Science (2010): Impact factor 1.004
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.513 SNIP 0.656
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.496 SNIP 0.696
Scopus rating (2007): SJR 0.472 SNIP 0.66
Scopus rating (2006): SJR 0.541 SNIP 0.894
Scopus rating (2005): SJR 0.395 SNIP 0.746
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.538 SNIP 0.893
Scopus rating (2003): SJR 0.202 SNIP 0.353
Scopus rating (2002): SJR 0.217 SNIP 0.301
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Evaluation of the Danish cultivated sugarkelp as possible future source of ingredients such as minerals and pigments

General information
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Organisations: National Food Institute, Research Group for Bioactives – Analysis and Application, Department of Environmental Engineering, Residual Resource Engineering, Research Group for Nano-Bio Science
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Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2015

High performance of nanoscaled Fe$_2$O$_3$ catalyzing UV-Fenton under neutral condition with a low stoichiometry of H$_2$O$_2$: Kinetic study and mechanism
Kinetics and mechanism of nano-Fe2O3 catalyzing UV-Fenton were investigated in this study with catechol as model pollutant. This type of heterogeneous UV-Fenton was proven to be characteristic of a wide pH range from mildly acidic to slightly alkaline and low H2O2 requirement accompanied with H2O2 utilization efficiency of larger than 1.0. Experiments of degradation under neutral condition with and without pH process control and analysis of several carboxylic acids were performed to find out the reason for treatment effectiveness under neutral condition. Kinetics study using the pseudo-first-order equation was performed to evaluate the effects of initial pH, H2O2 dose, nano-Fe2O3 dose, and reaction temperature on the rate constant of COD reduction, it was interesting to find the rate constant was similar among initial pH values from 3.0 to 8.0. Based on the data of rate constant under different temperatures, Ea (activation energy), ΔH (enthalpy change) and ΔS (entropy change) were calculated to be 45.1(±6.3) kJ/mol, 42.6(±6.3) kJ/mol and -148.0(±20.8) J/K/mol, respectively. Radical identification experiments based on inhibition of methylene blue degradation under respective scavenger for HO (hydroxyl radical), O21 (singlet oxygen) and O2- (superoxide radical) showed HO, O21 and O2- participated in nano-Fe2O3 catalyzing UV-Fenton. Presence of oxygen could greatly enhance the degradation rate compared with the case of bubbling nitrogen, and a possible mechanism of catechol oxidation in nano-Fe2O3 catalyzing UV-Fenton was proposed. At last, reusability and stability of nano-Fe2O3 were evaluated in six repeated runs. This study will provide some deep understanding of nano-Fe2O3 catalyzing UV-Fenton with respect to technical advantage and oxidation mechanism. [All rights reserved Elsevier].
Hydrogen mediated biogas upgrading in a two-stage mesophilic reactor

General information
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Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Bassani, I., Kougias, P. G., Treu, L., Angelidaki, I.
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Publisher: Technical University of Denmark (DTU)
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Innovative bioelectrochemical-anaerobic-digestion coupled system for ammonia recovery and biomethane production from ammonia-rich residues

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Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Zhang, Y., Angelidaki, I.
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Innovative bioelectrochemical-anaerobic-digestion integrated system for ammonia recovery and bioenergy production from ammonia-rich residues

Ammonia (NH4+/NH3) inhibition during anaerobic digestion process is one of the most frequent problems existing in biogas plants, resulting in unstable process and reduced biogas production. In this study, we developed a novel hybrid system, consisted of a submersed microbial resource recovery cell (SMRC) and a continuous stirred tank reactor (CSTR), to prevent ammonia toxicity during anaerobic digestion by in-situ ammonia recovery and electricity production (Figure 1).

In batch experiment, the ammonia concentration in the CSTR decreased from 6 to 0.7 g-N/L with an average recovery rate of 0.18 g-N/L(CSTR)/d. Meanwhile, a maximum power density of 0.71±0.5 W/m2 was produced (10 Ω). Both current driven NH4+ migration and free NH3 diffusion were identified as the mechanisms responsible for the ammonia transportation. With an increase in initial ammonia concentration and a decrease in external resistance, the SMRC performance was enhanced. In addition, the coexistence of other cations in CSTR or cathode had no negative effect on the ammonia transportation. In continuous reactor operation, 112% extra biogas production was achieved due to ammonia recovery. High-throughput molecular sequencing analysis showed an impact of ammonia recovery on the microbial community composition in the integrated system. Results clearly indicate the great potential of the SMRC-CSTR-coupled system for efficient and cost-effective ammonia recovery, energy production and treatment of ammonia-rich residues.

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Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Zhang, Y., Angelidaki, I.
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Laminaria digitata as a potential carbon source for succinic acid and bioenergy production in a biorefinery perspective

A novel biorefinery concept utilizing macroalgae Laminaria digitata to produce succinic acid, and direct the process residues for feed and energy production, is investigated in the present study. Enzymatic hydrolysis was performed at high solid loading (25% w v− 1) resulting in solubilization of the carbohydrates to soluble sugars, which accumulated in the liquid hydrolysate. The overall sugar recovery in the macroalgal hydrolysate was 78.23%. Actinobacillus succinogenes 130Z was able to ferment macroalgal hydrolysate to succinic acid with a yield of 86.49% (g g− 1 of total sugars) and an overall productivity of 0.50 g L− 1 h− 1. Removal of carbohydrates from the macroalgal biomass through enzymatic hydrolysis resulted in up-concentration of protein and lipid fractions in the post-hydrolysis solid residue (PHSR). Energy recovery of PHSR and fermentation broth through anaerobic digestion corresponded to 298 and 285 NmL CH4 g− 1 VSadded, respectively. PHSR could potentially be used for: dietary food additive, fish feed, bioenergy production and added value products. This study opens possibility to conceive different biorefinery scenarios in which the efficient use of the macroalgal biomass fractions can provide numerous added-value bio-based products and energy.

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Journal: Algal Research
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BFI (2018): BFI-level 1
Lipids and Composition of Fatty Acids of Saccharina latissima Cultivated Year-round in Integrated Multi-trophic Aquaculture

This study is evaluating the seasonal lipid and fatty acid composition of the brown seaweed Saccharina latissima. Biomass was sampled throughout the year (bi-monthly) at the commercial cultivation site near a fish farm in an integrated multi-trophic aquaculture (IMTA) and at a reference site in Denmark (2013-2014). Generally, there was no difference in the biomass composition between sites; however, significant seasonal changes were found. The lipid concentration varied from 0.62%-0.88% dry weight (DW) in July to 3.33%-3.35% DW in November (p < 0.05) in both sites. The fatty acid composition in January was significantly different from all the other sampling months. The dissimilarities were mainly explained by changes in the relative abundance of 20:5n-3 (13.12%-33.35%), 14:0 (11.07%-29.37%) and 18:1n-9 (10.15%-16.94%). Polyunsaturated fatty acids (PUFA's) made up more than half of the fatty acids with a maximum in July (52.3%-54.0% fatty acid methyl esters; FAME). This including the most appreciated health beneficial PUFA’s, eicosapentaenoic (EPA; 20:5n-3) and docosahexaenoic acid (DHA; 22:6n-3), but also arachidonic (ARA) and stearidonic acid (SDA), which are not found in land vegetables such as cabbage and lettuce. Compared to fat (salmon) and lean fish (cod) this seaweed species contains higher proportions of ARA and SDA, but lower EPA (only cod) and DHA. Conclusively, the season of harvest is important for the choice of lipid quantity and quality, but the marine vegetables provide better sources of EPA, DHA and long-chain (LC)-PUFA’s in general compared to traditional vegetables.
Macroalgae Laminaria digitata as potential carbon source in heterotrophic Chlorella protothekoides cultivation: an innovative biorefinery concept

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Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: D’Este, M., Alvarado-Morales, M., Angelidaki, I.
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Place of publication: Lyngby
Publisher: Technical University of Denmark (DTU)
Mechanical Pretreatment to Increase the Bioenergy Yield for Full-scale Biogas Plants
This study investigated the efficiency of commercially available harvesting machines for mechanical pretreatment of meadow grass, in order to enhance the energy yield per hectare. Excoriator was shown to be the most efficient mechanical pretreatment increasing the biogas yield of grass by 16% compared to the untreated one. The digestion of meadow grass as an alternative co-substrate had positive impact on the energy yield of full-scale biogas reactors operating with cattle manure, pig manure or mixture of both. A preliminary analysis showed that the addition of meadow grass in a manure based biogas reactor was possible with biomass share of 10%, leading to energy production of 280 GJ/day. The digestion of pretreated meadow grass as alternative co-substrate had clearly positive impact in all the examined scenarios, leading to increased biogas production in the range of 10%-20%.

Metagenomic analysis on thermophilic biogas reactors fed with high load of Long Chain Fatty Acids (LCFA)
In anaerobic digestion systems, the accumulation of long chain fatty acids (LCFA) leads to process instability and decrease of the methane production. This detrimental condition is known to be reversible depending on the concentration of the accumulated LCFA and mainly on the microbial consortium populating the biogas reactors. Therefore, the understanding of how the microbial communities change in response to LCFA pulses is essential to optimize the overall process. In this study two lab-scale continuously stirred reactors were used to characterize, via 16s rRNA gene analysis, the microbial shifts due to LCFA increase in the feedstock composition. The result shows that the addition of sodium oleate caused a reversible inhibition of reactor. The correlation between the microbial community’s profile and the reactors performance indicated that Syntrophomonas was the genus most likely involved in sodium oleate degradation. Other genera that were found abundant are Pseudomonas, Clostridium XI and Clostridium III. The relative abundance of these genera was not significantly affected by the addition of sodium oleate, and this indicates that they are probably involved in later steps of degradation. Methanoculleus was the main methanogen that was found in the reactors and its relative abundance was also not significantly affected by the addition of sodium oleate. This indicates that the main methanogenic pathway was not shifted with the addition of sodium oleate.
Microbial diversity and dynamicity of biogas reactors due to radical changes of feedstock composition

The anaerobic digestion process is often inhibited by alteration of substrates and/or organic overload. This study aimed to elucidate changes of microbial ecology in biogas reactors upon radical changes of substrates and to determine their importance to process imbalance. For this reason, continuously fed reactors were disturbed with pulses of proteins, lipids and carbohydrates and the microbial ecology of the reactors were characterized by 16S rRNA gene sequencing before and after the imposed changes. The microbial composition of the three reactors, initially similar, diverged greatly after substrate change. The greatest increase in diversity was observed in the reactor supplemented with carbohydrates and the microbial community became dominated by lactobacilli, while the lowest corresponded to the reactor overfed with proteins, where only Desulfotomaculum showed significant increase. The overall results suggest that feed composition has a decisive impact on the microbial composition of the reactors, and thereby on their performance.

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Microbial dynamics in anaerobic digestion (AD) reactors with sodium oleate in the substrate

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Microbial electrochemical monitoring of volatile fatty acids during anaerobic digestion
Due to increasing environmental concerns of using fossil fuels and decreasing in their reserves, the promotion of renewable energy technologies is crucial. Anaerobic digestion (AD), a well-developed technology converting organic waste into biogas, is gaining increased attention in recent years. Bioelectrochemical systems (e.g. MFC, MDC, MEC et al.) which transfer chemical energy to electricity by degrading organic waste have attracted great interest due to their environmental friendly and sustainability. In this study, to control and optimize AD process, a smart bioelectrochemical system (microbial desalination cell, MDC) was built to realize the on-line measuring the concentration of volatile fatty acid (VFA). The correlation between current densities of the biosensor and VFA concentrations was firstly evaluated with
Two linear relationships were observed between current densities and VFA levels from 1 mM to 200 mM. The detection range was much broader than that of other existing VFA biosensors. The MDC biosensor had no response to protein and lipid which are frequently found along with VFAs in the organic waste streams from AD, suggesting the selective detection of VFAs. The current displayed different responses to VFA levels when different ionic strengths and external resistances were applied, though linear relationships were always observed. Finally, the biosensor was further explored with real AD effluents and the results did not show significance differences with those measured by GC. The simple MDC-based biosensor showed promising potential for online, inexpensive and reliable measurement of VFA levels. The outcomes offer a powerful tool for cost-effective monitoring and optimization of AD process and expand the application of bioelectrochemical system.

New steady-state microbial community compositions and process performances in biogas reactors induced by temperature disturbances

Background
The microbial community in a biogas reactor greatly influences the process performance. However, only the effects of deterministic factors (such as temperature and hydraulic retention time (HRT)) on the microbial community and performance have been investigated in biogas reactors. Little is known about the manner in which stochastic factors (for example, stochastic birth, death, colonization, and extinction) and disturbance affect the stable-state microbial community and reactor performances.

Results
In the present study, three replicate biogas reactors treating cattle manure were run to examine the role of stochastic factors and disturbance in shaping microbial communities. In the triplicate biogas reactors with the same inoculum and operational conditions, similar process performances and microbial community profiles were observed under steady-state conditions. This indicated that stochastic factors had a minor role in shaping the profile of the microbial community composition and activity in biogas reactors. On the contrary, temperature disturbance was found to play an important role in the microbial community composition as well as process performance for biogas reactors. Although three different temperature disturbances were applied to each biogas reactor, the increased methane yields (around 10% higher) and decreased volatile fatty acids (VFAs) concentrations at steady state were found in all three reactors after the temperature disturbances. After the temperature disturbance, the biogas reactors were brought back to the original operational conditions; however, new steady-state microbial community profiles were observed in all the biogas reactors.

Conclusions
The present study demonstrated that temperature disturbance, but not stochastic factors, played an important role in shaping the profile of the microbial community composition and activity in biogas reactors. New steady-state microbial community profiles and reactor performances were observed in all the biogas reactors after the temperature disturbance.
Salinity-Gradient Energy Driven Microbial Electrosynthesis of Hydrogen Peroxide from Oxygen Reduction

Hydrogen peroxide (H2O2) is widely used in various chemical industries and environmental remediation. Recently, bioelectrochemical systems (BES) have gained increasing attention for synthesizing H2O2 with simultaneous wastewater treatment[1]. However, in order to get high-yield H2O2 requires additional electrical energy to power these BES or control the cathode potential. In this study, we develop an innovative BES called microbial reverse-electrodialysis electrolysis cell (MREC) to produce H2O2 in cathode. In the MREC(See Fig.1), the salinity-gradient energy between seawater and river water can be used to generated renewable electrical energy to replace the external power supply[2]. Operational parameters such as air flow rate, pH, cathodic potential, flow rate of high and low concentration NaCl solution in RED were investigated as to improve the H2O2 yield. The optimal parameters for H2O2 production are air gas flow rate of 8-20
ml/min, cathode potential of -0.485 ± 0.025 V vs Ag/AgCl, the corresponding dissolved oxygen is 6.80 ± 0.30 mg/l in catholyte. Under the optimal conditions, a maximum H2O2 yield of 770 ± 18 mg/L could be obtained with corresponding H2O2 production rates of 0.44 ± 0.04 g/m2/h and current density of 1.40 ± 0.13 A/m2. Results indicate the air gas flow rate and cathode potential are the key parameters for H2O2 production in MREC. This study indicate for the first time high yield synthesis of H2O2 from oxygen reduction in BES without external power supply, furthermore, we also discover the cathode potential can be controlled through adjusting the air flow rate without power supply and potentiostat.

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Contributors: Li, X., Zhang, Y., Angelidaki, I.
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Seasonal Amino Acid Profile and Nutritional Value of Saccharina Latissima in a Commercial IMTA System

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Organisations: National Food Institute, Division of Industrial Food Research, Department of Environmental Engineering, Residual Resource Engineering
Contributors: Holdt, S. L., Silva Marinho, G., Angelidaki, I.
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Research output: Research › Conference abstract for conference – Annual report year: 2015

Seasonal variations in the amino acid profile and protein nutritional value of Saccharina latissima cultivated in a commercial IMTA system

Seaweeds have potential for the provision of biomass for food and feed supplements. The demand is increasing especially for proteins as ingredients; however, the amino acid profile is essential for evaluation of the nutritional value of proteins. The year-round protein concentration and amino acid profiles of Saccharina latissima were determined, and the harvest time and nutritional potential were evaluated. Bi-monthly samples were analyzed from S. latissima (including epiphytes, when present) cultivated commercially at an integrated multi-trophic aquaculture (IMTA) site and a reference site in Denmark in 2013–2014. Overall, there was no significant difference for the tested parameters between the two sampling sites; however, seasonal variations were found. The protein concentration varied markedly reaching a maximum of 10.8 % dry weight (DW) in November and a minimum of 1.3 % DW in May 2013. Aspartic and glutamic acids dominated the amino acid profile, accounting for up to 49 % of the total. Greatest seasonal differences in amino acid composition occurred in July, with leucine contributing most (22.7–26.7 %) of the observed differences. A maximal essential amino acid (EAA) score of 68.9 % (based on WHO/FAO/UNU requirements) was achieved in November 2013. The presence of epiphytes in July to November changed neither the amino acid content nor the EAA score. S. latissima is comparable with wheat as a protein ingredient for fish feed and appears to be a suitable protein/amino acid source for human consumption. This study proposes that there may be a mismatch between harvest time and nutritional value. The preferable harvest time for S. latissima is November, due to high protein content and EAA score. However, higher yield and cleaner biomass for human consumption would be found in May.

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Organisations: Department of Environmental Engineering, Residual Resource Engineering, National Food Institute, Division of Industrial Food Research
Contributors: Silva Marinho, G., Holdt, S. L., Angelidaki, I.
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Seaweed potentials – evaluation of year-round biomass composition of commercial cultivated sugarkelp- results from project KOMBI

In this study, the year-round protein, amino acid, fatty acid, pigments, mineral and vitamin content and profiles were considered to evaluate the nutritional value and harvest time of the Saccharina latissima biomass for optimized value and application. Sugarkelp was cultivated both in close proximity to a blue mussel and fish farm (IMTA) and in a reference site, both outside Horsens fjord in Denmark. Sugarkelp biomass was measured by harvesting sporophytes (deployed in February 2013) from 1m rope droppers (n=3) at 2 m depth in 2013-2014. Biomass was weighed, followed by freeze drying, homogenizing and chemical characterization by various methods for the specific analyses of biomass composition. Protein content varied throughout the experimental period with the highest values recorded in November (10.8%) and the lowest values recorded in May 2013 (1.3 %). The lipid concentration varied from 0.62-0.88% DW in July to 3.33-3.35% DW in November (P<0.05). Polyunsaturated fatty acids (PUFA’s) made up more than half of the fatty acids with a maximum in July (52.3-54.0% FAME), including the most appreciated health beneficial EPA and DHA. Mineral content are discussed in relation to legislations, and a few trace metals such as Cd, Pb, Iodine may be problematic in some seasons. The pigment profile did not change during the year, however the concentration did, and with fucoxanthin as the most interesting. Generally the year-round variations were due season, and no difference between the two locations (reference and IMTA).

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Solutions for Foaming Problems in Biogas Reactors Using Natural Oils or Fatty Acids as Defoamers

Foaming is one of the most common and important problems in biogas plants, leading to severe operational, economical, and environmental drawbacks. Because addition of easily degradable co-substrates for boosting the biogas production can suddenly raise the foaming problem, the full-scale biogas plants face an increasing necessity in finding efficient and cost-effective antifoaming solutions to avoid the dramatic consequences of foaming incidents. One of the most common solutions to suppress foaming is the use of chemical defoamers. The present work is a mini-review summarizing the aggregated results from our previous extensive research along with some unpublished data on defoaming by rapeseed oil and oleic acid in manure-based biogas reactors. It was found that both compounds exhibited remarkable defoaming efficiency ranging from 30 to 57% in biogas reactors suffering from foaming problems promoted by the addition of protein, lipid, or carbohydrate co-substrates. However, in most cases, the defoaming efficiency of rapeseed oil was greater than that of oleic acid, and therefore, rapeseed oil is recommended to be used in biogas reactors to solve foaming problems.

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Submersible microbial desalination cell for simultaneous ammonia recovery and electricity production from anaerobic reactors containing high levels of ammonia

High ammonia concentration in anaerobic reactors can seriously inhibit the anaerobic digestion process. In this study, a submersible microbial desalination cell (SMDC) was developed as an innovative method to lower the ammonia level in a continuous stirred tank reactor (CSTR) by in situ ammonia recovery and electricity production. In batch experiment, the ammonia concentration in the CSTR decreased from 6 to 0.7g-N/L during 30 days, resulting in an average recovery rate of
80g-N/m²/d. Meanwhile, a maximum power density of 0.71±0.5W/m² was generated at 2.85A/m². Both current driven NH₄⁺ migration and free NH₃ diffusion were identified as the mechanisms responsible for the ammonia transportation. With an increase in initial ammonia concentration and a decrease in external resistance, the SMDC performance was enhanced. In addition, the coexistence of other cations in CSTR or cathode had no negative effect on the ammonia transportation.

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- Web of Science (2017): Indexed yes
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- Scopus rating (2013): CiteScore 5.97 SJR 2.405 SNIP 2.477
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- ISI indexed (2012): ISI indexed yes
- Web of Science (2012): Indexed yes
- BFI (2011): BFI-level 2
- Scopus rating (2011): CiteScore 5.56 SJR 2.306 SNIP 2.507
- Web of Science (2011): Impact factor 4.98
- ISI indexed (2011): ISI indexed yes
- Web of Science (2011): Indexed yes
- BFI (2010): BFI-level 2
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The biodegradability of a feedstock is determining the optimal C/N ratios in anaerobic digestion

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Contributors: Kaldis, F., Karakashev, D., Angelidaki, I.
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Thermochemical pretreatments for enhancing succinic acid production from industrial hemp (Cannabis sativa L.)
The aim of this study was to develop an efficient thermochemical method for treatment of industrial hemp biomass, in order to increase its bioconversion to succinic acid. Industrial hemp was subjected to various thermochemical pretreatments using 0-3% H2SO4, NaOH or H2O2 at 121-180°C prior to enzymatic hydrolysis. The influence of the different pretreatments on hydrolysis and succinic acid production by Actinobacillus succinogenes 130Z was investigated in batch mode, using anaerobic bottles and bioreactors. Enzymatic hydrolysis and fermentation of hemp material pretreated with 3% H2O2 resulted in the highest overall sugar yield (73.5%), maximum succinic acid titer (21.9gL-1), as
well as the highest succinic acid yield (83%). Results obtained clearly demonstrated the impact of different pretreatments on the bioconversion efficiency of industrial hemp into succinic acid.

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Web of Science (2011): Indexed yes
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Scopus rating (2009): SJR 1.915 SNIP 2.236
Unconventional biomasses as feedstocks for production of biofuels and succinic acid in a biorefinery concept

Biorefinery has the potential of displacing fossil fuels and oil-refinery based products. Within the biorefinery a palette of marketable commodities can be produced from biomass, including food, feed, biochemicals and biofuels. Which bioproducts are produced is largely dependent on the chemical composition of the specific biomass feedstock, as well as which pretreatment, saccharification, fermentation and extraction techniques are used. Furthermore, integrating biological processes into the biorefinery that effectively consume CO2 will become increasingly important. Such process integration could significantly improve the sustainability indicators of the overall biorefinery process.

In this study, unconventional lignocellulosic- and aquatic biomasses were investigated as biorefinery feedstocks. The studied biomasses were Jerusalem artichoke, industrial hemp and macroalgae species Laminaria digitata. The chemical composition of biomasses was determined in order to demonstrate their biorefinery potential. Bioethanol and biogas along with succinic acid production were the explored bioconversion routes, while potential production of other compounds was also investigated.

Differences and changes in biomass composition and productivity of eleven different Jerusalem artichoke clones was examined at three harvest times. Yields of up to 35 t ha-1 of dry lignocellulose matter was reported, nonetheless the amount of cellulose in many cases was less than 50% of what was observed in e.g. hemp. However, the underground tubers which the plant produces, contained high amounts carbohydrates (≤88% of dry weight) and yielded up to 6 t ha-1 dry matter of additional carbohydrates. The carbohydrate content found in L. digitata was also shown to be exceptionally high (77.6% of dry weight) compared to other studies.

Diverse methods for pretreatment and saccharification of biomass were used depending on the type of biomass. L. digitata did not required any pretreatment before enzymatic hydrolysis other than milling and drying. Pretreatments using H2SO4, NaOH and H2O2 at different conditions were used to pretreat hemp prior to enzymatic hydrolysis, while Jerusalem artichoke tubers needed 0.2% H2SO4 in combination with heat-treatment as a direct hydrolysis method. Bioethanol was produced from industrial hemp hydrolysates. Ethanol yields in the range of 74-92% of theoretical yield were reported, while ethanol concentrations amounted up to 10.0 g L-1. However, the production of succinic acid from this type of hydrolysate resulted in much higher product titer and substrate utilization compared to ethanol fermentation, partially because A. succinogenes is able to ferment both glucose and xylose into succinic acid.

Jerusalem artichoke tubers, industrial hemp and L. digitata all showed considerable potential as feedstock for succinic acid production. The maximum succinic acid production from the different feedstocks ranged between 21.9 and 47.4 g L-1. The highest succinic acid titer was reached when fermenting Jerusalem artichoke hydrolysate, while the maximum succinic acid yield (86.5%) was reached when fermenting L. digitata hydrolysate. In the case of tuber biomass it was shown that tubers could be readily hydrolyzed without enzymes and fermented without any addition of nutrients, which clearly indicates that utilization of this feedstock could potentially lower the costs for succinic acid production. The biochemical methane potential of L. digitata, post hydrolysis solid residue (PHSR) and fermentation broth after
succinic acid fermentation was also determined. In a biorefinery, biogas production is important for energy recovery as well as for minimizing waste and generating an additional product in the form of fertilizer. Energy recovery of PHSR and fermentation broth through anaerobic digestion corresponded to 298 and 285 NmL CH4 g-1 VSadded, respectively. To further increase the integration of the different processes in the biorefinery concept, a novel biogas upgrading technology was developed. The approach was based on the CO2 fixation abilities of A. succinogenes to simultaneously produce high purity CH4 and succinic acid. The system was able to reach 95.4% CH4 content, which is similar purity as commercial biogas upgrading technologies deliver.

Results obtained in this study constitute the first report for utilization of macroalgae, hemp and Jerusalem artichoke tuber biomass for fermentative succinic acid production. It was demonstrated that all biomasses are attractive biomass feedstocks for succinic acid production mainly due to their high carbohydrate content. A case study of a proposed macroalgae biorefinery concept highlighted the potential of post hydrolysis solid residue (PHSR) for the production of numerous additional products such as ω-3 and ω-6 fatty acids, biodiesel, protein, feed, biogas and fertilizer, thereby diversifying the biorefinery product portfolio.

A bio-electrochemical system for removing inhibitors of anaerobic digestion processes from anaerobic reactors

Inhibition of anaerobic digestion process by high level of ammonia (NH4+ / NH3) is the most serious problem existing in biogas plants. No viable/applicable method to overcome this problem has been found up to now. This invention proposes an innovative submersible bio-electrochemical membrane reactor to recover ammonia from anaerobic digestion reactor, and thereby alleviate or counteract ammonia inhibition and enhance the conversion of ammonia-rich wastes to biogas. The invention may further reduce overall cost, giving synergistic advantages for both ammonia recycling and biogas plants by recovering acid (e.g., H2SO4, HCl), that can be used to treat the recovered ammonia.

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15 ud af 16 biogasani læg oplever problemer med skum

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A Green Micro-Algal Growth Model developed in the Activated Sludge Modeling Framework

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An Activated Sludge Model for Mixed Green Microalgae (ASM-A): model identification and calibration

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Anaerobic digestion foaming in full-scale biogas plants: A survey on causes and solutions
Anaerobic digestion foaming is a common operation problem in biogas plants with negative impacts on the biogas plants economy and environment. A survey of 16 Danish full-scale biogas plants on foaming problems revealed that most of them had experienced foaming in their processes up to three times per year. Foaming incidents often lasted from one day to three weeks, causing 20-50% biogas production loss. One foaming case at Lemvig biogas plant has been investigated and the results indicated that the combination of feedstock composition and mixing pattern of the reactor was the main cause of foaming in this case. Moreover, no difference in bacterial communities between the foaming and non-foaming reactors was observed, showing that filamentous bacteria were not the main reason for foaming in this case. © IWA Publishing 2014.

General information
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Organisations: Department of Environmental Engineering, Residual Resource Engineering, Lemvig Biogasanlæg A.m.b.A.
Contributors: Kougias, P., Boe, K., O-Thong, S., Angelidaki, I., Kristensen, L.
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Analysis of bacterial communities and bacterial pathogens in a biogas plant by the combination of ethidium monoazide, PCR and Ion Torrent sequencing

The present study investigated the changes of bacterial community composition including bacterial pathogens along a biogas plant, i.e. from the influent, to the biogas reactor and to the post-digester. The effects of post-digestion temperature and time on the changes of bacterial community composition and bacterial pathogens were also studied. Microbial analysis was made by Ion Torrent sequencing of the PCR amplicons from ethidium monoazide treated samples, and ethidium monoazide was used to cleave DNA from dead cells and exclude it from PCR amplification. Both similarity and taxonomic analysis showed that the bacterial community composition in the influent was changed after anaerobic digestion. Firmicutes were dominant in all the samples, while Proteobacteria decreased in the biogas reactor compared with the influent. Variations of bacterial community composition in the biogas reactor with time were also observed. This could be attributed to varying composition of the influent. Batch experiments showed that the methane recovery from the digested residues (obtained from biogas reactor) was mainly related with post-digestion temperature. However, post-digestion time rather than temperature had a significant effect on the changes of bacterial community composition. The changes of bacterial community composition were also reflected in the changes of relative abundance of bacterial pathogens. The richness and relative abundance of bacterial pathogens were reduced after anaerobic digestion in the biogas reactor. It was found in batch experiments that bacterial pathogens showed the highest relative abundance and richness after 30days' post-digestion. Streptococcus bovis was found in all the samples. Our results showed that special attention should be paid to the post-digestion since the increase in relative abundance of bacterial pathogens after post-digestion might reflect regrowth of bacterial pathogens and limit biosolids disposal vectors. © 2014 Elsevier Ltd.
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Scopus rating (2008): SJR 2.073 SNIP 2.178
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An environmentally-friendly fluorescent method for quantification of lipid contents in yeast

This study aimed at developing an efficient, fast and environmentally-friendly method to quantify neutral lipid contents in yeast. After optimising the fluorescence instrument parameters and influence of organic solvent concentrations, a new method to quantify neutral lipids in yeast based on fluorescence was demonstrated. Isopropanol and Nile red in concentrations of 5% (final volume%) and 500 μg/L, respectively, were added to washed cells suspended in potassium chloride phosphate buffered saline (PBSKCl). Fluorescence was measured after 10 min in the dark. Glyceryltriboileate was used as model lipid and the calibration curve showed linearity ($R^2 = 0.994$) between 0.50 and 25 mg/L. Compared with traditional gravimetric analysis, the developed method is much faster and uses less organic solvents. Lipid contents determined by fluorescence and gravimetry were the same for some strains, but for other strains the lipid contents determined by fluorescence were less. This new method will therefore be suitable for fast screening purposes.
A new degassing membrane coupled upflow anaerobic sludge blanket (UASB) reactor to achieve in-situ biogas upgrading and recovery of dissolved CH4 from the anaerobic effluent

A new technology for in-situ biogas upgrading and recovery of CH4 from the effluent of biogas reactors was proposed and demonstrated in this study. A vacuum degassing membrane module was used to desorb CO2 from the liquid phase of a biogas reactor. The degassing membrane was submerged into a degassing unit (DU). The results from batch experiments showed that mixing intensity, transmembrane pressure, pH and inorganic carbon concentration affected the CO2 desorption rate in the DU. Then, the DU was directly connected to an upflow anaerobic sludge blanket (UASB) reactor. The results showed the CH4 content was only 51.7% without desorption of CO2, while it increased when the liquid of UASB was recycled through the DU. The CH4 content increased to 71.6%, 90%, and 94% with liquid recirculation rate through the DU of 0.21, 0.42 and 0.63L/h, respectively. The loss of methane due to dissolution in the effluent was reduced by directly pumping the reactor effluent through the DU. In this way, the dissolved CH4 concentration in the effluent decreased from higher than 0.94mM to around 0.13mM, and thus efficient recovery of CH4 from the anaerobic effluent was achieved. In the whole operational period, the COD removal efficiency and CH4 yield were not obviously affected by the gas desorption.

General information

State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering, Fudan University, Beijing University of Chemical Technology
An innovative bioelectrochemical-anaerobic digestion-coupled system for in-situ ammonia recovery and biogas enhancement: process performance and microbial ecology

Ammonia (NH4+/NH3) inhibition during anaerobic digestion process is one of the most frequent problems existing in biogas plants, resulting in unstable process and reduced biogas production. In this study, we developed a novel hybrid system, consisted of a submersed microbial resource recovery cell (SMRC) and a continuous stirred tank reactor (CSTR), to prevent ammonia toxicity during anaerobic digestion by in-situ ammonia recovery and electricity production. In batch experiment, the ammonia concentration in the CSTR decreased from 6 to 0.7 g-N/L with an average recovery rate of 0.18 g-N/L(CSTR)/d. Meanwhile, a maximum power density of 0.71±0.5 W/m2 was produced (10 Ω). Both current driven NH4+ migration and free NH3 diffusion were identified as the mechanisms responsible for the ammonia transportation. With an increase in initial ammonia concentration and a decrease in external resistance, the SMRC performance was enhanced. In addition, the coexistence of other cations in CSTR or cathode had no negative effect on the ammonia transportation. In continuous reactor operation, 112% extra biogas production was achieved due to ammonia recovery. High-throughput molecular sequencing analysis showed an impact of ammonia recovery on the microbial community composition in the integrated system. Results clearly indicate the great potential of the SMRC-CSTR-coupled system for efficient and cost-effective ammonia recovery, energy production and treatment of ammonia-rich residues.

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A novel bioinformatic strategy to characterise microbial communities in biogas reactors

Sequences encoding ribosomal Bacterial and Archeal genes are very similar among species of the same genus, in fact, in some cases, similarity is 99% or higher among the 1500 bp that compose the 16S rDNA. For this reason today it is still a challenge to gain the species level characterisation using 16S hypervariable regions, especially when working with the not high quality very short reads characteristics of next generation sequencers (Mande S.S. et al., 2012). Previous works analysed the microbial community composition in biogas reactors via 16S rDNA sequencing (Luo, G. et al., 2013; Werner, J.J. et al., 2011). For this reason we developed a bioinformatics strategy in order to create a tool to review the generated dataset and to obtain a more strict control on the bacterial composition at the species level, with estimation of its reliability. The program perform local similarity search and evaluate the results with high stringency (95 up to 100%) and returns all the possible candidate species with unique or multiple matches for each genus. In the process of species identification, different categories of reliability can be generated: certain can lead to univocal species identification even in the same
genus, while others give multiple matches with the same probability. The software was used to analyse samples taken during the digestion process in three independent biogas reactors continuously fed with raw cattle manure. Among the most represented (>1%) considering the relative abundance of the community Clostridium resulted to be the most complex genus to elucidate. Some species in this genus, Clostridium ultunense and Clostridium irregular, have been assigned with high probability (100% and 99.7% of unique matches) while other 11 have only few unique matches (0.1 to 10%). Bacteroides, Acetobacterium and Pseudomonas genera had difficulties in the assignment, gathering medium-low probability as well (1 to 50%). On the contrary several other genera were assigned with high probability and no multiple matches. Some of them including only one species uniquely identified, some other including more than one (i.e. Dialister succinitophilus with 37% and Dialister propionicifaciens with 63%, Tissierella praeacuta with 26% and Tissierella creatinophila with 74%, Proteiniphilum acetatigenes with 100%, Halothermothrix oreani with 100%, Thermoflavimicrobium dichotomicum with 100%). Furthermore comparative analyses with MG-RAST (Meyer F. et al., 2008) results have been performed to test our strategy. We also found that our method can be used to understand which hypervariable region of 16S rDNA is more efficient in the identification at the species level in different genera. Our conclusion is that the identification at the species level remains a challenge of major interest but it can be done reliably for specific genera. In fact we uniquely identified the species of up to 67% of the most abundant genera and we obtained a less reliable identification for the remaining 33%.

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Antifoaming effect of rapeseed oil and oleic acid in biogas reactors

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Bioaugmentation as a solution to increase methane production from an ammonia-rich substrate
Ammonia-rich substrates inhibit anaerobic digestion (AD) process and constitute the main reason of low energy recovery in full-scale reactors. It is estimated that many full-scale AD reactors are operating in ammonia induced "inhibited steady-state" with significant losses of the potential biogas production yield. To date there are not any reliable methods to alleviate the ammonia toxicity effect and/or to efficiently digest ammonia-rich waste. In the current study, bioaugmentation as a possible method to alleviate ammonia toxicity effect in a mesophilic continuously stirred-tank reactor (CSTR) operating under "inhibited steady state" was tested. A fast growing hydrogenotrophic methanogen (i.e. Methanoculleus bourgensis MS2T) was bioaugmented in the CSTR reactor at high ammonia levels (5 g NH4+-N L-1). A second CSTR reactor used as control with no bioaugmentation. The results derived from this study clearly demonstrated a 31.3% increase in methane production yield in the CSTR reactor, at steady-state, after bioaugmentation. Additionally, high-throughput 16S rRNA gene sequencing analysis showed a fivefold increase in relative abundance of Methanoculleus spp. after bioaugmentation. On contrary to all methods used today to alleviate ammonia toxicity effect, the tested bioaugmentation process performed without interrupting the continuous operation of the reactor and without replacing the ammonia-rich feedstock.
Bioaugmentation with a hydrogenotrophic methanogen: a powerful tool to overcome ammonia inhibition of anaerobic digestion process

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Bioelectrode-based approach for enhancing nitrate and nitrite removal and electricity generation from eutrophic lakes

Nitrate and nitrite contamination of surface waters (e.g., lakes) has become a severe environmental and health problem, especially in developing countries. The recent demonstration of nitrate reduction at the cathode of microbial fuel cell (MFC) provides an opportunity to develop a new technology for nitrogen removal from surface waters. In this study, a sediment-type MFC based on two pieces of bioelectrodes was employed as a novel in situ applicable approach for nitrogen removal, as well as electricity production from eutrophic lakes. Maximum power density of 42 and 36 mW/m² were produced respectively from nitrate- and nitrite-rich synthetic lake waters at initial concentration of 10 mg-N/L. Along with the electricity production a total nitrogen removal of 62% and 77% was accomplished, for nitrate and nitrite, respectively. The nitrogen removal was almost 4 times higher under close-circuit condition with biocathode, compared to either the open-circuit operation or with abiotic cathode. The mass balance on nitrogen indicates that most of the removed nitrate and nitrite (84.7±0.1% and 81.8±0.1%, respectively) was reduced to nitrogen gas. The nitrogen removal and power generation was limited by the dissolved oxygen (DO) level in the water and acetate level injected to the sediment. Excessive oxygen resulted in dramatically decrease of nitrogen removal efficiency and only 7.8% removal was obtained at DO level of 7.8 mg/l. The power generation and nitrogen removal increased with acetate level and was nearly saturated at 0.84 mg/g-sediment. This bioelectrode-based in situ approach is attractive not only due to the electricity production, but also due to no need of extra reactor construction, which may broaden the application possibilities of sediment MFC technology.
Changes in the microbial profile of biogas reactors due to variations in the feedstock composition

Comparative analysis of the microbial diversity in liquid and foaming layer in biogas reactors

Foaming incidents have been recorded in many biogas plants causing severe operational, economical and environmental problems (Kougias et al., 2014). However, the foaming phenomenon in biogas reactors fed with agro-industrial wastes has not been extensively investigated, especially with respect to the microbial composition of the digesters (Moeller et al., 2012). In the cited literature, it has been reported that specific microorganisms, which are mainly filamentous (e.g. Gordonia species, Microthrix parvicella), are attached to biogas bubbles and transferred to the air/liquid interface of sludge reactors or wastewater treatment works (Ganidi et al., 2009). Once these microorganisms accumulate on the liquid surface, they initiate biosurfactants production due to their metabolic activity, leading to the decrease of the surface tension and thus generate foaming. The aim of the present study was to investigate the microbial diversity in the liquid versus the foaming layer in manure-based biogas reactors suffering by foaming incidents in order to elucidate potential role and contribution of the microorganisms in foam promotion.

The experimental work was carried out in three thermophilic continuous stirred tank reactors (CSTR) fed with manure and supplemental amounts of lipids, proteins and carbohydrates. Once foaming was formed in the reactors, samples from the liquid and foaming layer were obtained and screened using 16S rDNA sequencing. The results of these analyses revealed that there are indeed some species that significantly vary their relative abundance in the foaming layer compared to the liquid one (e.g. Methanoculleus sp., Dialister sp.). However, based on the cited literature and to the best of our knowledge there was not a direct correlation of these species with foaming. Further investigation is needed in order to define the properties of these species on foam generation. Finally, it was observed that particles of barley plant (that was contained in the raw manure as ingredient of animal nutrition) were accumulated in the foaming layer. It has been previously documented that barley contributes in stabilization of beer foam due to the activity of one of its proteins (Brey et al., 2003). For that reason, it could be hypothesised that the existence of barley particles in our reactors could contribute in foaming although their presence was also prior to the foaming incidents; their effect on foam formation or stabilization might be enhanced in correlation with other parameters (i.e. presence of specific microorganisms).
Comparative titration analysis before and after foaming incidents in biogas reactors

Foaming is one of the major problems that occasionally occurring in biogas plants affecting negatively the overall anaerobic digestion (AD) process. According to a recent survey, 15 out of 16 full-scale biogas plants, which were surveyed in Denmark, faced foaming incidents in the main reactor and/or in the pre-storage feeding tank, resulting in 30-50% biogas production loss (Kougias et al., 2014). In activated sludge systems and in wastewater treatment plants the major causes of foaming are organic overload, the presence of surface active agents, operational parameters (e.g. digester's shape, mixing system etc) and filamentous microorganisms (e.g. Gordonia species, Microthrix parvicella) (Ganidi et al., 2009). However, the contribution of specific microorganisms on foam generation in biogas reactors fed with agro-industrial wastes has not been previously investigated. The aim of the present study was to elucidate the microbiology of biogas reactors fed with different substrates prior and after foaming incidents.

The experiment was carried out in three continuous stirred tank reactors (CSTR) denoted as R1, R2 and R3. The total and the working volume of each reactor was 2 and 1.5 L, respectively. Each reactor was continuously stirred using a magnetic stirrer. The operating temperature was maintained at 54 ± 1 °C using thermal jackets. Each reactor was fed with a different mixed substrate, which was found to have an influence on foam formation in our previous study (Kougias et al., 2013). The hydraulic retention time (HRT) of all reactors was kept constant at 15 days. The whole experiment was divided into two periods. During the first period, the reactors were fed only with cattle manure. Once steady state conditions were reached, liquid sample from all reactors was obtained for DNA extraction and metagenomic analysis. After sampling, the feedstock composition of each reactor was changed by the addition of gelatine or Na-Oleate or glucose (second experimental period). As a consequence, foam formation was observed in all reactors approximately after one HRT period. Once the daily volume of the formed foam was steady, samples were taken again for DNA extraction and metagenomic analysis.

Results from the present study revealed significant variations in the microbiology of the manure-based biogas reactors after foam initiation. A number of genera could be linked to foaming as they produce biosurfactants (Lactobacillus, Bacillus, Pseudomonas, Thermotoga), others contain mycolic acid in their cell wall (Thermoactinomyces, Pseudonocardia) or decrease the surface tension of the media (Micrococcus, Streptococcus). Frankia, Dialister and Paenibacillus are known to be correlated to this phenomenon but their mechanism is still unclear. Finally, microorganisms that have a widely known association with foaming were identified when the identification threshold for the microorganisms was decreased to similar levels reported in the cited literature; however, the latter, due to its high importance, needs to be further investigated.

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Comparison of VFA titration procedures used for monitoring the biogas process

Titrimetric determination of volatile fatty acids (VFAs) contents is a common way to monitor a biogas process. However, digested manure from co-digestion biogas plants has a complex matrix with high concentrations of interfering components, resulting in varying results when using different titration procedures. Currently, no standardized procedure is used and it is therefore difficult to compare the performance among plants. The aim of this study was to evaluate four titration procedures (for determination of VFA-levels of digested manure samples) and compare results with gas chromatographic (GC) analysis. Two of the procedures are commonly used in biogas plants and two are discussed in literature. The results showed that the optimal titration results were obtained when 40mL of four times diluted digested manure was gently stirred (200rpm). Results from samples with different VFA concentrations (1-11g/L) showed linear correlation between titration results and GC measurements. However, determination of VFA by titration generally overestimated the VFA contents compared with GC measurements when samples had low VFA concentrations, i.e. around 1g/L. The accuracy of titration increased when samples had high VFA concentrations, i.e. around 5g/L. It was further found that the studied ionisable interfering components had lowest effect on titration when the sample had high VFA concentration. In contrast, bicarbonate, phosphate and lactate had significant effect on titration accuracy at low VFA concentration. An extended 5-point titration procedure with pH correction was best to handle interferences from bicarbonate, phosphate and lactate at
low VFA concentrations. Contrary, the simplest titration procedure with only two pH end-points showed the highest accuracy among all titration procedures at high VFA concentrations. All in all, if the composition of the digested manure sample is not known, the procedure with only two pH end-points should be the procedure of choice, due to its simplicity and accuracy. © 2014 Published by Elsevier Ltd.
Danish Biomethanation Technologies for Novel Substrates Evaluation in Remote Rural Areas of India

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Contributors: Fotidis, I., Laranjeiro, T., Angelidaki, I.
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Effective harvesting of the microalgae Chlorella protothecoides via bioflocculation with cationic starch.

In the present work, the flocculation efficiency of cationic starch (Greenfloc 120) was tested on the fresh water microalga Chlorella protothecoides under different conditions (pH and flocculant concentrations). Different concentrations of Greenfloc 120 (0, 2.5, 5, 10, 20, 40mgL^{-1}) were screened against different algal densities (0.44, 0.56 and 0.77gL^{-1}). Once the optimal flocculation concentration had been established (40mgL^{-1}) for all different biomasses densities a more detailed analysis was performed in order to investigate if different pH (4.0, 7.7, and 10.0) could increase the flocculation efficiency of cationic starch. Highest flocculation efficiency without addition of Greenfloc 120 was obtained at pH 10, while in the presence of flocculant, the efficiency increased for all the tested pH values, with a maximum of 98% for pH 7.7 and 10. Cationic starch confirmed to be as an easy to use, efficient and cost-effective flocculant for harvesting of microalgae.

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Effect of mechanical pre-treatment methods on the anaerobic digestibility and structure change of meadow grass for biogas production

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Effect of pH and H$_2$O$_2$ dosage on catechol oxidation in nano-Fe$_3$O$_4$ catalyzing UV-Fenton and identification of reactive oxygen species

This laboratory scale batch study examined catechol oxidation by UV-Fenton with commercial nanosized Fe$_3$O$_4$ as catalyst, focusing on influence of initial pH and H$_2$O$_2$ dosage on oxidation efficiency (represented by COD removal) and H$_2$O$_2$ utilization efficiency. In a wide initial pH range (2.0-8.0), this heterogeneous UV-Fenton process was powerful, especially reaction at pH 7.0 obtaining the highest COD removal of 93%. The remarkably high oxidation efficiency under neutral and slightly basic conditions was due to fast decrease of solution pH to be strongly acidic. Solution pH decreased until 120min and then increased, which was ascribed to the formation and destruction of some carboxylic acids. During the degradation, formic acid, acetic acid, oxalic acid, and maleic acid were detected. The values of H$_2$O$_2$ utilization efficiency at 240min near 1.30 in reactions with 11.80mM H$_2$O$_2$ under initial pH from 5.0 to 8.0 indicated this process would consume 23% less H$_2$O$_2$ dosage than the theoretical value for obtaining the same oxidation efficiency. Increasing H$_2$O$_2$ dosage accelerated catechol oxidation rate, but decreased the H$_2$O$_2$ utilization efficiency when H$_2$O$_2$ dosage enhanced from 0.50×δH$_2$O$_2$ (δH$_2$O$_2$: theoretical H$_2$O$_2$ dosage of 11.80mM for complete oxidation of 100mgL$^{-1}$ catechol) to 1.00×δH$_2$O$_2$. Radical identification experiments based on inhibition of methylene blue degradation rate under respective scavenger for HO, O$_2^{-}$ and O$_2$- showed HO, O$_2$ and O$_2$- were involved in nano-Fe$_3$O$_4$ catalyzing UV-Fenton, and total scavenging of HO would completely inhibit degradation. This result implied only HO was the direct product, while O$_2$ and O$_2$- were secondary oxidants coming from HO involved reactions. This finding increases insight into the mechanism for nano-Fe$_3$O$_4$ catalyzing UV-Fenton. Maintenance of catalytic ability of nano-Fe$_3$O$_4$ was also evaluated in six repeated runs.

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Organisations: Department of Environmental Engineering, Residual Resource Engineering, Harbin Institute of Technology
Ethanol production from industrial hemp: effect of combined dilute acid/steam pretreatment and economic aspects

In the present study, combined steam (140-180 °C) and dilute-acid pre-hydrolysis (0.0-2.0%) were applied to industrial hemp (Cannabis sativa L.), as pretreatment for lignocellulosic bioethanol production. The influence of the pretreatment conditions and cultivation type on the hydrolysis and ethanol yields were also evaluated. Pretreatment with 1% sulfuric acid at 180 °C resulted in the highest glucose yield (73-74%) and ethanol yield of 75-79% (0.38-0.40 g-ethanol/g-glucose). Taking into account the costs of biomass processing, from field to ethanol facility storage, the field-dried hemp pretreated at the optimal conditions showed positive economic results. The type of hemp cultivation (organic or conventional) did not influence significantly the effectiveness of the pretreatment and subsequent enzymatic hydrolysis and ethanol fermentation.

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Web of Science (2016): Impact factor 5.651
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Foam suppression in overloaded manure-based biogas reactors using antifoaming agents

Foam control is an imperative need in biogas plants, as foaming is a major operational problem. In the present study, the effect of oils (rapeseed oil, oleic acid, and octanoic acid) and tributylphosphate on foam reduction and process performance in batch and continuous manure-based biogas reactors was investigated. The compounds were tested in dosages of 0.05%, 0.1% and 0.5% v/vfeed. The results showed that rapeseed oil was most efficient to suppress foam at the dosage of 0.05% and 0.1% v/vfeed, while octanoic acid was most efficient to suppress foam at dosage of 0.5% v/vfeed. Moreover, the addition of rapeseed oil also increased methane yield. In contrast, tributylphosphate, which was very efficient antifoam, was found to be inhibitory to the biogas process. © 2013 Elsevier Ltd.

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Contributors: Kougias, P., Boe, K., Tsapekos, P., Angelidaki, I.
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Web of Science (2015): Impact factor 4.917
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BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.3 SJR 2.399 SNIP 2.087
Web of Science (2014): Impact factor 4.494
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 5.97 SJR 2.405 SNIP 2.477
Web of Science (2013): Impact factor 5.039
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.25 SJR 2.334 SNIP 2.461
Web of Science (2012): Impact factor 4.75
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
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Scopus rating (2011): CiteScore 5.56 SJR 2.308 SNIP 2.507
Web of Science (2011): Impact factor 4.98
ISI indexed (2011): ISI indexed yes
Integrated multi-trophic aquaculture (combined production of fish, mussels and seaweed)
The Danish marine aquaculture has, despite the huge potential, only been slowly increasing the last 25 years because of the imposed limits to the nitrogen (N) released to the environment. Mussels, seaweed and other organisms have been successfully tested as biofilters in integrated multi-trophic aquaculture (IMTA) worldwide, where nutrients emissions (especially N) from e.g. fish production are assimilated and removed by valuable biomasses (crops; Fig.1). This IMTA production unit, and even spatial decoupling of the biofilter organisms from the fish, have been recognized by the Danish national authorities in off-shore fish farming. The bioremediation potential and yield of the “new” crop, seaweed (sugarkelp, Saccharina latissima) was monitored in a commercial off-shore IMTA system year round at Hjarnø Havbrug fish farm near Horsens. Furthermore, the year-round protein, amino acid, fatty acid, mineral and vitamin content and profiles were monitored to evaluate the nutritional value and harvest time of the seaweed biomass. Sugarkelp showed to be efficient for bioremediation of nitrogen, with environmental and potentially economic benefits (e.g. waste water management and for production of valuable biomass). The seaweed protein content varied throughout the experimental period with the highest values recorded in November (14-20% of dry weight) and the lowest values recorded in May-July (2.8-6.7%). The lowest lipid content was observed in July, while the highest values were observed in November (approx. 4% of dw), with EPA (20:5(n-3)) and DHA (22:6(n-3)) accounting for 11.3-14.4% and 2.5-4.6% of total fatty acids, respectively. This “new” Danish aquatic crop has potential applications. The harvest time should be settled around May for human consumption and September in order to achieve maximum biofiltration efficiency with harvested biomass for feed utilization. This considering both biology/life cycle, biofouling and yield, which may compromise with seasons with higher nutritional value of the produced biomass.

General information
State: Published
Organisations: National Food Institute, Division of Industrial Food Research, Department of Environmental Engineering, Residual Resource Engineering
Metagenomic analysis of foaming in biogas reactors

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering, University of Padova
Contributors: Kougias, P., De Francisci, D., Treu, L., Campanaro, S., Angelidaki, I.
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Place of publication: Vienna, Austria
Electronic versions: Metagenomic_analysis_on_foaming.pdf
Research output: Research - peer-review » Conference abstract in proceedings – Annual report year: 2014

Methods for upgrading of a fuel gas and succinic acid production

The present invention provides methods of upgrading of a CO2-containing fuel gas comprising the use of anaerobic succinic acid-producing microorganisms. Thus, the present invention provides a method for simultaneous upgrading of a CO2-containing fuel gas and biosuccinic acid production.

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State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Angelidaki, I., Gunnarsson, I. B., Alvarado-Morales, M.
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Publication information
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Date: 27/11/2014
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Original language: English
Research output: Research » Patent – Annual report year: 2014

Microbial analysis in biogas reactors suffering by foaming incidents

Foam formation can lead to total failure of digestion process in biogas plants. In the present study, possible correlation between foaming and the presence of specific microorganisms in biogas reactors was elucidated. The microbial ecology of continuous fed digesters overloaded with proteins, lipids and carbohydrates before and after foaming incidents was characterized using 16S rRNA gene sequencing. Moreover, the microbial diversity between the liquid and foaming layer was assessed. A number of genera that are known to produce biosurfactants, contain mycolic acid in their cell wall, or decrease the surface tension of the media, increased their relative abundance after foam formation. Finally, a microorganism similar to widely known foaming bacteria (Nocardia and Desulfotomaculum) was found to increase its relative abundance in all reactors once foam was observed, regardless of the used substrate. These findings suggest that foaming and specific microorganisms might have direct association which requires to be further investigated.

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering, University of Padova
Contributors: Kougias, P., De Francisci, D., Treu, L., Campanaro, S., Angelidaki, I.
Number of pages: 9
Microbial diversity and dynamicity of biogas reactors fed with different substrates

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State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering, University of Padova
Contributors: De Francisci, D., Kougias, P., Treu, L., Campanaro, S., Angelidaki, I.
Number of pages: 2
Publication date: 2014

Microbial diversity and dynamicity of biogas reactors fed with different substrates

Microbial electrolysis cells turning to be versatile technology: recent advances and future challenges

Microbial electrolysis cells (MECs) are an electricity-mediated microbial bioelectrochemical technology, which is originally developed for high-efficiency biological hydrogen production from waste streams. Compared to traditional biological technologies, MECs can overcome thermodynamic limitations and achieve high-yield hydrogen production from wide range of organic matters at relatively mild conditions. This approach greatly reduces the electric energy cost for hydrogen production in contrast to direct water electrolysis. In addition to hydrogen production, MECs may also support several energetically unfavorable biological/chemical reactions. This unique advantage of MECs has led to several alternative applications such as chemicals synthesis, recalcitrant pollutants removal, resources recovery, bioelectrochemical research platform and biosensors, which have greatly broaden the application scopes of MECs. MECs are becoming a versatile platform technology and offer a new solution for emerging environmental issues related to waste streams treatment and energy and resource recovery. Different from previous reviews that mainly focus on hydrogen production, this paper provides an up-to-date review of all the new applications of MECs and their resulting performance, current challenges and prospects of future.

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Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Zhang, Y., Angelidaki, I.
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BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 7.49 SJR 2.663 SNIP 2.563
Web of Science (2016): Impact factor 6.942
Web of Science (2016): Indexed yes
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Web of Science (2015): Impact factor 5.991
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 6.13 SJR 2.946 SNIP 2.702
Web of Science (2014): Impact factor 5.528
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 6.02 SJR 2.956 SNIP 2.676
Web of Science (2013): Impact factor 5.323
ISI indexed (2013): ISI indexed yes
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BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.15 SJR 2.914 SNIP 2.442
Web of Science (2012): Impact factor 4.655
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 5.43 SJR 2.862 SNIP 2.355
Web of Science (2011): Impact factor 4.865
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.592 SNIP 2.192
Web of Science (2010): Impact factor 4.546
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.319 SNIP 2.224
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.073 SNIP 2.178
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.94 SNIP 2.184
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.902 SNIP 2.233
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 2.113 SNIP 2.334
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 2.209 SNIP 2.108
Microplate-based method for high-throughput screening of microalgae growth potential

Microalgae cultivation conditions in microplates will differ from large-scale photobioreactors in crucial parameters such as light profile, mixing and gas transfer. Hence volumetric productivity (Pv) measurements made in microplates cannot be directly scaled up. Here we demonstrate that it is possible to use microplates to measure characteristic exponential growth rates and determine the specific growth rate light intensity dependency (μ-I curve), which is useful as the key input for several models that predict Pv. Nannochloropsis salina and Chlorella sorokiniana specific growth rates were measured by repeated batch culture in microplates supplied with continuous light at different intensities. Exponential growth unlimited by gas transfer or self-shading was observable for a period of several days using fluorescence, which is an order of magnitude more sensitive than optical density. The microplate datasets were comparable to similar datasets obtained in photobioreactors and were used an input for the Huesemann model to accurately predict Pv.

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Scopus rating (2016): CiteScore 5.94 SJR 2.215 SNIP 1.932
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Web of Science (2016): Indexed yes
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Scopus rating (2015): CiteScore 5.47 SJR 2.243 SNIP 1.897
Web of Science (2015): Impact factor 4.917
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.3 SJR 2.399 SNIP 2.087
Modelling and assessment of the storage of nutrients in a mixed green microalgae culture

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering, Residual Resource Engineering, Technical University of Denmark
Nanomodification of the electrodes in microbial fuel cell: impact of nanoparticle density on electricity production and microbial community

The nano-decoration of electrode with nanoparticles is one effective way to enhance power output of microbial fuel cells (MFCs). However, the amount of nanoparticles used for decoration has not been optimized yet, and how it affects the microbial community is still unknown. In this study, different densities of gold (Au) nanoparticles were sputtered on carbon paper as electrodes of MFCs.

The results show that power generation increased with Au nanoparticle density on the electrodes. The highest power density was obtained by depositing carbon paper with an Au thickness of 50 nm and 100 nm on each side, respectively, which was 1.22-1.88 times higher than that obtained with plain carbon paper electrode (control). Furthermore, the Coulombic efficiency was increased with the Au density. Consequently, the maximum lag time before stable power generation was shortened by 1.22 times the lag time of the control. Different densities of Au nanoparticles also resulted in different microbial communities on the anode. More diverse bacterial communities were found with higher Au nanoparticle densities. These results provide new dimensions in understanding electrode modification with nanoparticles in MFC systems.

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Organisations: Department of Environmental Engineering, Residual Resource Engineering
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Scopus rating (2016): CiteScore 7.78 SJR 3.011 SNIP 2.61
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BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 6.4 SJR 2.835 SNIP 2.593
Web of Science (2015): Impact factor 5.746
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 6.93 SJR 3.158 SNIP 3.218
Web of Science (2014): Impact factor 5.613
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Optimization of extraction process of crude alginate from Sargassum muticum by response surface methodology

General Information
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Organisations: National Food Institute, Division of Industrial Food Research, Department of Environmental Engineering, Residual Resource Engineering, Indian Institute of Technology, Kharagpur
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Photomicrobial fuel cell (PFC) for simultaneous organic carbon, nutrients removal and energy production

A sediment-type photomicrobial fuel cell (PFC), based on the synergistic interaction between microalgae (Chlorella vulgaris) and electrochemically active bacteria, was developed to remove carbon and nutrients from wastewater, and produce electricity and algal biomass simultaneously. Under illumination, stable power density of 68±5 mW/m² and biomass of 0.56±0.02 g/L were generated at initial algae concentration of 3.5 g/L. Accordingly, the removal efficiency of organic carbon, nitrogen and phosphorus was 99.6%, 87.6% and 69.8%, respectively. Mass balance analysis suggested the main removal mechanism of nitrogen and phosphorus was algae biomass uptake (75% and 93%, respectively), while nitrification and denitrification process contributed to part of nitrogen removal (22%). In addition, the effect of illumination period on the performance of PFC was investigated. Except notable fluctuation of power generation, carbon and nutrients removal was not significantly affected after changing the light/dark photoperiod from 24 h/0 h to 10 h/14 h. This work represents the first successful attempt to develop an effective bacteria-algae coupled system, capable for extracting energy and removing carbon, nitrogen and phosphorus from wastewater in one-step.

Potential of Jerusalem artichoke (Helianthus tuberosus L.) as a biorefinery crop

The utilization of Jerusalem artichoke in a biorefinery context was not investigated so far. Therefore the aim of this study was to evaluate the potential of this plant as feedstock for production of bioethanol, protein and inulin. We investigated the biomass productivity and chemical composition of 11 different clones, harvested on three occasions during the fall and early winter of 2011. The results obtained showed that cellulose production per hectare was at least double compared to corn stover, rice straw, sugarcane bagasse and wheat straw, showing high bioethanol production potential of Jerusalem artichoke. Although not high (in total <6% of dry matter), protein and lipid levels could be of importance when biomass is utilized in a biorefinery concept. Harvest occasion determined the biomass productivity and chemical composition to a higher degree than the choice of clone. The average biomass productivity was 88% higher in September than in December. Fresh tuber biomass productivity showed large variations between harvests, where the maximum average productivity in December was 3.4 times higher than in September. Inulin content in dry tubers was between 76 and 85% making the plant an excellent crop, for e.g. inulin extraction, production of high fructose syrup or fermentations. Less mature plants were shown to have degree of polymerization (DP) up to 14, which makes biomass useful as dietary fibre, while the inulin DP in tubers harvested later became as low as 6, showing lower potential with respect to plant utilization for dietary purposes. Results obtained clearly demonstrated that crop harvesting time was an important factor affecting biomass productivity and composition.
Removal of organic pollutants in tannery wastewater from wet-blue fur processing by integrated Anoxic/Oxic (A/O) and Fenton: Process optimization

Removal of organic pollutants in tannery wastewater from wet-blue fur processing has been a challenge in remediation of aquatic environment in developing countries. Removal of organic pollutants in tannery wastewater from wet-blue fur processing was studied using integrated processes of Anoxic/Oxic and Fenton. Analysis of COD composition based on particle size found about 10% of the total COD was in the particulate and colloidal range, the remaining 90% was soluble with 72% biodegradable. Biodegradation of real tannery wastewater as well as typical tanning agents were performed in batch experiments, aerobic degradation presented much better performance than anaerobic degradation. Effect of hydraulic retention time on A/O performance in terms of COD removal efficiency was evaluated, excess HRT like 60h would reduce the effluent quality, and the appropriate organic load rate was at least up to 0.8kgCODm⁻³d⁻¹ with corresponding COD removal of about 80%. In the subsequent Fenton oxidation, effects of initial pH and H₂O₂ dose on COD removal were investigated, and response surface methodology was adopted to obtain the optimal conditions as initial pH of 4.0, H₂O₂ dose of 14.0mM, H₂O₂:Fe²⁺ molar ratio of 10.6, and reaction time of 3h to achieve the highest COD removal of 55.87%. GC-MS analysis was carried out to observe the change of organic composition during Fenton oxidation, and most of the residual organic pollutants resistant to Fenton treatment belonged to organosilanes and saturated alkanes. This study will provide useful information for treatment of a special type of tannery wastewater from wet-blue fur processing with low organic load. © 2014 Elsevier B.V.
Succinic acid production by fermentation of Jerusalem artichoke tuber hydrolysate with Actinobacillus succinogenes 130Z

**General information**

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Web of Science (2017): Impact factor 3.849  
Web of Science (2017): Indexed yes
The dominant acetate degradation pathway/methanogenic composition in full-scale anaerobic digesters operating under different ammonia levels

Ammonia is a major environmental factor influencing biomethanation in full-scale anaerobic digesters. In this study, the effect of different ammonia levels on methanogenic pathways and methanogenic community composition of full-scale biogas plants was investigated. Eight full-scale digesters operating under different ammonia levels were sampled, and the residual biogas production was followed in fed-batch reactors. Acetate, labelled in the methyl group, was used to determine the methanogenic pathway by following the 14CH4 and 14CO2 production. Fluorescence in situ hybridisation was used to determine the methanogenic communities’ composition. Results obtained clearly demonstrated that syntrophic acetate oxidation coupled with hydrogenotrophic methanogenesis was the dominant pathway in all digesters with high ammonia levels (2.8–4.57 g NH4+-N L−1), while acetoclastic methanogenic pathway dominated at low ammonia (<1.21 g NH4+-N L−1). Thermophilic Methanomicrobiales spp. and mesophilic Methanobacteriales spp. were the most abundant methanogens at free ammonia concentrations above 0.44 g NH3-N L−1 and total ammonia concentrations above 2.8 g NH4+-N L−1, respectively. Meanwhile, in anaerobic digesters with low ammonia (<1.21 g NH4+-N L−1) and free ammonia (<0.07 g NH3-N L−1) levels, mesophilic and thermophilic Methanosetaeaceae spp. were the most abundant methanogens.

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  Web of Science (2017): Indexed yes
  Scopus rating (2016): CiteScore 2.11 SJR 0.592 SNIP 0.977
  Web of Science (2016): Impact factor 1.915
  Scopus rating (2015): CiteScore 1.95 SJR 0.568 SNIP 1.035
  Web of Science (2015): Impact factor 2.344
  Scopus rating (2014): CiteScore 2.2 SJR 0.77 SNIP 1.558
  Web of Science (2014): Impact factor 2.19
  Web of Science (2014): Indexed yes
  Scopus rating (2013): CiteScore 2.15 SJR 0.754 SNIP 1.869
  Web of Science (2013): Impact factor 1.794
  ISI indexed (2013): ISI indexed yes
  Web of Science (2013): Indexed yes
  Scopus rating (2012): CiteScore 2.13 SJR 0.84 SNIP 1.717
  Web of Science (2012): Impact factor 1.844
  ISI indexed (2012): ISI indexed yes
  Scopus rating (2011): CiteScore 4.13 SJR 1.268 SNIP 1.875
  Web of Science (2011): Impact factor 3.051
  ISI indexed (2011): ISI indexed no
  Scopus rating (2010): SJR 0.801 SNIP 1.697
  Scopus rating (2009): SJR 0.552 SNIP 1.031
The Effect Of Light On Mixed Green Micro-Algal Growth: Experimental Assessment And Modelling

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Organisations: Department of Environmental Engineering, Urban Water Engineering, Residual Resource Engineering, Technical University of Denmark
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Utilization of CO₂ fixing bacterium Actinobacillus succinogenes 130Z for simultaneous biogas upgrading and bio-succinic acid production

Biogas is an attractive renewable energy carrier. However, it contains CO₂ which limits certain applications of biogas. Here we report a novel approach for removing CO₂ from biogas and capturing it as a biochemical through a biological process. This approach entails converting CO₂ into bio-succinic acid using the bacterial strain Actinobacillus succinogenes 130Z, and simultaneously producing high purity CH₄ (>95%). Results showed that when pressure during fermentation was increased from 101.325 to 140 kPa, higher CO₂ solubility was achieved, thereby positively affecting final succinic acid yield and titre, CO₂ consumption rate and CH₄ purity. When using biogas as the only CO₂ source at 140 kPa, the CO₂ consumption rate corresponded to 2.59 L CO₂ L⁻¹ d⁻¹ with a final succinic acid titre of 14.4 g L⁻¹. Under this pressure condition the highest succinic acid yield and biogas quality reached corresponded to 0.635 g g⁻¹ and 95.4% (v v⁻¹) CH₄ content respectively after 24 hours fermentation. This work represents the first successful attempt to develop a system capable of upgrading biogas to vehicle fuel/gas grid quality and simultaneously produce bio-succinic acid, a valuable building block with large market potential in the near term.

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Scopus rating (2017): CiteScore 6.58 SJR 2.535 SNIP 1.941
Web of Science (2017): Impact factor 6.653
Web of Science (2017): Indexed yes
A Mixed Green Micro-Algal Model (MAMO) – Model Identification And Calibration Using Synthetic Medium And Nutrient Rich Carbon Depleted Wastewater

The reuse of wastewater resources via micro-algal cultivation is a cost-effective and sustainable solution for third generation biofuel production. A process model, describing photobioreactor operation – also in combination with activated sludge processes, however, is still missing. In this paper, we present a mathematical model, accounting for photoautotrophic and heterotrophic algal growth, nutrient uptake and storage in a mixed microalgae culture cultivated on nutrient rich carbon depleted (NRCD) wastewater. The process model is developed as an extension to the Activated Sludge Model 2d, ASM2d (Henze et al., 1999), and thus it also accounts for bacterial growth in the photobioreactor. We assess the factors, influencing algae growth and nutrient uptake, including macro-nutrient availability and light irradiance rate. Model parameters were estimated through microplate screenings and a series of batch experiments using a mixed green microalgal culture isolated in a wastewater pond, growing strictly in suspension.

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Organisations: Department of Environmental Engineering, Urban Water Engineering, Residual Resource Engineering, Technical University of Denmark
Contributors: Sæbø, M., Valverde Perez, B., Van Wagenen, J., Angelidaki, I., Smets, B. F., Plósz, B.
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Anaerobic digestion foaming in Danish full-scale biogas plants: a survey on causes and solutions

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Organisations: Department of Environmental Engineering, Residual Resource Engineering
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Anaerobic digestion for simultaneous sewage sludge treatment and CO biomethanation: process performance and microbial ecology

Syngas is produced by thermal gasification of both non-renewable and renewable sources including biomass and coal, and it consists mainly of CO, CO2 and H2. In this paper we aim to bio-convert CO in the syngas to CH4. A novel technology for simultaneous sewage sludge treatment and CO biomethanation in an anaerobic reactor was presented. Batch experiments showed that CO was inhibitory to methanogens, but not to bacteria, at CO partial pressure between 0.25 and 1 atm under thermophilic conditions. During anaerobic digestion of sewage sludge supplemented with CO added through a hollow fiber membrane (HFM) module in continuous thermophilic reactors, CO did not inhibit the process even at a pressure as high as 1.58 atm inside the HFM, due to the low dissolved CO.
concentration in the liquid. Complete consumption of CO was achieved with CO gas retention time of 0.2 d. Results from high-throughput sequencing analysis showed clear differences of the microbial community structures between the samples from liquid and biofilm on the HFM in the reactor with CO addition. Species close to Methanosarcina barkeri and Methanothermobacter thermautotrophicus were the two main archaeal species involved in CO biomethanation. However, the two species were distributed differently in the liquid phase and in the biofilm. Although carboxidotropic activities test showed that CO was converted by both archaea and bacteria, the bacterial species responsible for CO conversion are unknown.

**General information**

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Organisations: Department of Environmental Engineering, Technical University of Denmark
Contributors: Luo, G., Wang, W., Angelidaki, I.
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- Web of Science (2016): Indexed yes
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- BFI (2014): BFI-level 2
- Scopus rating (2014): CiteScore 5.5 SJR 2.777 SNIP 2.003
- Web of Science (2014): Impact factor 5.33
- Web of Science (2014): Indexed yes
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- Scopus rating (2013): CiteScore 5.52 SJR 2.952 SNIP 2.102
- Web of Science (2013): Impact factor 5.481
- ISI indexed (2013): ISI indexed yes
- Web of Science (2013): Indexed yes
- BFI (2012): BFI-level 2
- Scopus rating (2012): CiteScore 5.17 SJR 3.115 SNIP 2.043
- Web of Science (2012): Impact factor 5.257
- ISI indexed (2012): ISI indexed yes
- Web of Science (2012): Indexed yes
- BFI (2011): BFI-level 2
- Scopus rating (2011): CiteScore 5.16 SJR 3.18 SNIP 1.945
- Web of Science (2011): Impact factor 5.228
- ISI indexed (2011): ISI indexed yes
- Web of Science (2011): Indexed yes
- BFI (2010): BFI-level 2
- Scopus rating (2010): SJR 2.979 SNIP 1.726
A new method for in situ nitrate removal from groundwater using submerged microbial desalination-denitrification cell (SMDDC)

A considerable increase in nitrate concentration in groundwater has become a serious concern worldwide. We developed a novel submerged microbial desalination-denitrification cell (SMDDC) to in situ remove nitrate from groundwater, produce electric energy, and potentially treat wastewater. The SMDDC, which was composed of an anode and a cathode chamber, can be easily applied to subsurface environments. When current was produced by bacteria on the anode, NO₃⁻ and Na⁺ were transferred into the anode and cathode through anion and cation exchange membrane, respectively; the anode effluent was directed to the cathode where NO₃⁻ was reduced to N₂ through autotrophic denitrification. For proof-of-concept, the SMDDC was fed with synthetic wastewater as fuel and submerged into a glass reactor filled with synthetic groundwater. The SMDDC produced 3.4 A/m² of current density, while removing 90.5% of nitrate from groundwater with 12 h wastewater hydraulic retention time (HRT) and 10 Ω of external resistance. The nitrate concentration and ionic strength of groundwater were the main limiting factors to the system performance. Besides, the external resistance and HRT were also affecting the system performance. Furthermore, the SMDDC showed improved performance with high ionic strength of groundwater (2200 μS/cm) and was able to reduce groundwater salinity as well. External nitrification was beneficial to the current generation and nitrate removal rate, but was not affecting total nitrogen removal. Results clearly indicate that this system holds a great potential for efficient and cost-effective treatment of nitrate-containing groundwater and energy recovery.

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Contributors: Zhang, Y., Angelidaki, I.
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<td>SJR 2.113, SNIP 2.334</td>
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A novel and quick method to avoid H$_2$O$_2$ interference on COD measurement in Fenton system by Na$_2$SO$_3$ reduction and O$_2$ oxidation.

Hydrogen peroxide interference on chemical oxygen demand (COD) measurement has been a big problem in the application of the Fenton process. However, there is no simple and effective method available to address this problem, although several methods have been reported in the literature. In this study, a new method has been developed based on Na$_2$SO$_3$ reduction and O$_2$ oxidation, which has easy operation and short time requirement. Na$_2$SO$_3$ reduction was used to remove H$_2$O$_2$ in water samples, which was independent of pH in the investigated range of 2.50-11.95. Residual Na$_2$SO$_3$ was removed by subsequent O$_2$ oxidation, and effects of initial solution pH, ferric ion dosage, and stirring speed were explored. Solution pH below 3.0 and stirring speed of 700 rev min$^{-1}$ could ensure a sufficiently high oxidation rate for Na$_2$SO$_3$ with ferric ion higher than 0.469 mM. This new method was proven to be effective in the matrix of Fenton treating real landfill leachate. Meanwhile, the procedure for this method in other applications was proposed in detail. To the best of our knowledge, this newly developed method is the most simple and effective way to avoid H$_2$O$_2$ interference on COD analysis.
Antifoaming effect of chemical compounds in manure biogas reactors

A precise and efficient antifoaming control strategy in bioprocesses is a challenging task as foaming is a very complex phenomenon. Nevertheless, foam control is necessary, as foam is a major operational problem in biogas reactors. In the present study, the effect of 14 chemical compounds on foam reduction was evaluated at concentration of 0.05%, 0.1% and 0.5% v/v sample, in raw and digested manure. Moreover, two antifoam injection methods were compared for foam reduction efficiency. Natural oils (rapeseed and sunflower oil), fatty acids (oleic, octanoic and derivative of natural fatty acids), siloxanes (polydimethylsiloxane) and ester (tributylphosphate) were found to be the most efficient compounds to suppress foam. The efficiency of antifoamers was dependant on their physicochemical properties and greatly correlated to their chemical characteristics for dissolving foam. The antifoamers were more efficient in reducing foam when added directly into the liquid phase rather than added in the headspace of the reactor.

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Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Kougias, P., Tsapekos, P., Boe, K., Angelidaki, I.
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Web of Science (2016): Impact factor 6.942
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Scopus rating (2015): CiteScore 6.63 SJR 2.665 SNIP 2.482
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BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 6.02 SJR 2.956 SNIP 2.676
Web of Science (2013): Impact factor 5.323
ISI indexed (2013): ISI indexed yes
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BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.15 SJR 2.914 SNIP 2.442
Web of Science (2012): Impact factor 4.655
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 5.43 SJR 2.862 SNIP 2.355
Web of Science (2011): Impact factor 4.865
ISI indexed (2011): ISI indexed yes
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Bioaugmentation of an acetate-oxidising anaerobic consortium in up-flow sludge blanket reactor subjected to high ammonia loads

Ammonia is the major inhibitor of anaerobic digestion (AD) process leading to suboptimal utilisation of the biogas potential of the feedstocks and causing economical losses to the biogas plants. However, ammonia is mainly inhibiting the aceticlastic methanogens, while the hydrogenotrophic methanogens, in syntrophic association with acetate oxidising bacteria, are more resistant to ammonia toxicity effect. The use of syntrophic acetate oxidising methanogenic consortia could provide a new approach to tackle ammonia toxicity effect in AD. The SAO culture (i.e. Clostridium ultunense spp. nov. in association with Methanoculleus spp. strain MAB1), is an acetate oxidising methanogenic consortium that can produce methane (CH4) at high ammonia levels. In the current study the bioaugmentation of the SAO culture in a mesophilic up-flow anaerobic sludge blanket (UASB) reactor subjected to high ammonia loads was tested. The cocultivation in fed-batch of a fast-growing hydrogenotrophic methanogen (i.e. Methanoculleus bourgensis) with the SAO culture was also investigated. Results obtained clearly demonstrated that bioaugmentation of SAO culture in a UASB reactor was not possible most probably due to the slow growth of the culture. The incubation period (duration of lag+exponential phase) of SAO culture was reduced more than 30% when it was cocultivated with Methanoculleus bourgensis, in fed-batch reactors. Therefore, the bioaugmentation of the SAO culture along with Methanoculleus bourgensis in a UASB reactor is a promising approach to overcome ammonia toxicity.

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Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Fotidis, I., Karakashev, D. B., Angelidaki, I.
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Bioaugmentation with an acetate-oxidising consortium as a tool to tackle ammonia inhibition of anaerobic digestion

Ammonia is the major inhibitor of anaerobic digestion (AD) process in biogas plants. In the current study, the bioaugmentation of the ammonia tolerant SAO co-culture (i.e. Clostridium ultunense spp. nov. in association with Methanoculleus spp. strain MAB1) in a mesophilic up-flow anaerobic sludge blanket (UASB) reactor subjected to high ammonia loads was tested. The co-cultivation in fed-batch reactors of a fast-growing hydrogenotrophic methanogen (i.e. Methanoculleus bourgensis MS2T) with the SAO co-culture was also investigated. Results demonstrated that bioaugmentation of SAO co-culture in a UASB reactor was not possible most likely due to the slow maximum growth rate ($\mu_{max}=0.007h^{-1}$) of the culture caused by the methanogenic partner. The addition of M. bourgensis to SAO led to 42% higher growth rate ($\mu_{max}=0.01h^{-1}$) in fed-batch reactors. This indicates that methanogens were the slowest partners of the SAO co-culture and therefore were the limiting factor during bioaugmentation in the UASB reactor. © 2013 Elsevier Ltd.

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Web of Science (2017): Indexed yes
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Scopus rating (2016): CiteScore 5.94 SJR 2.215 SNIP 1.932
Web of Science (2016): Impact factor 5.651
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.47 SJR 2.243 SNIP 1.897
Web of Science (2015): Impact factor 4.917
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.3 SJR 2.399 SNIP 2.087
Web of Science (2014): Impact factor 4.494
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 5.97 SJR 2.405 SNIP 2.477
Web of Science (2013): Impact factor 5.039
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.25 SJR 2.334 SNIP 2.461
In the present study the potential of bioethanol production using carbohydrate-enriched biomass of the cyanobacterium Arthrospira platensis was studied. For the saccharification of the carbohydrate-enriched biomass, four acids (H2SO4, HNO3, HCl and H3PO4) were investigated. Each acid were used at four concentrations, 2.5 N, 1 N, 0.5 N and 0.25 N, and for each acid concentration the saccharification was conducted under four temperatures (40 °C, 60 °C, 80 °C and 100 °C). Higher acid concentrations gave in general higher reducing sugars (RS) yields (%, gRS/gTotal sugars) with higher rates, while the increase in temperature lead to higher rates at lower acid concentration. The hydrolysates then were used as substrate for ethanolic fermentation by a salt stress-adapted Saccharomyces cerevisiae strain. The bioethanol yield (%, gEtOH/gBiomass) was significantly affected by the acid concentration used for the saccharification of the carbohydrates. The highest bioethanol yields of 16.32% ± 0.90% (gEtOH/gBiomass) and 16.27% ± 0.97% (gEtOH/gBiomass) were obtained in hydrolysates produced with HNO3 0.5 N and H2SO4 0.5 N, respectively.

Bioethanol Production by Carbohydrate-Enriched Biomass of Arthrospira (Spirulina) platensis

In the present study the potential of bioethanol production using carbohydrate-enriched biomass of the cyanobacterium Arthrospira platensis was studied. For the saccharification of the carbohydrate-enriched biomass, four acids (H2SO4, HNO3, HCl and H3PO4) were investigated. Each acid were used at four concentrations, 2.5 N, 1 N, 0.5 N and 0.25 N, and for each acid concentration the saccharification was conducted under four temperatures (40 °C, 60 °C, 80 °C and 100 °C). Higher acid concentrations gave in general higher reducing sugars (RS) yields (%, gRS/gTotal sugars) with higher rates, while the increase in temperature lead to higher rates at lower acid concentration. The hydrolysates then were used as substrate for ethanolic fermentation by a salt stress-adapted Saccharomyces cerevisiae strain. The bioethanol yield (%, gEtOH/gBiomass) was significantly affected by the acid concentration used for the saccharification of the carbohydrates. The highest bioethanol yields of 16.32% ± 0.90% (gEtOH/gBiomass) and 16.27% ± 0.97% (gEtOH/gBiomass) were obtained in hydrolysates produced with HNO3 0.5 N and H2SO4 0.5 N, respectively.

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering, Agricultural University of Athens, Technological Educational Institution of Athens
Carbohydrate-enriched cyanobacterial biomass as feedstock for bio-methane production through anaerobic digestion

The anaerobic digestion performance using carbohydrate-enriched biomass of Arthrospira platensis was studied. The carbohydrate enrichment was achieved after the cultivation of A. platensis under phosphorus limitation conditions. Three biomass compositions (60%, 40% and 20% carbohydrates content) were used. The overall observation as the biomass carbohydrates increased was that bio-methane yield increased. The highest bio-methane yield in bioreactors with 60% carbohydrates was 203±10ml CH4 gCODinfl-1, while the lowest bio-methane yield in bioreactors with 20% carbohydrates was 123±10ml CH4 gCODinfl-1. The trend of increasing bio-methane yield as carbohydrates content of the biomass increased was observed almost in all three HRT (15, 20 and 30days) studied and after thermal pre-treatment. However, thermal pre-treatment did not improve the bio-methane yield. Ammonia concentration had an overall trend to decrease as the biomass carbohydrates content increased. This study concludes that the increase of biomass carbohydrates through phosphorus limitation process is an attractive technique to improve the bio-methane yield.

General information

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Organisations: Department of Environmental Engineering, Residual Resource Engineering, Agricultural University of Athens
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- Web of Science (2017): Impact factor 4.908
- Web of Science (2017): Indexed yes
- BFI (2016): BFI-level 2
- Scopus rating (2016): CiteScore 4.9 SJR 1.736 SNIP 2.207
- Web of Science (2016): Impact factor 4.601
- Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 2
- Scopus rating (2015): CiteScore 4.46 SJR 1.781 SNIP 2.123
- Web of Science (2015): Indexed yes
- BFI (2014): BFI-level 2
- Scopus rating (2014): CiteScore 4.14 SJR 1.634 SNIP 2.294
- Web of Science (2014): Impact factor 3.52
- Web of Science (2014): Indexed yes
- BFI (2013): BFI-level 2
- Scopus rating (2013): CiteScore 4.31 SJR 1.762 SNIP 2.544
- ISI indexed (2013): ISI indexed yes
- Web of Science (2013): Indexed yes
- BFI (2012): BFI-level 2
- Scopus rating (2012): CiteScore 3.99 SJR 1.813 SNIP 2.425
- ISI indexed (2012): ISI indexed yes
- Web of Science (2012): Indexed yes
- BFI (2011): BFI-level 2
- Scopus rating (2011): CiteScore 4.1 SJR 2.041 SNIP 2.423
- Web of Science (2011): Impact factor 3.248
Co-digestion of manure and whey for in situ biogas upgrading by the addition of H₂: process performance and microbial insights

In situ biogas upgrading was conducted by introducing H₂ directly to the anaerobic reactor. As H₂ addition is associated with consumption of the CO₂ in the biogas reactor, pH increased to higher than 8.0 when manure alone was used as substrate. By co-digestion of manure with acidic whey, the pH in the anaerobic reactor with the addition of hydrogen could be maintained below 8.0, which did not have inhibition to the anaerobic process. The H₂ distribution systems (diffusers with different pore sizes) and liquid mixing intensities were demonstrated to affect the gas-liquid mass transfer of H₂ and the biogas composition. The best biogas composition (75:6.6:18.4) was obtained at stirring speed 150 rpm and using ceramic diffuser, while the biogas in the control reactor consisted of CH₄ and CO₂ at a ratio of 55:45. The consumed hydrogen was almost completely converted to H₂ and there was no significant accumulation of VFA in the effluent. The study showed that addition of hydrogen had positive effect on the methanogenesis, but had no obvious effect on the acetogenesis. Both hydrogenotrophic methanogenic activity and the concentration of coenzyme F₄₂₀ involved in methanogenesis were increased. The archaeal community was also altered with the addition of hydrogen, and a Methanothermobacter thermautotrophicus related band appeared in a denaturing gradient gel electrophoresis gel from the sample of the reactor with hydrogen addition. Though the addition of hydrogen increased the dissolved hydrogen concentration, the degradation of propionate was still thermodynamically feasible at the reactor conditions.
Development and evaluation of a fast screening method of microalgal performance using microplates

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Organisations: Department of Environmental Engineering, Residual Resource Engineering, Technical University of Denmark
Contributors: Holdt, S. L., De Francisci, D., Angelidaki, I., Borch, M. M.
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Development of an algal wastewater treatment concept, based on the selection of microalgal strains with optimal bioextraction characteristics

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Event: Poster session presented at International Conference on Algal Biorefinery, Kharagpur, India.
Electronic versions:
e4water 4-final.pdf
Source: dtu
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Effect of ammonium and acetate on methanogenic pathway and methanogenic community composition
Methanogenesis from acetate (acetoclastic methanogenesis or syntrophic acetate oxidation (SAO) coupled with hydrogenotrophic methanogenesis) is the most important step for the biogas process. The major environmental factors influencing methanogenesis are volatile fatty acids, ammonia, pH, and temperature. In our study, the effect of acetate and ammonia concentration on the methanogenic pathway from acetate and on the methanogenic communities was elucidated in two experiments: one where inocula were gradually exposed to increasing concentrations of acetate or ammonia, and another with direct exposure to different ammonia concentrations. The methanogenic pathway was determined by following the production of (14) CH(4) and (14) CO(2) from acetate labeled in the methyl group (C-2). Microbial communities' composition was determined by fluorescence in situ hybridization. Upon acclimatization to acetate and ammonia, thermophilic cultures clearly shifted their acetate bioconversion pathway from SAO with subsequent hydrogenotrophic methanogenesis (mediated by Methanobacteriales spp. and/or Methanomicrobiales spp.) to aceticlastic methanogenesis (mediated by Methanosarcinaceae spp.). On the contrary, acclimatization process resulted in no pathway shift with the mesophilic acclimatized culture. When nonacclimatized thermophilic culture was exposed to high ammonia levels (7 g NH4 + N L(-1) ), aceticlastic Methanosarcinaceae spp. was found to be the dominant methanogen.

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BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 12.68
Web of Science (2017): Impact factor 11.392
Effect of organic loading rate and feedstock composition on foaming in manure-based biogas reactors

Foaming is one of the major problems that occasionally occur in biogas plants, affecting negatively the overall digestion process. In the present study, the effect of organic loading rate (OLR) and feedstock composition on foaming was elucidated in continuous reactor experiments. By stepwise increasing the OLR and the concentration of proteins or lipids in the substrate, foaming in biogas reactors was investigated. No foam formation was observed at the OLR of 3.5 g volatile solids/(L-reactor·day). Organic loading was the main factor affecting foam formation in manure digester, while the organic composition, such as content of proteins or lipids were factors that in combination with the organic loading were
triggering foaming. More specifically, gelatine could initiate foam formation at a lower OLR than sodium oleate. Moreover, the volume of foam produced by gelatine was relatively stable and was not increased when further increasing either OLR or gelatine concentration in the feed. © 2013 Elsevier Ltd.

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BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.94 SJR 2.215 SNIP 1.932
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Web of Science (2016): Indexed yes
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Scopus rating (2015): CiteScore 5.47 SJR 2.243 SNIP 1.897
Web of Science (2015): Impact factor 4.917
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.3 SJR 2.399 SNIP 2.087
Web of Science (2014): Impact factor 4.494
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BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 5.97 SJR 2.405 SNIP 2.477
Web of Science (2013): Impact factor 5.039
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.25 SJR 2.334 SNIP 2.461
Web of Science (2012): Impact factor 4.75
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 5.56 SJR 2.308 SNIP 2.507
Web of Science (2011): Impact factor 4.98
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.089 SNIP 2.344
Web of Science (2010): Impact factor 4.365
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.915 SNIP 2.236
Effects of hydrothermal pre-treatments on Giant reed (Arundo donax) methane yield

Twelve hydrothermal pre-treatment combinations of temperature (150 and 180°C), time (10 and 20min) and acid catalyst (no catalyst; H2SO4 at 2% w/w immediately before steam cooking or in 24-h pre-soaking) were tested to assess their effects on methane yield of Giant reed biomass vs. untreated control. A batch anaerobic digestion was conducted with 4g VS l−1 at 53°C for 39 days. Untreated biomass exhibited a potential CH4 yield of 273ml g−1 VS; the four pre-treatments without acid catalyst achieved a 10%, 7%, 23% and 4% yield gain in the respective temperature/time combinations 150°C/10min, 150°C/20min, 180°C/10min and 180°C/20min. Conversely, the eight pre-treatments with H2SO4 catalyst incurred a methanogenic inhibition in association with high SO42− concentration in the hydrolysate, known to enhance sulphate reducing bacteria. Furfurals were also detected in the hydrolysate of five strong pre-treatments with H2SO4 catalyst.
Ethanol production from glucose and xylose by immobilized Thermoanaerobacter pentosaceus at 70 °C in an up-flow anaerobic sludge blanket (UASB) reactor

The newly isolated extreme thermophilic ethanologen Thermoanaerobacter pentosaceus was immobilized in different support materials in order to improve its ethanol production ability. In batch fermentation, a maximum ethanol yield of 1.36 mol mol\(^{-1}\) consumed sugars was obtained by T. pentosaceus immobilized on rapeseed straw. Additionally, immobilized T. pentosaceus' ethanol production was improved by 11 % in comparison to free cells. In continuous mode, it was shown that hydraulic retention time (HRT) affected ethanol yield, and a dramatic shift from ethanol to acetate and lactate production occurred at an HRT of 6 h. The maximum ethanol yield and concentration, 1.50 mol mol\(^{-1}\) consumed sugars and 12.4 g l\(^{-1}\), were obtained with an HRT of 12 h. The latter represented an improvement of 60 % in relation to previously obtained results. This indicates that immobilization of T. pentosaceus is an effective strategy to improve its ethanol production ability.

General information

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Organisations: Department of Environmental Engineering, Residual Resource Engineering, Technical University of Denmark, Burapha University, Thaksin University
Contributors: Sittijunda, S., Tomás, A. F., Reungsang, A., O-thong, S., Angelidaki, I.
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Web of Science (2015): Impact factor 4.917
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BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.3 SJR 2.399 SNIP 2.087
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ISI indexed (2013): ISI indexed yes
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BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.25 SJR 2.334 SNIP 2.461
Web of Science (2012): Impact factor 4.75
ISI indexed (2012): ISI indexed yes
Extreme thermophilic ethanol production from rapeseed straw: using the newly isolated Thermoanaerobacter pentosaceus and combining it with Saccharomyces cerevisiae in a two-step process

The newly isolated extreme thermophile Thermoanaerobacter pentosaceus was used for ethanol production from alkaline-peroxide pretreated rapeseed straw (PRS). Both the liquid and solid fractions of PRS were used. T. pentosaceus was able to metabolize the typical process inhibitors present in lignocellulosic hydrolysate, namely 5-hydroxymethyl furfural (HMF) and furfural, up to concentrations of 1 and 0.5 g l⁻¹, respectively. Above these levels, xylose consumption was inhibited up to 70% (at 3.4 g-furfural l⁻¹) and 75% (at 3.4 g-HMF l⁻¹). T. pentosaceus was able to grow and produce ethanol directly from the liquid fraction of pretreated rapeseed straw, without any dilution or need for additives. However, when the hydrolysate was used undiluted the ethanol yield was only 37% compared to yield of the control, in which pure sugars in synthetic medium were used. The decrease of ethanol yield was attributed to the high amounts of salts resulting from the alkaline-peroxide pretreatment. Finally, a two-stage ethanol production process from PRS using Saccharomyces cerevisiae (utilization of hexoses in the first step) and T. pentosaceus (utilization of pentoses in the second step) was developed. Results showed that the two strains together could achieve up to 85% of the theoretical ethanol yield based on the sugar composition of the rapeseed straw, which was 14% and 50% higher compared to the yield with the yeast or the bacteria alone, respectively. Biotechnol. Bioeng. © 2012 Wiley Periodicals, Inc.
Foaming in manure based digesters: Effect of overloading and foam suppression using antifoam agents

Anaerobic digestion foaming is one of the major problems that occasionally occur in full-scale biogas plants, affecting negatively the overall digestion process. The foam is typically created either in the main biogas reactor or/and in the pre-storage tank and the entrapped solids in the foam cause severe operational problems, such as blockage of mixing devices and collapse of pumps. Furthermore, the foaming problem is linked with economic consequences for biogas plants, due to income losses derived from the reduced biogas production, extra labour work and additional maintenance costs. Moreover, foaming presents adverse environmental impacts owing to the overflowing of the pre-storage or digester tanks.

So far, there has never been thoroughly investigation of foaming problem in manure-based digesters, which is the main anaerobic digestion system applied in Denmark. The purpose of the present study was to investigate the effect of organic loading rate on foam formation and also to evaluate the antifoam efficiency of different chemical compounds on foam suppression.

Thus, the impact of organic loading rate on anaerobic digestion foaming was studied in a continuous mode experiment. A continuous stirred tank reactor, operating under thermophilic conditions (55 °C) was fed with cattle manure. In order to investigate the effect of organic overloading on foam formation, a stepwise increase of the organic loading rate was performed by the addition of glucose in the feeding substrate. Biogas production, methane content in biogas, pH, VFA concentration and the volume of foam formed in the reactor were monitored and recorded in daily basis.

The investigation of possible solutions to counteract foam formation was achieved through the evaluation of the antifoam efficiency of five commercial and non-commercial chemical compounds. The antifoam agents were tested on samples derived from a reactor that was facing foaming problems due to organic overload. The antifoam potential was determined by the aeration method and was defined using three parameters: foaming tendency, normalised foaming tendency and foam stability.

The results obtained from the above experiments showed that the organic loading rate had a significant impact on foam formation. Finally, it was observed that using specific chemical defoamers, the foaming propensity of the substrate was minimized. However, the efficiency of the defoamers varied significantly, revealing that their chemical composition affected differently the foam mechanism.

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Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Kougias, P., Tsapekos, P., Boe, K., Angelidaki, I.
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Growth of Saccharina and Palmaria compared to chemical and physical parameters in the inner Danish waters

Algae as feedstock for high value-added products such as nutraceuticals and low value product such as energy are getting more attention in Denmark. Few macroalgal producers have initiated off shore cultivation of macroalgae, even though the high demand on cultivation ropes and algal biomass. Algal biomass (and the seeded cultivation ropes) is the bottle neck in algal research as well as business in Denmark. Furthermore, cultivation experiments are needed to investigate the suitability of the inner Danish water (with e.g. decreasing salinity, and different nutrient regimes) for macroalgal cultivation.

Macroalgae will be cultivated on ropes deployed at 6 locations in the sea more specifically Limfjorden in the North to further South in Horsens, Fredericia, Fåborg, Agersø and Bisserup in the Southern part of Denmark. Among other things, salinity and nutrient availability are important variables for the fitness and growth of macroalgae. The macroalgae will be deployed at 2 depths; 3 m and 6 m to see a possible effect of halocline (salinity stratification). Growth data of weight, length and biomass composition (especially N, P, TS, VS) will be analyzed in different seasons. A modeling in the Geographical Information System ArcGIS on the obtained field data compared to the chemical and physical parameters (e.g. salinity (halocline), nutrient availability, currents, and cultivation areas for organic macroalgae). The macroalgal growth, biomass composition, the arcGIS, and the field samples on the variables will give a map of suitable areas for S. latissima and P. palmata cultivation in the inner Danish waters. The hypothesis is that the macroalgae perform better at higher salinities (further North and/or below the halocline) and in nutrient rich areas where light is not limited.

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Organisations: Department of Environmental Engineering, Residual Resource Engineering, Roskilde University
Contributors: Holdt, S. L., Grandorf, U. S., Angelidaki, I., Pedersen, M. F.
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High effective harvesting of microalgae Chlorella prothocoloides via flocculation with cationic starch

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Hollow fiber membrane based H-2 diffusion for efficient in situ biogas upgrading in an anaerobic reactor

Bubbleless gas transfer through a hollow fiber membrane (HFM) module was used to supply H2 to an anaerobic reactor for in situ biogas upgrading, and it creates a novel system that could achieve a CH4 content higher than 90 % in the biogas. The increase of CH4 content and pH, and the decrease of bicarbonate concentration were related with the increase of the H2 flow rate. The CH4 content increased from 78.4 % to 90.2 % with the increase of the H2 flow rate from 930 to 1,440 ml/(l day), while the pH in the reactor remained below 8.0. An even higher CH4 content (96.1 %) was achieved when the H2 flow rate was increased to 1,760 ml/(l/day); however, the pH increased to around 8.3 due to bicarbonate consumption which hampered the anaerobic process. The biofilm formed on the HFM was found not to be beneficial for the process since it increased the resistance of H2 diffusion to the liquid. The study also demonstrated that the biofilm formed on the membrane only contributed 22-36 % to the H2 consumption, while most of the H2 was consumed by the microorganisms in the liquid phase.
Hydrogen and methane production from desugared molasses using a two-stage thermophilic anaerobic process

Hydrogen and methane production from desugared molasses by a two-stage thermophilic anaerobic process was investigated in a series of two up-flow anaerobic sludge blanket (UASB) reactors. The first reactor that was dominated with hydrogen-producing bacteria of Thermoanaerobacterium thermosaccharolyticum and Thermoanaerobacterium aciditolerans could generate a high hydrogen production rate of 5600 mL H2/day/L, corresponding to a yield of 132 mL H2/g volatile solid (VS). The effluent from the hydrogen reactor was further converted to methane in the second reactor with the optimal production rate of 3380 mL CH4/day/L, corresponding to a yield of 239 mL CH4/g VS. Aceticlastic Methanosarcina mazei was the dominant methanogen in the methanogenesis stage. This work demonstrates that biohydrogen production can be very efficiently coupled with a subsequent step of methane production using desugared molasses. Furthermore, the mixed gas with a volumetric content of 16.5% H2, 38.7% CO2, and 44.8% CH4, containing approximately 15% energy by hydrogen is viable to be bio-hythane.

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Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Kongjan, P., O-Thong, S., Angelidaki, I.
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Scopus rating (2016): CiteScore 2.1 SJR 0.656 SNIP 0.779
Web of Science (2016): Impact factor 1.698
Scopus rating (2015): CiteScore 2.24 SJR 0.738 SNIP 0.894
Web of Science (2015): Impact factor 2.168
Increased power generation from primary sludge by a submersible microbial fuel cell and optimum operational conditions

Microbial fuel cells (MFCs) have received attention as a promising renewable energy technology for waste treatment and energy recovery. We tested a submersible MFC with an innovative design capable of generating a stable voltage of 0.250 ± 0.008 V (with a fixed 470 Ω resistor) directly from primary sludge. In a polarization test, the maximum power density was 0.18 W/m² at a current density of 0.8 A/m² with an external resistor of 300 Ω. The anodic solution of the primary sludge needs to be adjusted to a pH 7 for high power generation. The modified primary sludge with an added phosphate buffer prolonged the current generation and increased the power density by 7 and 1.5 times, respectively, in comparison with raw primary sludge. These findings suggest that energy recovery from primary sludge can be maximized using an advanced MFC system with optimum conditions.

General information
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Organisations: Department of Environmental Engineering, Residual Resource Engineering, Technical University of Denmark, Kyung Hee University
Contributors: Vologni, V., Kakarla, R., Angelidaki, I., Min, B.
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Scopus rating (2017): CiteScore 2.22 SJR 0.64 SNIP 0.829
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Web of Science (2016): Indexed yes
Increasing the precision of microplate measurements of algal growth rate

General information
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Organisations: Department of Environmental Engineering, Residual Resource Engineering, Technical University of Denmark
Life Cycle Assessment of a brown seaweed-based third-generation biorefinery process

General information
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Research output: Research - peer-review › Poster – Annual report year: 2013

The use of algae for biofuel production is expected to play an important role in securing energy supply in the next decades. A consequential lifecycle assessment (LCA) and an energy analysis of seaweed-based biofuel production were carried out in Nordic conditions to document and improve the sustainability of the process. Two scenarios were analyzed for the brown seaweed (Laminaria digitata), namely, biogas production (scenario 1) and bioethanol + biogas production (scenario 2). Potential environmental impact categories under investigation were Global Warming, Acidification and Terrestrial Eutrophication. The production of seaweed was identified to be the most energy intensive step. Scenario 1 showed better performance compared to scenario 2 for all impact categories, partly because of the energy intensive bioethanol separation process and the consequently lower overall efficiency of the system. For improved environmental performance, focus should be on optimization of seaweed production, bioethanol distillation, and management of digestate on land.

Life cycle assessment of biofuel production from brown seaweed in Nordic conditions

The use of algae for biofuel production is expected to play an important role in securing energy supply in the next decades. A consequential lifecycle assessment (LCA) and an energy analysis of seaweed-based biofuel production were carried out in Nordic conditions to document and improve the sustainability of the process. Two scenarios were analyzed for the brown seaweed (Laminaria digitata), namely, biogas production (scenario 1) and bioethanol + biogas production (scenario 2). Potential environmental impact categories under investigation were Global Warming, Acidification and Terrestrial Eutrophication. The production of seaweed was identified to be the most energy intensive step. Scenario 1 showed better performance compared to scenario 2 for all impact categories, partly because of the energy intensive bioethanol separation process and the consequently lower overall efficiency of the system. For improved environmental performance, focus should be on optimization of seaweed production, bioethanol distillation, and management of digestate on land.
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Web of Science (2015): Indexed yes
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Scopus rating (2014): CiteScore 5.3 SJR 2.399 SNIP 2.087
Web of Science (2014): Impact factor 4.494
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Scopus rating (2012): CiteScore 5.25 SJR 2.334 SNIP 2.461
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ISI indexed (2012): ISI indexed yes
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Scopus rating (2009): SJR 1.915 SNIP 2.236
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BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.736 SNIP 2.74
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Scopus rating (2007): SJR 1.403 SNIP 2.396
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Scopus rating (2005): SJR 1.278 SNIP 1.98
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.19 SNIP 1.655
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.942 SNIP 1.665
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.908 SNIP 1.294
Web of Science (2002): Indexed yes
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Scopus rating (2000): SJR 0.653 SNIP 1.023
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Lipid profiles of yeast cells under different growth conditions

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Methods and apparatus for hydrogen based biogas upgrading
The present invention relates to an anaerobic process for biogas upgrading and hydrogen utilization comprising the use of acidic waste as co-substrate. In this process, H2 and CO2 will be converted to CH4, which will result in lower CO2 content in the biogas. The invention relates to both in situ and ex situ methods of biogas upgrading. The invention further relates to a bioreactor comprising hollow fibre membranes.

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Contributors: Luo, G., Angelidaki, I., Lyhne, P.
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Microalgae Biorefinery - Industrial Symbiosis

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Microwave and thermal pretreatment as methods for increasing the biogas potential of secondary sludge from municipal wastewater treatment plants
In the present study, the sludge was pretreated with microwave irradiation and low-temperature thermal method, both conducted under the same temperature range (30–100°C). Microwave pretreatment was found to be superior over the thermal treatment with respect to sludge solubilization and biogas production. Taking into account the specific energy demand of solubilization, the sludge pre-treated at 60–70°C by microwaves of 900W was chosen for further experiments in continuous mode, which was more energetically sustainable compared to lower value (700W) and thermal treatment. Continuous biogas reactor experiments indicated that pre-treated sludge (microwave irradiation: 900W, temperature:...
60–70°C) gave 35% more methane, compared to untreated sludge. Moreover, the results of this study clearly demonstrated that microwave pretreated sludge showed better degree of sanitation.
Optimization of bioethanol production from carbohydrate rich wastes by extreme thermophilic microorganisms

Second-generation bioethanol is produced from residual biomass such as industrial and municipal waste or agricultural and forestry residues. However, Saccharomyces cerevisiae, the microorganism currently used in industrial first-generation bioethanol production, is not capable of converting all of the carbohydrates present in these complex substrates into ethanol. This is in particular true for pentose sugars such as xylose, generally the second major sugar present in
 lignocellulosic biomass. The transition of second-generation bioethanol production from pilot to industrial scale is hindered by the recalcitrance of the lignocellulosic biomass, and by the lack of a microorganism capable of converting this feedstock to bioethanol with high yield, efficiency and productivity. In this study, a new extreme thermophilic ethanologenic bacterium was isolated from household waste. When assessed for ethanol production from xylose, an ethanol yield of 1.39 mol mol⁻¹ xylose was obtained. This represents 83 % of the theoretical ethanol yield from xylose and is to date the highest reported value for a native, not genetically modified microorganism. The bacterium was identified as a new member of the genus *Thermoanaerobacter*, named *Thermoanaerobacter pentosaceus* and was subsequently used to investigate some of the factors that influence second-generation bioethanol production, such as initial substrate concentration and sensitivity to inhibitors. Furthermore, *T. pentosaceus* was used to develop and optimize bioethanol production from lignocellulosic biomass using a range of different approaches, including combination with other microorganisms and immobilization of the cells. *T. pentosaceus* could produce ethanol from a wide range of substrates without the addition of nutrients such as yeast extract and vitamins to the medium. It was initially sensitive to concentrations of 10 g l⁻¹ of xylose and 1 % (v/v) ethanol. However, long term repeated batch cultivation showed that the strain was capable of adaptation to higher substrate concentrations, at least up to 20 g l⁻¹ xylose. *T. pentosaceus* was able to metabolize two typical inhibitors present in lignocellulosic hydrolysate, 5-hydroxymethylfurfural (HMF) and 2-furfural, up to concentrations of 1 and 0.5 g l⁻¹, respectively. Above these levels, xylose consumption was inhibited up to 75 % (at 3.4 g l⁻¹ 5-HMF) and 70 % (at 3.4 g l⁻¹ furfural). *T. pentosaceus* could grow and produce ethanol directly from the liquid fraction of pretreated rapeseed straw, without any dilution or need for additives. When *T. pentosaceus* was used in combination with *S. cerevisiae* in a sequential fermentation of pretreated rapeseed straw, it achieved 85 % of the theoretical ethanol yield based on the sugar composition of the rapeseed straw. This was 50 % and 14 % higher than the yield obtained with the bacteria or the yeast alone, respectively. When *T. pentosaceus* was immobilized in rapeseed straw, an improvement of 11 % in ethanol production was observed in batch mode. In continuous mode, it was shown that hydraulic retention time (HRT) affected ethanol yield, and a dramatic shift from ethanol to acetate and lactate production occurred at an HRT of 6 h. The maximum ethanol yield and concentration, 1.50 mol mol⁻¹ consumed sugars and 12.4 g l⁻¹, were obtained with an HRT of 12 h. The latter represented an improvement of 60 % in relation to previously obtained results. The results obtained confirm that the extreme thermophile *T. pentosaceus* is a promising candidate for bioethanol production from lignocellulosic biomass, and that improvement and optimization of existing processes are possible using different approaches. Further insight into the metabolism of the strain, as well as its improvement by genetic engineering can bring second-generation ethanol production one step closer to its industrial application.

**General information**

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Contributors: Tomás, A. F., Angelidaki, I., Karakashev, D. B.
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**Performance and microbial community analysis of the anaerobic reactor with coke oven gas biomethanation and in situ biogas upgrading**

A new method for simultaneous coke oven gas (COG) biomethanation and in situ biogas upgrading in anaerobic reactor was developed in this study. The simulated coke oven gas (SCOG) (92% H₂ and 8% CO) was injected directly into the anaerobic reactor treating sewage sludge through hollow fiber membrane (HFM). With pH control at 8.0, the added H₂ and CO were fully consumed and no negative effects on the anaerobic degradation of sewage sludge were observed. The maximum CH₄ content in the biogas was 99%. The addition of SCOG resulted in enrichment and dominance of homoacetogenetic genus Treponema and hydrogenotrophic genus Methanoculleus in the liquid, which indicated that H₂ were converted to methane by both direct (hydrogenotrophic methanogenesis) and indirect (homoacetogenesis + aceticlastic methanogenesis) pathways in the liquid. However, the aceticlastic genus Methanosaeta was dominant for archaea in the biofilm on the HFM, which indicated indirect (homoacetogenesis + aceticlastic methanogenesis) H₂ conversion pathway on the biofilm.

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**General information**

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Simultaneous production of hydrogen and ethanol from waste glycerol by Enterobacter aerogenes KKU-S1

Factors affecting simultaneous hydrogen and ethanol production from a newly isolated bacterium Enterobacter aerogenes KKU-S1 were investigated employing response surface methodology (RSM) with central composite design (CCD). The Plackett-Burman design was first used to screen the factors influencing simultaneous hydrogen and ethanol production, i.e., initial pH, temperature, amount of vitamin solution, yeast extract (YE) concentration and glycerol concentration. Results indicated that initial pH, temperature, YE concentration, and glycerol concentration had a statistically significant effect ($p \leq 0.05$) on hydrogen production rate (HPR) and ethanol production. The significant factors were further optimized using CCD. Optimum conditions for simultaneously maximizing HPR and ethanol production were YE concentration of 1.00 g/L, glycerol concentration of 37 g/L, initial pH of 8.14, and temperature of 37 °C in which a maximum HPR and ethanol production of 0.24 mmol H2/L h and 120 mmol/L were achieved.

General information
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Contributors: Reungsang, A., Sittijunda, S., Angelidaki, I.
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BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.74 SJR 1.145 SNIP 1.315
Web of Science (2016): Impact factor 3.582
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
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Web of Science (2015): Indexed yes
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Scopus rating (2014): CiteScore 3.54 SJR 1.207 SNIP 1.484
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Scopus rating (2013): CiteScore 3.38 SJR 1.265 SNIP 1.449
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ISI indexed (2013): ISI indexed yes
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BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 3.96 SJR 1.499 SNIP 1.708
Web of Science (2012): Impact factor 3.548
ISI indexed (2012): ISI indexed yes
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Web of Science (2011): Impact factor 4.054
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Scopus rating (2010): SJR 1.579 SNIP 1.854
Web of Science (2010): Impact factor 4.057
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.32 SNIP 1.87
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.389 SNIP 2.073
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.266 SNIP 2.197
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.061 SNIP 2.202
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.116 SNIP 1.825
Scopus rating (2004): SJR 1.232 SNIP 1.626
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.996 SNIP 1.289
Scopus rating (2002): SJR 0.748 SNIP 1.156
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Scopus rating (2000): SJR 0.384 SNIP 0.83
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Succinic acid production from Jerusalem artichoke

General information
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Organisations: Department of Environmental Engineering, Residual Resource Engineering
Number of pages: 1
Publication date: 2013
Peer-reviewed: Yes
Succinic acid production from Jerusalem artichoke

In this work, A. succinogenes 130Z was used to produce succinic acid from Jerusalem artichoke tuber hydrolysate. Results showed that both fructose and glucose in the tuber hydrolysate were utilized for succinic acid production. The sugar utilization was found to be dependent on process control, hence, when pH was fixed at 6.8 the sugar utilization of fructose was increased from 68.6% to 96.5% and the succinic acid production was also increased by 26.4% to yield 26.8 g/L succinic acid. In this study a one-step pretreatment/hydrolysis method was used where no enzymes were used. Our work suggests that Jerusalem artichoke tubers could be utilized for production of bio-succinic acid.

Thermoanaerobacter pentosaceus sp. nov., an anaerobic, extreme thermophilic, high ethanol-yielding bacterium isolated from household waste

An extremely thermophilic, xylanolytic, spore-forming and strict anaerobic bacterium DTU01(T) was isolated from a continuously stirred tank reactor fed with xylose and household waste. Cells stained Gram-negative and were rod-shaped (0.5-2 µm in length). Spores were terminal with a diameter of approximately 0.5 µm. Optimal growth occurred at 70 °C and pH(25°C) 7, with a maximum growth rate of 0.1 h-1. DNA G+C content was 34.2 mol %. Strain DTU01(T) could ferment arabinose, cellobiose, fructose, galactose, glucose, inulin, lactose, mannose, melibiose, pectin, starch, sucrose, xylan, yeast extract and xylose, but not cellulose, Avicel®, mannitol, inositol, glycerol, acetate, lactate, ethanol, butanol or peptone. Ethanol was the major fermentation product and a maximum yield of 1.39 mol of ethanol per mol xylose was achieved when sulphite was added to the cultivation medium. Thiou sulphite, but not sulphate, nitrate or nitrite, could be used as electron acceptor. On the basis of 16S rRNA gene sequence similarity, strain DTU01(T) was shown to be closely related to Thermoanaerobacter mahanii A3(T), T. italicus Ab9(T) and T. thermocopriae JT3-3(T), with 98-99% similarity. Despite this, the physiological and phylogenetic differences (DNA G+C content, substrate utilization, electron acceptors, phylogenetic distance, isolation site) allow for the proposal of strain DTU01(T) as a new species within the genus Thermoanaerobacter, for which the name Thermoanaerobacter pentosaceus sp. nov. is proposed, with the type strain DTU01(T) (DSM 25963 = KCTC 4529).
Alkaline peroxide pretreatment of rapeseed straw for enhancing bioethanol production by Same Vessel Saccharification and Co-Fermentation

Alkaline peroxide pretreatment of rapeseed straw was evaluated for conversion of cellulose and hemicellulose to fermentable sugars. After pretreatment, a liquid phase called pretreatment liquid and a solid phase were separated by filtration. The neutralized pretreatment liquids were used in a co-fermentation process, with Saccharomyces cerevisiae and Pichia stipitis. The solid fraction was used for simultaneous saccharification and co-fermentation process in the same vessel. The effects of various operating variables were investigated. Pretreatment with 5% (v/v) H2O2 at 50°C for 1h was found to be the optimal pretreatment combination with respect to overall ethanol production. At this condition, 5.73g ethanol was obtained from pretreatment liquid and 14.07g ethanol was produced by co-fermentation of solid fraction with P. stipitis. Optimum delignification was observed when 0.5M MgSO4 was included in the pretreatment mixture, and it resulted in 0.92% increase in ethanol production efficiency.
A simple and rapid method for monitoring dissolved oxygen in water with a submersible microbial fuel cell (SBMFC)

A submersible microbial fuel cell (SBMFC) was developed as a biosensor for in situ and real time monitoring of dissolved oxygen (DO) in environmental waters. Domestic wastewater was utilized as sole fuel for powering the sensor. The sensor performance was firstly examined with tap water at varying DO levels. With an external resistance of 1000 Ω, the current density produced by the sensor (5.6±0.5~462.2±0.5 mA/m²) increased linearly with DO level up to 8.8±0.3 mg/L (regression coefficient, R²=0.9912), while the maximum response time for each measurement was less than 4 min. The current density showed different response to DO levels when different external resistances were applied, but a linear relationship was always observed. Investigation of the sensor performance at different substrate concentrations indicates that the organic matter contained in the domestic wastewater was sufficient to power the sensing activities. The sensor ability was further explored under different environmental conditions (e.g., pH, temperature, conductivity, alternative electron acceptor), and the results indicated that a calibration would be required before field application. Lastly, the sensor was tested with different environmental waters and the results showed no significant difference (p>0.05) with that measured by DO meter. The simple, compact SBMFC sensor showed promising potential for direct, inexpensive and rapid DO monitoring in various environmental waters.

General information
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Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Zhang, Y., Angelidaki, I.
Pages: 189-194
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BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 7.83 SJR 2.373 SNIP 1.65
Web of Science (2017): Impact factor 8.173
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 7.22 SJR 2.095 SNIP 1.619
Web of Science (2016): Impact factor 7.78
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 7.07 SJR 2.044 SNIP 1.671
Web of Science (2015): Impact factor 7.476
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 6.57 SJR 2.057 SNIP 1.716
Web of Science (2014): Impact factor 6.409
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 6.34 SJR 2.029 SNIP 1.726
Web of Science (2013): Impact factor 6.451
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 5.7 SJR 2.397 SNIP 1.592
Web of Science (2012): Impact factor 5.437
Bioaugmentation strategies of ammonia tolerant methanogenic consortia in continuous stirred tank reactors

General information
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Organisations: Department of Environmental Engineering, Residual Resource Engineering, Technical University of Denmark
Number of pages: 1
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Bioaugmentation strategies of ammonia tolerant methanogenic consortia in continuous stirred tank reactors.pdf
Source: dtu
Source-ID: u::6892
Research output: Research - peer-review › Poster – Annual report year: 2013

Bioelectrode-based approach for enhancing nitrate and nitrite removal and electricity generation from eutrophic lakes
Nitrate and nitrite contamination of surface waters (e.g., lakes) has become a severe environmental and health problem, especially in developing countries. The recent demonstration of nitrate reduction at the cathode of microbial fuel cell (MFC) provides an opportunity to develop a new technology for nitrogen removal from surface waters. In this study, a sediment-type MFC based on two pieces of bioelectrodes was employed as a novel in situ applicable approach for nitrogen removal, as well as electricity production from eutrophic lakes. Maximum power density of 42 and 36 mW/m²
were produced respectively from nitrate- and nitrite-rich synthetic lake waters at initial concentration of 10 mg-N/L. Along with the electricity production a total nitrogen removal of 62% and 77% was accomplished, for nitrate and nitrite, respectively. The nitrogen removal was almost 4 times higher under close-circuit condition with biocathode, compared to either the open-circuit operation or with abiotic cathode. The mass balance on nitrogen indicates that most of the removed nitrate and nitrite (84.7±0.1% and 81.8±0.1%, respectively) was reduced to nitrogen gas. The nitrogen removal and power generation was limited by the dissolved oxygen (DO) level in the water and acetate level injected to the sediment. Excessive oxygen resulted in dramatically decrease of nitrogen removal efficiency and only 7.8% removal was obtained at DO level of 7.8 mg/l. The power generation and nitrogen removal increased with acetate level and was nearly saturated at 0.84 mg/g-sediment. This bioelectrode-based in situ approach is attractive not only due to the electricity production, but also due to no need of extra reactor construction, which may broaden the application possibilities of sediment MFC technology.

**General information**

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BFI (2017): BFI-level 2  
Scopus rating (2017): CiteScore 7.55 SJR 2.601 SNIP 2.358  
Web of Science (2017): Impact factor 7.051  
Web of Science (2017): Indexed yes  
BFI (2016): BFI-level 2  
Scopus rating (2016): CiteScore 7.49 SJR 2.663 SNIP 2.563  
Web of Science (2016): Impact factor 6.942  
Web of Science (2016): Indexed yes  
BFI (2015): BFI-level 2  
Scopus rating (2015): CiteScore 6.63 SJR 2.665 SNIP 2.482  
Web of Science (2015): Impact factor 5.991  
Web of Science (2015): Indexed yes  
BFI (2014): BFI-level 2  
Scopus rating (2014): CiteScore 6.13 SJR 2.946 SNIP 2.702  
Web of Science (2014): Impact factor 5.528  
Web of Science (2014): Indexed yes  
BFI (2013): BFI-level 2  
Scopus rating (2013): CiteScore 6.02 SJR 2.956 SNIP 2.676  
Web of Science (2013): Impact factor 5.323  
ISI indexed (2013): ISI indexed yes  
Web of Science (2013): Indexed yes  
BFI (2012): BFI-level 2  
Scopus rating (2012): CiteScore 5.15 SJR 2.914 SNIP 2.442  
Web of Science (2012): Impact factor 4.655  
ISI indexed (2012): ISI indexed yes  
Web of Science (2012): Indexed yes  
BFI (2011): BFI-level 2  
Scopus rating (2011): CiteScore 5.43 SJR 2.862 SNIP 2.355  
Web of Science (2011): Impact factor 4.865  
ISI indexed (2011): ISI indexed yes
Biohydrogen production from arabinose and glucose using extreme thermophilic anaerobic mixed cultures

Background Second generation hydrogen fermentation technologies using organic agricultural and forestry wastes are emerging. The efficient microbial fermentation of hexoses and pentoses resulting from the pretreatment of lignocellulosic materials is essential for the success of these processes. Results Conversion of arabinose and glucose to hydrogen, by extreme thermophilic anaerobic mixed cultures was studied in continuous (70°C, pH 5.5) and batch (70°C, pH 5.5 and pH 7) assays. Two EGSB reactors, Rarab and Rgluc, were continuously fed with arabinose and glucose, respectively. No significant differences in reactor performance were observed for arabinose and glucose organic loading rates (OLR) ranging from 4.3 to 7.1 kgCOD m⁻³ d⁻¹. However, for an OLR of 14.2 kgCOD m⁻³ d⁻¹, hydrogen production rate and hydrogen yield were higher in Rarab than in Rgluc (average hydrogen production rate of 3.2 and 2.0 LH₂ L⁻¹ d⁻¹ and hydrogen yield of 1.10 and 0.75 molH₂ mol⁻¹ substrate for Rarab and Rgluc, respectively). Lower hydrogen production in Rgluc was associated with higher lactate production. DGGE results revealed no significant difference on the bacterial community composition between operational periods and between the reactors. Increased hydrogen production was observed in batch experiments when hydrogen partial pressure was kept low, both with arabinose and glucose as substrate. Sugars were completely consumed and hydrogen production stimulated (62% higher) when pH 7 was used instead of pH 5.5. Conclusions Continuous hydrogen production rate from arabinose was significantly higher than from glucose, when higher organic loading rate was used. The effect of hydrogen partial pressure on hydrogen production from glucose in batch mode was related to the extent of sugar utilization and not to the efficiency of substrate conversion to hydrogen. Furthermore, at pH 7.0, sugars uptake, hydrogen production and yield were higher than at pH 5.5, with both arabinose and glucose as substrates.

General information
**DSMZ 24726 for second generation bioethanol production**

The present invention relates to a novel anaerobic, extreme thermophilic, ethanol high-yielding bacterium. The invention is based on the isolation of the bacterial strain referred to herein as "DTU01", which produces ethanol as the main fermentation product, followed by acetate and lactate. The isolated organism is an extremely interesting and very promising organism for the establishment of a sustainable bioethanol production process. The invention further relates to a method for producing a fermentation product such as ethanol.

**General information**

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Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Angelidaki, I., Tomás, A. F., Karakashev, D. B.
Publication date: 2012

**Publication information**

Country: Denmark
IPC: C12R1/01
Patent number: WO2012059105
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**Bibliographical note**

DTU reference number: 92541-10
Research output: Research - peer-review → Journal article – Annual report year: 2012

**Effect of continuous oleate addition on microbial communities involved in anaerobic digestion process**

In the present study, the microbial diversity in anaerobic reactors, continuously exposed to oleate, added to a manure reactor influent, was investigated. Relative changes in archaeal community were less remarkable in comparison to changes in bacterial community indicating that dominant archaeal composition remained relatively stable. Majority of the analyzed bacterial amplicons were phylogenetically affiliated with uncultured bacteria belonging to Firmicutes, Bacteroidetes, Proteobacteria and Thermotogae phyla. Bacterial community changes in response to oleate addition resulted in a less diverse bacterial consortium related to functional specialization of the species towards oleate degradation. For the archaeal domain, the sequences were affiliated within Euryarchaeota phylum with three major groups (Methanosarcina, Methanosaeta and Methanobacterium genera). Results obtained in this study deliver a comprehensive picture on oleate degrading microbial communities in high organic strength wastewater. The findings might be utilized for development of strategies for biogas production from lipid-riched wastes.

**General information**

State: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering, Catalan Institute for Water Research
Contributors: Baserba, M. G., Angelidaki, I., Karakashev, D. B.
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Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 6.28 SJR 2.029 SNIP 1.799
Web of Science (2017): Impact factor 5.807
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Effect of substrates and intermediate compounds on foaming in manure digestion systems

Manure contains several compounds that can potentially cause foaming during anaerobic digestion. Understanding the effect of substrates and intermediate compounds on foaming tendency and stability could facilitate strategies for foaming prevention and recovery of the process. In this study, the effect of physicochemical properties of substrates and intermediate compounds on liquid properties such as surface tension, surfactant property, and hydrophobicity were investigated and compared with the effect on foaming tendency and foam stability. The results showed that there was no consistent correlation between foaming potential and hydrophobicity, oil displacement area (ODA) or surface tension of the tested solutions, and the best way to determine the foaming property of the solution was to directly measure foaming tendency and foam stability. Na-oleate and acetic acid showed the highest potential to create foam in a manure digester. Moreover, high organic loading of lipids and protein, and high concentrations of acetic and butyric acids also showed a strong tendency to create foaming during anaerobic digestion. Due to their great ability to stabilize foam, high organic loadings of Na-oleate or gelatine were considered to be the main potential foaming problem.

General information
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Organisations: Department of Environmental Engineering, Residual Resource Engineering, Technical University of Denmark
Contributors: Boe, K., Koulias, P., Pacheco, F., O-Thong, S., Angelidaki, I.
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Peer-reviewed: Yes

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Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.34 SJR 0.429 SNIP 0.574
Web of Science (2017): Impact factor 1.247
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.3 SJR 0.404 SNIP 0.637
Web of Science (2016): Impact factor 1.197
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.19 SJR 0.464 SNIP 0.594
Web of Science (2015): Impact factor 1.064
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.14 SJR 0.585 SNIP 0.683
Web of Science (2014): Impact factor 1.106
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 1.3 SJR 0.571 SNIP 0.701
Web of Science (2013): Impact factor 1.212
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 1.13 SJR 0.597 SNIP 0.659
Web of Science (2012): Impact factor 1.102
Electric power generation by a submersible microbial fuel cell equipped with a membrane electrode assembly

Membrane electrode assemblies (MEAs) were incorporated into the cathode chamber of a submersible microbial fuel cell (SMFC). A close contact of the electrodes could produce high power output from SMFC in which anode and cathode electrodes were connected in parallel. In polarization test, the maximum power density was 631mW/m² at current density of 1772mA/m² at 82Ω. With 180-Ω external resistance, one set of the electrodes on the same side could generate more power density of 832±4mW/m² with current generation of 1923±4mA/m². The anode, inclusive a biofilm behaved ohmic, whereas a Tafel type behavior was observed for the oxygen reduction. The various impedance contributions from electrodes, electrolyte and membrane were analyzed and identified by electrochemical impedance spectroscopy. Air flow rate to the cathode chamber affected microbial voltage generation, and higher power generation was obtained at relatively low air flow less than 2mL/min.

General information
State: Published
Organisations: Department of Environmental Engineering, Department of Energy Conversion and Storage, Imaging and Structural Analysis, Department of Chemical and Biochemical Engineering, Center for BioProcess Engineering, Residual Resource Engineering
Contributors: Min, B., Poulsen, F. W., Thygesen, A., Angelidaki, I.
Energy recovery from waste streams with microbial fuel cell (MFC)-based technologies

Microbial fuel cell (MFC)-based technologies promise technologies for direct energy production from various wastewaters and waste streams. Besides electrical power production, more emphasis is recently devoted to alternative applications such as hydrogen production, bioremediation, seawater desalination, and biosensors. Although the technologies promise much, a number of hurdles need to be overcome before field applications are economically feasible. The main purpose of this work was to improve the performance, reduce the construction cost, and expand the application scopes of MFC-based bio-electrochemical systems.

A self-powered submersible microbial electrolysis cell was developed for in situ biohydrogen production from anaerobic reactors. The hydrogen production increased along with acetate and buffer concentration. The hydrogen production rate of 32.2 mL/L/d and yield of 1.43 mol-H2/mol-acetate were achieved. Alternate exchanging the function between the two cell units was found to be an effective approach to inhibit methanogens. A sensor, based on a submersible microbial fuel cell, was developed for in situ monitoring of microbial activity and biochemical oxygen demand in groundwater. Presence or absence of a biofilm on the anode was a decisive factor for the applicability of the sensor. Temperature, pH, conductivity and inorganic solid content were significantly affecting the sensitivity of the sensor. The sensor showed good performance both with artificial and real groundwater. A submersible microbial fuel cell sensor was developed for in situ and real time monitoring of dissolved oxygen (DO) in environmental waters. The current density produced by the sensor increased linearly with DO level up to 8.8±0.3 mg/L. The sensor ability was further explored under different environmental conditions. The sensor can measure DO in different environmental waters with less deviations.

To improve the voltage output of MFC from lake sediment, an innovative self-stacked submersible MFC was developed. The system successfully produced a maximum power density of 294 mW/m2 and had an open circuit voltage (OCV) of 1.12 V. In addition, voltage reversal was studied in detail in terms of its cause, determining parameters and elimination method. Use of a capacitor was found to be an effective way to prevent voltage reversal and at the same time store power. A sediment-type MFC based on two pieces of bioelectrodes was employed as a novel in situ applicable approach for nitrate/nitrite removal, as well as electricity production from eutrophic lakes. The nitrogen removal and power generation were limited by the DO level in the water and acetate level injected to the sediment. The proposed approach may be promising avenue for drinking water treatment and energy recovery.
Enrichment of high ammonia tolerant methanogenic culture
Ammonia is the major toxicant in full scale anaerobic digesters of animal wastes which are rich in proteins and/or urea, such as pig or poultry wastes. Ammonia inhibition decreases methane production rates, increases volatile fatty acids concentration and leads to economic losses for the biogas plants. The methods used today to counteract ammonia inhibition are slow and costexpensive. A new biological approach to avoid or counteract ammonia inhibition by using ammonia tolerant methanogens, could provide a sustainable solution for cost-effective digestion of abundant ammonia-rich wastes. The aim of the current study was to isolate and identify methanogenic cultures tolerant to high ammonia concentrations. A mixed methanogenic population was stepwise exposed to ammonia concentrations (1 to 9.26 g NH4+-N L-1) during an enrichment process with successive batch cultivations. The methanogenic population was derived from a full scale biogas reactor (Hashøj, Denmark), fed with 75% animal manure and 25% food industries organic waste. Basal anaerobic medium was used for the enrichment along with sodium acetate (1 g HAc L-1) as a carbon source. Fluorescence insitu hybridization (FISH) was used to determine microbial community composition. The outcome of the enrichment process was a mesophilic aceticlastic methanogenic enriched culture able to withstand high ammonia loads and utilize acetate and form methane stoichiometrically. FISH analysis showed that the methanogens of the enriched culture belonged exclusively to strict aceticlastic methanogens. Results obtained in this study, demonstrated for the first time that strictly aceticlastic methanogens, derived from an enriched culture, can efficiently produce methane under high ammonia levels.

Foaming in manure based digesters: Causes and solutions
Anaerobic digestion foaming is one of the major problems that occasionally occurred in the Danish full-scale biogas plants, affecting negatively the overall digestion process. The foam is typically formatted in the main biogas reactor or in the pre-storage tank and the entrapped solids in the foam cause severe operational problems, such as blockage of mixing devices, and collapse of pumps. Furthermore, the foaming problem is linked with economic consequences for biogas plants, due to income losses derived from the reduced biogas production, extra labour work and additional maintenance costs. Moreover, foaming presents adverse environmental impacts owing to the overflowing of the pre-storage or digester tanks. So far, there has never been thoroughly investigation of foaming problem in manure-based digesters, which is the main anaerobic digestion applied in Denmark. The purpose of the present study was to identify potential causes of foaming in manure based digesters. Moreover, it was also an aim to investigate possible solutions to counteract foam formation with the use of antifoam agents. Thus, the impact of organic loading rate and content of feeding substrate on anaerobic digestion foaming was studied in continuous mode experiments. Two sets of treatments were examined in duplicate using 5 continuous stirred tank reactors (working volume 1.5L), operating in thermophilic conditions. Two replicate reactors were fed with cattle manure and gelatine, as a representative of proteins, while the other two replicates were fed with cattle manure and Na-oleate, as a representative of lipids. One reactor was kept as a control and was fed only with cattle manure. The experiment was divided in 5 periods. During the 1st, 3rd and 5th period the organic loading rate of all reactors was increased by the addition of glucose in the feeding substrate. During the 2nd and 4th period the organic loading rate was maintained constant, but instead of glucose, higher concentration of Na-oleate or gelatine was added in the feeding substrate. The results obtained from the above experiment showed that the organic loading rate has...
a significant impact on foam formation, lowering the methane yield of the reactor. Moreover, it was found that an increase in gelatine concentration does not promote foam, while an increase in Na-oleate concentration enhances stable foam. Based on the above results, a new experiment was designed, where the antifoam efficiency of different commercial and non-commercial compounds, was investigated. The antifoam potential of the compounds was determined by aeration method. The apparatus comprised of a glass cylinder with a diffuser placed at the bottom. A 50 mL sample, derived from a foaming reactor, was aerated in the cylinder with an air flow rate of 60 mL/min for 10 minutes. After that, the aeration was repeated adding different concentrations of antifoam solutions in the sample. The foam height in the cylinder was measured as soon as the aeration was stopped and again 1 hour later. The antifoam potential was defined using two parameters: foaming tendency and foam stability. Foaming tendency (mL-foam/(mL-air·min)) was calculated from the volume of foam (mL) right after aeration divided by air flow rate (mL/min). Foam stability was determined as percentage of foam remaining in the cylinder 1 h after aeration compared to the volume of foam right after aeration.

General information
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Organisations: Residual Resource Engineering, Department of Environmental Engineering
Contributors: Kougias, P., Boe, K., Angelidaki, I.
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Green macroalgae for biomitigation of nutrients, purification of biogas and energy production

General information
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Organisations: Department of Environmental Engineering, Section for Population Ecology and Genetics, Residual Resource Engineering
Contributors: Holdt, S. L., Galanidis, S., Margarido Pargana, A., Angelidaki, I.
Number of pages: 1
Publication date: 2012
Peer-reviewed: No
Electronic versions:
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Immobilisation of an ammonia tolerant methanogenic consortium in high performance anaerobic digesters

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Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Fotidis, I., Karakashev, D. B., Angelidaki, I.
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Research output: Research - peer-review › Poster – Annual report year: 2013

Influence of microbial composition on foam formation in a manure-based digester
Foaming is one of the major problems that occasionally occur in the biogas plants, affecting negatively the overall digestion process and results in adverse operational, economical and environmental impacts. The most dominant factors contributing to foaming are organic overloading, feedstock composition and the presence of specific microorganisms. The
filamentous microorganisms are known to be the major cause of foaming in sludge digester as they are attached to the gas bubbles and accumulated on the surface of the reactor.

The present case study investigated the microbial composition of one manure-based digester of Lemvig biogas plant that was facing foaming problem, comparing with three non-foaming digesters. The research was focused on the quantitative and qualitative analysis of Bacteria and Archaea population and on the identification of Gordonia sp. The reactor samples were analysed for foaming properties and microbial analysis. The dynamic population of Bacteria and Archaea were studied by PCR-DGGE method.

The results obtained from this study showed that the composition of Bacteria in all reactors was not significantly different indicating that foaming was not caused by Bacteria. In contrary, the quantitative and qualitative analysis of Archaea revealed significant differences in their population and composition.
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Web of Science (2016): Impact factor 6.942
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 6.63 SJR 2.665 SNIP 2.482
Web of Science (2015): Impact factor 5.991
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 6.13 SJR 2.946 SNIP 2.702
Web of Science (2014): Impact factor 5.528
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 6.02 SJR 2.956 SNIP 2.676
Web of Science (2013): Impact factor 5.323
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.15 SJR 2.914 SNIP 2.442
Web of Science (2012): Impact factor 4.655
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 5.43 SJR 2.862 SNIP 2.355
Web of Science (2011): Impact factor 4.865
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.592 SNIP 2.192
Web of Science (2010): Impact factor 4.546
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.319 SNIP 2.224
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.073 SNIP 2.178
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.94 SNIP 2.184
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.902 SNIP 2.233
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 2.113 SNIP 2.334
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 2.209 SNIP 2.108
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.702 SNIP 1.908
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.568 SNIP 1.757
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.319 SNIP 1.69
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 1.399 SNIP 1.662
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 1.432 SNIP 1.55
Integrated biogas upgrading and hydrogen utilization in an anaerobic reactor containing enriched hydrogenotrophic methanogenic culture

Biogas produced by anaerobic digestion, is mainly used in a gas motor for heat and electricity production. However, after removal of CO2, biogas can be upgraded to natural gas quality, giving more utilization possibilities, such as utilization as autogas, or distant utilization by using the existing natural gas grid. The current study presents a new biological method for biogas upgrading in a separate biogas reactor, containing enriched hydrogenotrophic methanogens and fed with biogas and hydrogen. Both mesophilic- and thermophilic anaerobic cultures were enriched to convert CO2 to CH4 by addition of H2. Enrichment at thermophilic temperature (55°C) resulted in CO2 and H2 bioconversion rate of 320 mL CH4/(gVSS h), which was more than 60% higher than that under mesophilic temperature (37°C). Different dominant species were found at mesophilic- and thermophilic-enriched cultures, as revealed by PCR–DGGE. Nonetheless, they all belonged to the order Methanobacteriales, which can mediate hydrogenotrophic methanogenesis. Biogas upgrading was then tested in a thermophilic anaerobic reactor under various operation conditions. By continuous addition of hydrogen in the biogas reactor, high degree of biogas upgrading was achieved. The produced biogas had a CH4 content, around 95% at steady-state, at gas (mixture of biogas and hydrogen) injection rate of 6 L/(L·day). The increase of gas injection rate to 12 L/(L·day) resulted in the decrease of CH4 content to around 90%. Further study showed that by decreasing the gas–liquid mass transfer by increasing the stirring speed of the mixture the CH4 content was increased to around 95%. Finally, the CH4 content around 90% was achieved in this study with the gas injection rate as high as 24 L/(L·day). Biotechnol. Bioeng. 2012; 109: 2729–2736. © 2012 Wiley Periodicals, Inc.
Microalgal carbohydrates: an overview of the factors influencing carbohydrates production, and of main bioconversion technologies for production of biofuels

Microalgal biomass seems to be a promising feedstock for biofuel generation. Microalgae have relative high photosynthetic efficiencies, high growth rates, and some species can thrive in brackish water or seawater and wastewater from the food- and agro-industrial sector. Today, the main interest in research is the cultivation of microalgae for lipids production to generate biodiesel. However, there are several other biological or thermochemical conversion technologies, in which microalgal biomass could be used as substrate. However, the high protein content or the low carbohydrate...
content of the majority of the microalgal species might be a constraint for their possible use in these technologies. Moreover, in the majority of biomass conversion technologies, carbohydrates are the main substrate for production of biofuels. Nevertheless, microalgal biomass composition could be manipulated by several cultivation techniques, such as nutrient starvation or other stressed environmental conditions, which cause the microalgae to accumulate carbohydrates. This paper attempts to give a general overview of techniques that can be used for increasing the microalgal biomass carbohydrate content. In addition, biomass conversion technologies, related to the conversion of carbohydrates into biofuels are discussed.

**General information**

State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering, Agricultural University of Athens
Contributors: Markou, G., Angelidaki, I., Georgakakis, D.
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- BFI (2018): BFI-level 1
- Web of Science (2018): Indexed yes
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- Scopus rating (2017): CiteScore 3.64 SJR 1.182 SNIP 1.161
- Web of Science (2017): Impact factor 3.34
- Web of Science (2017): Indexed yes
- BFI (2016): BFI-level 1
- Scopus rating (2016): CiteScore 3.57 SJR 1.2 SNIP 1.182
- Web of Science (2016): Impact factor 3.42
- Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 1
- Scopus rating (2015): CiteScore 3.43 SJR 1.256 SNIP 1.221
- Web of Science (2015): Impact factor 3.376
- Web of Science (2015): Indexed yes
- BFI (2014): BFI-level 1
- Scopus rating (2014): CiteScore 3.71 SJR 1.332 SNIP 1.448
- Web of Science (2014): Impact factor 3.337
- Web of Science (2014): Indexed yes
- BFI (2013): BFI-level 1
- Scopus rating (2013): CiteScore 4.3 SJR 1.54 SNIP 1.43
- Web of Science (2013): Impact factor 3.811
- ISI indexed (2013): ISI indexed yes
- Web of Science (2013): Indexed yes
- BFI (2012): BFI-level 1
- Scopus rating (2012): CiteScore 4 SJR 1.488 SNIP 1.29
- Web of Science (2012): Impact factor 3.689
- ISI indexed (2012): ISI indexed yes
- Web of Science (2012): Indexed yes
- BFI (2011): BFI-level 1
- Scopus rating (2011): CiteScore 3.72 SJR 1.437 SNIP 1.229
- ISI indexed (2011): ISI indexed yes
- Web of Science (2011): Indexed yes
- BFI (2010): BFI-level 1
- Scopus rating (2010): SJR 1.389 SNIP 1.233
Microalgal Cultivation at Kalundborg Municipal Wastewater Treatment Facility

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering, Kalundborg Kommune
Number of pages: 1
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Peer-reviewed: Yes
Event: Poster session presented at Young Algaeneer Symposium, Wageningen, Netherlands.
Electronic versions:
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Source: PublicationPreSubmission
Source-ID: 100366459
Research output: Research - peer-review » Poster – Annual report year: 2012

Mikroorganismer kan øge gasudbyttet

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Fotidis, I., Karakashev, D. B., Angelidaki, I.
Pages: 17
Publication date: 2012
Peer-reviewed: Yes
Pilot-scale application of an online VFA sensor for monitoring and control of a manure digester

A volatile fatty acids (VFA) sensor based on headspace chromatography was tested for online monitoring and control of a pilot-scale manure digester. The sensor showed satisfying results in terms of sensitivity and reliability for monitoring of the digester. The online VFA and biogas production data were used for automatic control of the digester based on feed flow manipulation. The control approach was based on optimization of biogas production while using VFA concentration as the alarm threshold. A rule-based supervisory system with a cascade controller was used to optimize the biogas production from the digester. The alarm state was set at 40 mM total VFA and 10 mM propionate concentration. The control algorithms could successfully maximize the biogas production without overloading the process. However, as the algorithm was based on a fixed biogas yield parameter and only used the biogas parameter for optimization, it could not distinguish between the decreases of biogas production from inhibition and from lower organic content in the substrate, which resulted in undesired decreasing of the control gas setpoint when the substrate was diluted. It was necessary to adjust the yield parameter in order to get this control approach to function properly, which is not suitable for the full-scale biogas plant where the organic content of waste streams can vary. An alternative approach could be a modified rule-based algorithm that includes VFA parameters to help distinguish between different process scenarios.
Screening and Optimization of Case Specific Sustainable Mixotrophic Microalgal Medium

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Podevin, M., Borch, M. M., De Francisci, D., Holdt, S. L., Angelidaki, I., Møller, P.
Number of pages: 1
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Event: Poster session presented at Young Algaeneer Symposium, Wageningen, Netherlands.
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Self-stacked submersible microbial fuel cell (SSMFC) for improved remote power generation from lake sediments

Electric energy can be harvested from aquatic sediments by utilizing microbial fuel cells (MFCs). A main challenge of this application is the limited voltage output. In this study, an innovative self-stacked submersible MFC (SSMFC) was developed to improve the voltage generation from lake sediments. The SSMFC successfully produced a maximum power density of 294 mW/m² and had an open circuit voltage (OCV) of 1.12 V. However, voltage reversal was observed in one cell at high current density. Investigation on the cause for voltage reversal revealed that voltage reversal was occurring only when low external resistance (≤400 Ω in this study) was applied. In addition, the internal resistance and OCV were the most important parameters for predicting which cell unit had the highest probability to undergo voltage reversal. Use of a capacitor was found to be an effective way to prevent voltage reversal and at the same time store power. These results provide new insight into the development of effective MFC system, capable of extracting energy and promoting bioremediation of organic pollutants from sediments.

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Contributors: Zhang, Y., Angelidaki, I.
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BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 7.83 SJR 2.373 SNIP 1.65
Web of Science (2017): Impact factor 8.173
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 7.22 SJR 2.095 SNIP 1.619
Web of Science (2016): Impact factor 7.78
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 7.07 SJR 2.044 SNIP 1.671
Web of Science (2015): Impact factor 7.476
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 6.57 SJR 2.057 SNIP 1.716
Web of Science (2014): Impact factor 6.409
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 6.34 SJR 2.029 SNIP 1.726
Web of Science (2013): Impact factor 6.451
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 5.7 SJR 2.397 SNIP 1.592
Web of Science (2012): Impact factor 5.437
Simultaneous hydrogen utilization and in situ biogas upgrading in an anaerobic reactor

The possibility of converting hydrogen to methane and simultaneous upgrading of biogas was investigated in both batch tests and fully mixed biogas reactor, simultaneously fed with manure and hydrogen. Batch experiments showed that hydrogen could be converted to methane by hydrogenotrophic methanogenesis with conversion of more than 90% of the consumed hydrogen to methane. The hydrogen consumption rates were affected by both $P_{{\rm H}_2}$ (hydrogen partial pressure) and mixing intensity. Inhibition of propionate and butyrate degradation by hydrogen (1 atm) was only observed under high mixing intensity (shaking speed 300 rpm). Continuous addition of hydrogen (flow rate of 28.6 mL/(L/h)) to an anaerobic reactor fed with manure, showed that more than 80% of the hydrogen was utilized. The propionate and butyrate level in the reactor was not significantly affected by the hydrogen addition. The methane production rate of the reactor with H2 addition was 22% higher, compared to the control reactor only fed with manure. The CO2 content in the produced biogas was only 15%, while it was 38% in the control reactor. However, the addition of hydrogen resulted in increase of pH (from 8.0 to 8.3) due to the consumption of bicarbonate, which subsequently caused slight inhibition of methanogenesis. Biotechnol. Bioeng. 2012; 109:1088–1094. © 2011 Wiley Periodicals, Inc.
Surface Area Expansion of Electrodes with Grass-like Nanostructures to Enhance Electricity Generation in Microbial Fuel Cells

Microbial fuel cells (MFCs) have applications possibilities for wastewater treatment, biotransformation, and biosensor, but the development of highly efficient electrode materials is critical for enhancing the power generation. Two types of electrodes modified with nanoparticles or grass-like nanostructure (termed nanograss) were used. A two-chamber MFC with plain silicium electrodes achieved a maximum power density of 0.002 mW/m², while an electrode with nanograss of titanium and gold deposited on one side gave a maximum power density of 2.5 mW/m². Deposition of titanium and gold on both sides of plain silicium showed a maximum power density of 86.0 mW/m². Further expanding the surface area of carbon paper electrodes with gold nanoparticles resulted in a maximum stable power density of 346.9 mW/m² which is 2.9 times higher than that achieved with conventional carbon paper. These results show that fabrication of electrodes with nanograss could be an efficient way to increase the power generation.
Thermophilic anaerobic co-digestion of oil palm empty fruit bunches with palm oil mill effluent for efficient biogas production

The effect of pretreatment methods for improved biodegradability and biogas production of oil palm empty fruit bunches (EFB) and its co-digestion with palm oil mill effluent (POME) was investigated. The maximum methane potential of POME was 502 mL CH₄/g VS-added corresponding to 33.2 m³ CH₄/ton POME and 98% biodegradability. Meanwhile, the maximum methane potential of EFB was 202 mL CH₄/g VS-added corresponding to 79.1 m³ CH₄/ton EFB with 38% biodegradability. Co-digestion of EFB with POME enhanced microbial biodegradability and resulted in 25–32% higher methane production at mixing ratios of 0.4:1, 0.8:1 and 2:3:1 on VS basis than digesting EFB alone. The methane yield was 276–340 mL CH₄/g VS-added for co-digestion of EFB with POME at mixing ratios of 0.4:1–2:3:1, while minor improvement was observed at mixing ratios of 6:8:1 and 11:1 (175–197 mL CH₄/g VS-added). The best improved was achieved from co-digestion of treated EFB by NaOH presoaking and hydrothermal treatment with POME, which resulted in 98% improvement in methane yield comparing with co-digesting untreated EFB. The maximum methane production of co-digestion treated EFB with POME was 82.7 m³ CH₄/ton of mixed treated EFB and POME (6:8:1), corresponding to methane yield of 392 mL CH₄/g VS-added. The electricity production of 1 ton mixture of treated EFB and POME would be 1190 MJ or 330 kWh of electricity. The study shows that there is a great potential to co-digestion treated EFB with POME for bioenergy production.

General information
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Contributors: O-Thong, S., Boe, K., Angelidaki, I.
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Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
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Scopus rating (2017): CiteScore 8.44 SJR 3.162 SNIP 2.765
Web of Science (2017): Impact factor 7.9
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 7.78 SJR 3.011 SNIP 2.61
Web of Science (2016): Impact factor 7.182
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 6.4 SJR 2.835 SNIP 2.593
Web of Science (2015): Impact factor 5.746
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 6.93 SJR 3.158 SNIP 3.218
Web of Science (2014): Impact factor 5.613
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 6.59 SJR 3.06 SNIP 3.346
Web of Science (2013): Impact factor 5.261
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 5.69 SJR 2.778 SNIP 3.076
Web of Science (2012): Impact factor 4.781
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Use of a newly isolated extreme thermophile for the production of 2nd generation bio-ethanol

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Organisations: Department of Environmental Engineering, Residual Resource Engineering
Number of pages: 1
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Event: Poster session presented at 14th International Symposium on Microbial Ecology, Copenhagen, Denmark.
Electronic versions:
120814 ISME_poster (final).pdf
Source: dtu
Source-ID: u::6440
Research output: Research - peer-review › Poster – Annual report year: 2012

Anaerobic co-digestion of by-products from sugar production with cow manure
Sugar beet leaves (SBL), sugar beet top (SBT), sugar beet pulp (SBP) and desugared molasses (DM) are by-products from the sugar production. In the present study we investigated the potential of SBL, SBT and SBP as feedstock for biogas production. The maximum methane potential of SBL, SBT and SBP determined by batch assays was found to be 490, 500 and 240 mL-CH4/gVS-added respectively. Three reactor experiments were carried out to investigate the effect of co-digestion of SBP, DM and manure at different ratios, on biogas process efficiency and stability. The results showed that
DM was potentially inhibiting the biogas process and the co-digestion of SBP and DM was only successful at high dilution with manure or water. In contrast, SBP was shown to be a good substrate for biogas production and the methane yield of 280 mL-CH4/gVS-added was obtained in a thermophilic continuously operated reactor, co-digesting 50% of SBP with cow manure.

**General information**

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Organisations: Residual Resource Engineering, Department of Environmental Engineering
Contributors: Fang, C., Boe, K., Angelidaki, I.
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Journal: Water Research
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BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 7.55 SJR 2.601 SNIP 2.358
Web of Science (2017): Impact factor 7.051
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 7.49 SJR 2.663 SNIP 2.563
Web of Science (2016): Impact factor 6.942
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 6.63 SJR 2.665 SNIP 2.482
Web of Science (2015): Impact factor 5.991
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 6.13 SJR 2.946 SNIP 2.702
Web of Science (2014): Impact factor 5.528
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 6.02 SJR 2.956 SNIP 2.676
Web of Science (2013): Impact factor 5.323
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.15 SJR 2.914 SNIP 2.442
Web of Science (2012): Impact factor 4.655
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 5.43 SJR 2.862 SNIP 2.355
Web of Science (2011): Impact factor 4.865
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.592 SNIP 2.192
Web of Science (2010): Impact factor 4.546
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Anaerobic co-digestion of desugared molasses with cow manure; focusing on sodium and potassium inhibition

Desugared molasses (DM), a syrup residue from beet-molasses, was investigated for biogas production in both batch and in continuously-stirred tank reactor (CSTR) experiments. DM contained 2–3 times higher concentration of ions than normal molasses, which could inhibit the biogas process. The effect of sodium and potassium concentration on biogas production from manure was also investigated. Fifty percent inhibition occurred at sodium and potassium concentration of 11 and 28 g/L, respectively. The reactor experiments were carried out to investigate the biogas production from DM under different dilutions with water and co-digestion with manure. Stable operation at maximum methane yield of 300 mL-CH₄/gVS added was obtained at a mixture of 5% DM in cow manure. The biogas process was inhibited at DM concentrations higher than 15%. Manure was a good base substrate for co-digestion, and a stable anaerobic digestion could be achieved by co-digesting DM with manure at the concentration below 15% DM.

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Contributors: Fang, C., Boe, K., Angelidaki, I.
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Publication date: 2011
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 6.28 SJR 2.029 SNIP 1.799
Web of Science (2017): Impact factor 5.807
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.94 SJR 2.215 SNIP 1.932
Web of Science (2016): Impact factor 5.651
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.47 SJR 2.243 SNIP 1.897
Web of Science (2015): Impact factor 4.917
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.3 SJR 2.399 SNIP 2.087
Web of Science (2014): Impact factor 4.494
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 5.97 SJR 2.405 SNIP 2.477
Web of Science (2013): Impact factor 5.039
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.25 SJR 2.334 SNIP 2.461
Web of Science (2012): Impact factor 4.75
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 5.56 SJR 2.308 SNIP 2.507
Web of Science (2011): Impact factor 4.98
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.089 SNIP 2.344
Web of Science (2010): Impact factor 4.365
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.915 SNIP 2.236
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.736 SNIP 2.74
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.403 SNIP 2.396
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.314 SNIP 2.003
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.278 SNIP 1.98
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.19 SNIP 1.655
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.942 SNIP 1.665
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.908 SNIP 1.294
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.537 SNIP 1.2
Scopus rating (2000): SJR 0.653 SNIP 1.023
Anaerobic Digestion: Process

Organic waste may degrade anaerobically in nature as well as in engineered systems. The latter is called anaerobic digestion or biogasification. Anaerobic digestion produces two main outputs: An energy-rich gas called biogas and an effluent. The effluent, which may be a solid as well as liquid with very little dry matter may also be called a digest. The digest should not be termed compost unless it specifically has been composted in an aerated step. This chapter describes the basic processes of anaerobic digestion. Chapter 9.5 describes the anaerobic treatment technologies, and Chapter 9.6 addresses the mass balances and environmental aspects of anaerobic digestion.

Biogas production from potato-juice, a by-product from potato-starch processing, in upflow anaerobic sludge blanket (UASB) and expanded granular sludge bed (EGSB) reactors

In this study, the utilization of potato-juice, the organic by-product from potato-starch processing, for biogas production was investigated in batch assay and in high rate anaerobic reactors. The maximum methane potential of the potato-juice determined by batch assay was 470mL-CH₄/gVS-added. Anaerobic digestion of potato-juice in an EGSB reactor could obtain a methane yield of 380mL-CH₄/gVS-added at the organic loading rate of 3.2gCOD/(L-reactor.d). In a UASB reactor, higher organic loading rate of 5.1gCOD/(L-reactor.d) could be tolerated, however, it resulted in a lower methane yield of 240mL-CH₄/gVS-added. The treatment of reactor effluent was also investigated. By acidification with sulfuric acid to pH lower than 5, almost 100% of the ammonia content in the effluent could be retained during the successive up-concentration process step. The reactor effluent could be up-concentrated by evaporation to minimize its volume, and later be utilized as fertilizer.
Web of Science (2017): Impact factor 5.807
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.94 SJR 2.215 SNIP 1.932
Web of Science (2016): Impact factor 5.651
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.47 SJR 2.243 SNIP 1.897
Web of Science (2015): Impact factor 4.917
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.3 SJR 2.399 SNIP 2.087
Web of Science (2014): Impact factor 4.494
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 5.97 SJR 2.405 SNIP 2.477
Web of Science (2013): Impact factor 5.039
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.25 SJR 2.334 SNIP 2.461
Web of Science (2012): Impact factor 4.75
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 5.56 SJR 2.308 SNIP 2.507
Web of Science (2011): Impact factor 4.98
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.089 SNIP 2.344
Web of Science (2010): Impact factor 4.365
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.915 SNIP 2.236
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.736 SNIP 2.74
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.403 SNIP 2.396
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.314 SNIP 2.003
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.278 SNIP 1.98
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.19 SNIP 1.655
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.942 SNIP 1.665
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.908 SNIP 1.294
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.537 SNIP 1.2
Scopus rating (2000): SJR 0.653 SNIP 1.023
Biohydrogen production from desugared molasses (DM) using thermophilic mixed cultures immobilized on heat treated anaerobic sludge granules

Hydrogen production from desugared molasses (DM) was investigated in both batch and continuous reactors using thermophilic mixed cultures enriched from digested manure by load shock (loading with DM concentration of 50.1 g-sugar/L) to suppress methanogens. H2 gas, free of methane, was produced during batch cultivations, at different (DM) concentrations ranging from 1.5 g-sugars/L to 50.1 g-sugars/L. The highest yield of 237 ml-H2/g-sugar was achieved during the DM batch fermentation at concentration of 2.1 g-sugars/L, thereafter the yield decreased with increasing DM concentration. The enriched hydrogen producing mixed culture achieved from the 16.7 g-sugars/L DM batch cultivation was immobilized on heat treated anaerobic sludge granules in an up-flow anaerobic sludge blanket (UASB) reactor. The UASB reactor, operated at a hydraulic retention time (HRT) of 24 h fed with 16.7 g-sugars/L DM showed good performance with a satisfactory hydrogen yield of 269.5 ml-H2/g-sugar and rate of 4500 ml H2/l⋅d. Fluorescent in situ hybridization (FISH) analysis of the microbial community of sludge from batch fermentation and the UASB-granules after 54 days of operation, was dominated by Thermoanaerobacterium spp., which are key players in fermentative hydrogen production of DM under thermophilic conditions. Furthermore, the granules in the UASB reactor were also significantly containing Thermoanaerobacterium spp. and phylum Firmecutes (most Clostridium, Bacillus and Desulfobacterium) and Thermoanaerobacterium thermosaccharolyticum with a relative abundance of 36%, 27%, and 10% of total microorganisms, respectively. This study shows that hydrogen production could be efficiently facilitated by using anaerobic granules as a carrier, where microbes from mixed culture enriched in the DM batch cultivation were immobilized on, in an UASB reactor.
Biomethanation and Its Potential

Biomethanation is a process by which organic material is microbiologically converted under anaerobic conditions to biogas. Three main physiological groups of microorganisms are involved: fermenting bacteria, organic acid oxidizing bacteria, and methanogenic archaea. Microorganisms degrade organic matter via cascades of biochemical conversions to methane and carbon dioxide. Syntrophic relationships between hydrogen producers (acetogens) and hydrogen scavengers (homoacetogens, hydrogenotrophic methanogens, etc.) are critical to the process. Determination of practical and theoretical methane potential is very important for design for optimal process design, configuration, and effective evaluation of economic feasibility. A wide variety of process applications for biomethanation of wastewaters, slurries, and solid waste have been developed. They utilize different reactor types (fully mixed, plugflow, biofilm, UASB, etc.) and process conditions (retention times, loading rates, temperatures, etc.) in order to maximize the energy output from the waste and also to decrease retention time and enhance process stability. Biomethanation has strong potential for the
production of energy from organic residues and wastes. It will help to reduce the use of fossil fuels and thus reduce CO2 emission.

**General information**

**State:** Published  
**Organisations:** Residual Resource Engineering, Department of Environmental Engineering, University of Queensland, Wageningen IMARES  
**Contributors:** Angelidaki, I., Karakashev, D. B., Batstone, D. J., Plugge, C. M., Stams, A. J. M.  
**Publication date:** 2011  
**Peer-reviewed:** Yes

**Publication information**

**Journal:** Methods in Enzymology  
**Volume:** 494  
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**Ratings:**  
BFI (2018): BFI-level 1  
Web of Science (2018): Indexed yes  
BFI (2017): BFI-level 1  
Scopus rating (2017): CiteScore 1.96 SJR 1.479 SNIP 0.66  
Web of Science (2017): Impact factor 1.984  
Web of Science (2017): Indexed yes  
BFI (2016): BFI-level 1  
Scopus rating (2016): CiteScore 1.83 SJR 1.596 SNIP 0.528  
Web of Science (2016): Impact factor 1.972  
BFI (2015): BFI-level 1  
Scopus rating (2015): CiteScore 1.95 SJR 1.48 SNIP 0.568  
BFI (2014): BFI-level 1  
Scopus rating (2014): CiteScore 1.9 SJR 1.416 SNIP 0.655  
Web of Science (2014): Impact factor 2.088  
BFI (2013): BFI-level 1  
Scopus rating (2013): CiteScore 2.09 SJR 1.546 SNIP 0.597  
Web of Science (2013): Impact factor 2.194  
ISI indexed (2013): ISI indexed yes  
BFI (2012): BFI-level 1  
Scopus rating (2012): CiteScore 2.08 SJR 1.508 SNIP 0.692  
Web of Science (2012): Impact factor 2.002  
ISI indexed (2012): ISI indexed yes  
BFI (2011): BFI-level 1  
Scopus rating (2011): CiteScore 1.85 SJR 1.393 SNIP 0.598  
Web of Science (2011): Impact factor 2.042  
ISI indexed (2011): ISI indexed yes  
Web of Science (2011): Indexed yes  
BFI (2010): BFI-level 1  
Scopus rating (2010): SJR 1.408 SNIP 0.539  
Web of Science (2010): Impact factor 1.626  
BFI (2009): BFI-level 1  
Scopus rating (2009): SJR 1.747 SNIP 0.576  
BFI (2008): BFI-level 1  
Scopus rating (2008): SJR 1.744 SNIP 0.668  
Scopus rating (2007): SJR 1.51 SNIP 0.522  
Scopus rating (2006): SJR 1.426 SNIP 0.48  
Scopus rating (2005): SJR 1.285 SNIP 0.472  
Scopus rating (2004): SJR 1.071 SNIP 0.468  
Scopus rating (2003): SJR 1.25 SNIP 0.478
Comment on "Parameter Identification and Modeling of the Biochemical Methane Potential of Waste Activated Sludge" (1)

General information
State: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering, University of Queensland, Georgia Institute of Technology
Contributors: Batstone, D., Pavlostathis, S., Jensen, P., Angelidaki, I.
Pages: 7596-7597
Publication date: 2011
Peer-reviewed: Yes

Publication information
Journal: Environmental Science & Technology (Washington)
Volume: 45
Issue number: 17
ISSN (Print): 0013-936X
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 6.58 SJR 2.535 SNIP 1.941
Web of Science (2017): Impact factor 6.653
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 6.26 SJR 2.559 SNIP 1.902
Web of Science (2016): Impact factor 6.198
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.61 SJR 2.546 SNIP 1.838
Web of Science (2015): Impact factor 5.393
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.5 SJR 2.777 SNIP 2.003
Web of Science (2014): Impact factor 5.33
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 5.52 SJR 2.952 SNIP 2.102
Web of Science (2013): Impact factor 5.481
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.17 SJR 3.115 SNIP 2.043
Web of Science (2012): Impact factor 5.257
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
Comparison of UASB and EGSB reactors performance, for treatment of raw and deoiled palm oil mill effluent (POME)

Anaerobic digestion of palm oil mill effluent (POME) and deoiled POME was investigated both in batch assays and continuous reactor experiments using up-flow anaerobic sludge blanket (UASB) and expanded granular sludge bed (EGSB) reactors. The methane potential determined from batch assays of POME and deoiled POME was 503 and 610mL-CH4/gVS-added, respectively. For the treatment of POME in continuously fed reactors, both in UASB and EGSB reactors more than 90% COD removal could be obtained, at HRT of 5 days, corresponding to OLR of 5.8gVS/(L-reactor.d). Similar methane yields of 436–438mL-CH4/gVS-added were obtained for UASB and EGSB respectively. However, for treatment of deoiled POME, both UASB and EGSB reactors could operate at lower OLR of 2.6gVS/(L-reactor.d), with the methane yield of 600 and 555mL-CH4/gVS-added for UASB and EGSB, respectively. The higher methane yield achieved from the deoiled POME was attributed to lower portion of biofibers which are more recalcitrant compared the rest of organic matter in POME. The UASB reactor was found to be more stable than EGSB reactor under the same OLR, as could be seen from lower VFA concentration, especially propionic acid, compared to the EGSB reactor.
Cultivation of the green macroalgae Ulva lactuca and Ulvaria splendens for biofuels production

General information
State: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering, Technical University of Denmark
Contributors: Angelidaki, I., Galanidis, S., Holdt, S. L., Jørgensen, M. W.
Publication date: 2011
Peer-reviewed: No
Electronic versions:
Ulva.pdf
URLs:
http://www.isap2011-halifax.org/

Effect of xylose and nutrients concentration on ethanol production by a newly isolated extreme thermophilic bacterium
An extreme thermophilic ethanol-producing strain was isolated from an ethanol high-yielding mixed culture, originally isolated from a hydrogen producing reactor operated at 70 °C. Ethanol yields were assessed with increasing concentrations of xylose, up to 20 g/l. The ability of the strain to grow without nutrient addition (yeast extract, peptone and vitamins) was also assessed. The maximum ethanol yield achieved was 1.28 mole ethanol/ mole xylose consumed (77% of the theoretical yield), at 2 g/l of initial xylose concentration. The isolate was able to grow and produce ethanol as the main fermentation product under most of the conditions tested, including in media lacking vitamins, peptone and yeast extract. The results indicate that this new organism is a promising candidate for the development of a second generation bio-ethanol production process. © IWA Publishing 2011.

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Pages: 341-347
Publication date: 2011
Peer-reviewed: Yes
Electricity generation and microbial community response to substrate changes in microbial fuel cell

The effect of substrate changes on the performance and microbial community of two-chamber microbial fuel cells (MFCs) was investigated in this study. The MFCs enriched with a single substrate (e.g., acetate, glucose, or butyrate) had different acclimatization capability to substrate changes. The MFC enriched with glucose showed rapid and higher power generation, when glucose was switched with acetate or butyrate. However, the MFC enriched with acetate needed a longer adaptation time for utilizing glucose. Microbial community was also changed when the substrate was changed. Clostridium and Bacilli of phylum Firmicutes were detected in acetate-enriched MFCs after switching to glucose. By contrast, Firmicutes completely disappeared and Geobacter-like species were specifically enriched in glucose-enriched MFCs after feeding acetate to the reactor. This study further suggests that the type of substrate fed to MFC is a very important parameter for reactor performance and microbial community, and significantly affects power generation in MFCs.

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Zhang, Y., Min, B., Huang, L., Angelidaki, I.
Pages: 1166-1173
Publication date: 2011
Peer-reviewed: Yes

Publication information
Journal: Bioresource Technology
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BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 6.28 SJR 2.029 SNIP 1.799
Web of Science (2017): Impact factor 5.807
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.94 SJR 2.215 SNIP 1.932
Web of Science (2016): Impact factor 5.651
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.47 SJR 2.243 SNIP 1.897
Web of Science (2015): Impact factor 4.917
Electricity generation by microbial fuel cells fuelled with wheat straw hydrolysate

Electricity production from microbial fuel cells fueled with hydrolysate produced by hydrothermal treatment of wheat straw can achieve both energy production and domestic wastewater purification. The hydrolysate contained mainly xylan,
carboxylic acids, and phenolic compounds. Power generation and substrate utilization from the hydrolysate was compared with the ones obtained by defined synthetic substrates. The power density increased from 47 mW m⁻² to 148 mW m⁻² with the hydrolysate:wastewater ratio (RHW in m³ m⁻³) increasing from 0 to 0.06 (corresponding to 0–0.7 g dm⁻³ of carbohydrates). The power density with the hydrolysate was higher than the one with only xylan (120 mW m⁻²) and carboxylic acids as fuel. The higher power density can be caused by the presence of phenolic compounds in the hydrolysates, which could mediate electron transport. Electricity generation with the hydrolysate resulted in 95% degradation of the xylan and glucan. The study demonstrates that lignocellulosic hydrolysate can be used for co-treatment with domestic wastewater for power generation in microbial fuel cells.

General information
State: Published
Organisations: Bioenergy and Biomass, Biosystems Division, Risø National Laboratory for Sustainable Energy, Microstructures and Interfaces. Fuel Cells and Solid State Chemistry Division, Residual Resource Engineering, Department of Environmental Engineering, Kyung Hee University
Contributors: Thygesen, A., Poulsen, F. W., Angelidaki, I., Min, B., Thomsen, A. B.
Pages: 4732-4739
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Journal: Biomass & Bioenergy
Volume: 35
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Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 4 SJR 1.235 SNIP 1.436
Web of Science (2017): Impact factor 3.358
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.71 SJR 1.198 SNIP 1.385
Web of Science (2016): Impact factor 3.219
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 4.03 SJR 1.51 SNIP 1.596
Web of Science (2015): Impact factor 3.249
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 4.36 SJR 1.865 SNIP 1.964
Web of Science (2014): Impact factor 3.394
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 4.42 SJR 1.666 SNIP 1.811
Web of Science (2013): Impact factor 3.411
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 3.66 SJR 1.516 SNIP 1.754
Web of Science (2012): Impact factor 2.975
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 4.74 SJR 1.759 SNIP 2.296
Web of Science (2011): Impact factor 3.646
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
Emerging Biological Technologies: Biofuels and Biochemicals

Composting and anaerobic digestion are well established technologies, although the latter is a relative recent technology regarding solid waste and full scale plants still are relatively few. However, alternative technologies based on biotechnology are emerging. These technologies are focused around ethanol production, hydrogen production and production of organic chemicals. It is too early to say if these emerging technologies will play a real role in solid waste management in the future, but they may have a potential for treatment of some organic waste streams.

General information
State: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering
Contributors: Karakashev, D. B., Angelidaki, I.
Pages: 639-650
Publication date: 2011
Enhanced bioenergy recovery from rapeseed plant in a biorefinery concept

The present study investigated the utilization of the whole rapeseed plant (seed and straw) for multi-biofuels production in a biorefinery concept. Results showed that bioethanol production from straw was technically feasible with ethanol yield of 0.15 g ethanol/g dry straw after combined alkaline peroxide and stream pretreatment. The byproducts (rapeseed cake, glycerol, hydrolysate and stillage) were evaluated for hydrogen and methane production. In batch experiments, the energy yields from each feedstock for, either methane production alone or for both hydrogen and methane, were similar. However, results from continuous experiments demonstrated that the two-stage hydrogen and methane fermentation process could work stably at organic loading rate up to 4.5 gVS/(L d), while the single-stage methane production process failed. The energy recovery efficiency from rapeseed plant increased from 20% in the conventional biodiesel process to 60% in the biorefinery concept, by utilization of the whole rapeseed plant for biodiesel, bioethanol, biohydrogen and methane production.

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BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 6.28 SJR 2.029 SNIP 1.799
Web of Science (2017): Impact factor 5.807
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.94 SJR 2.215 SNIP 1.932
Web of Science (2016): Impact factor 5.651
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.47 SJR 2.243 SNIP 1.897
Web of Science (2015): Impact factor 4.917
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.3 SJR 2.399 SNIP 2.087
Web of Science (2014): Impact factor 4.494
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 5.97 SJR 2.405 SNIP 2.477
Web of Science (2013): Impact factor 5.039
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.25 SJR 2.334 SNIP 2.461
Web of Science (2012): Impact factor 4.75
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 5.56 SJR 2.308 SNIP 2.507
Web of Science (2011): Impact factor 4.98
ISI indexed (2011): ISI indexed yes
Enhancement of bioenergy production from organic wastes by two-stage anaerobic hydrogen and methane production process

The present study investigated a two-stage anaerobic hydrogen and methane process for increasing bioenergy production from organic wastes. A two-stage process with hydraulic retention time (HRT) 3d for hydrogen reactor and 12d for methane reactor, obtained 11% higher energy compared to a single-stage methanogenic process (HRT 15d) under organic loading rate (OLR) 3gVS/(Ld). The two-stage process was still stable when the OLR was increased to 4.5gVS/(Ld), while the single-stage process failed. The study further revealed that by changing the HRT_{hydrogen}:HRT_{methane} ratio of the two-stage process from 3:12 to 1:14, 6.7%, more energy could be obtained. Microbial community analysis indicated that the dominant bacterial species were different in the hydrogen reactors (Thermoanaerobacterium thermosaccharolyticum-like species) and methane reactors (Clostridium thermocellum-like species). The changes of substrates and HRT did not change the dominant species. The archaeal community structures in methane reactors were similar both in single- and two-stage reactors, with acetoclastic methanogens Methanosarcina acetivorans-like organisms as the dominant species.

General information
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Organisations: Department of Environmental Engineering, Residual Resource Engineering, Tongji University
Pages: 8700-8706
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BFI (2018): BFI-level 2
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BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 6.28 SJR 2.029 SNIP 1.799
Web of Science (2017): Impact factor 5.807
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.94 SJR 2.215 SNIP 1.932
Web of Science (2016): Impact factor 5.651
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.47 SJR 2.243 SNIP 1.897
Web of Science (2015): Impact factor 4.917
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.3 SJR 2.399 SNIP 2.087
Web of Science (2014): Impact factor 4.494
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 5.97 SJR 2.405 SNIP 2.477
Web of Science (2013): Impact factor 5.039
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.25 SJR 2.334 SNIP 2.461
Web of Science (2012): Impact factor 4.75
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 5.56 SJR 2.308 SNIP 2.507
Web of Science (2011): Impact factor 4.98
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.089 SNIP 2.344
Web of Science (2010): Impact factor 4.365
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.915 SNIP 2.236
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.736 SNIP 2.74
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.403 SNIP 2.396
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.314 SNIP 2.003
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.278 SNIP 1.98
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.19 SNIP 1.655
Web of Science (2004): Indexed yes
In situ microbial fuel cell-based biosensor for organic carbon

The biological oxygen demand (BOD) may be the most used test to assess the amount of pollutant organic matter in water; however, it is time and labor consuming, and is done ex-situ. A BOD biosensor based on the microbial fuel cell principle was tested for online and in situ monitoring of biodegradable organic content of domestic wastewater. A stable current density of 282±23mA/m² was obtained with domestic wastewater containing a BOD5 of 317±15mg O₂/L at 22±2°C, 1.53±0.04mS/cm and pH 6.9±0.1. The current density showed a linear relationship with BOD5 concentration ranging from 17±0.5mg O₂/L to 78±7.6mg O₂/L. The current generation from the BOD biosensor was dependent on the measurement conditions such as temperature, conductivity, and pH. Thus, a correction factor should be applied to measurements done under different environmental conditions from the ones used in the calibration. These results provide useful information for the development of a biosensor for real-time in situ monitoring of wastewater quality.

High rate algal biomass production for food, biochemicals and Biofuels: An Indo-Danish collaboration project.

General information
State: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering, Technical University of Denmark, IIT Kharagpur, Indian Agricultural Research Institute, SPRTC, India
Publication date: 2011
Peer-reviewed: No
Electronic versions: isap-Angelidaki-et.pdf
Source: orbit
Source-ID: 282861
Research output: Research › Conference abstract for conference – Annual report year: 2011
Long-term effect of inoculum pretreatment on fermentative hydrogen production by repeated batch cultivations: homoacetogenesis and methanogenesis as competitors to hydrogen production

Long-term effects of inoculum pretreatments (heat, acid, loading-shock) on hydrogen production from glucose under different temperatures (37°C, 55°C) and initial pH (7 and 5.5) were studied by repeated batch cultivations. Results obtained showed that it was necessary to investigate the long-term effect of inoculum pretreatment on hydrogen production since pretreatments may just temporarily inhibit the hydrogen consuming processes. After long-term cultivation, pretreated inocula did not enhance hydrogen production compared to untreated inocula under mesophilic conditions (initial pH 7 and pH 5.5) and thermophilic conditions (initial pH 7). However, pretreatment could inhibit lactate production and lead to higher hydrogen yield under thermophilic conditions at initial pH 5.5. The results further demonstrated that inoculum pretreatment could not permanently inhibit either methanogenesis or homoacetogenesis, and methanogenesis and homoacetogenesis could only be inhibited by proper control of fermentation pH and temperature. Methanogenic activity could be inhibited at pH lower than 6, both under mesophilic and thermophilic conditions, while homoacetogenic activity could only be inhibited under thermophilic condition at initial pH 5.5. Microbial community analysis showed that pretreatment did not affect the dominant bacteria. The dominant bacteria were Clostridium butyricum related organisms under mesophilic condition (initial pH 7 and 5.5), Thermoanaerobacterium sp. related organisms under thermophilic condition (initial pH 7), and Thermoanaerobacterium thermosaccharolyticum related organisms under thermophilic condition (initial pH 5.5). Results from this study clearly indicated that the long-term effects of inoculum pretreatments on hydrogen production, methanogenesis, homoacetogenesis and dominant bacteria were dependent on fermentation temperature and pH.

General information
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Organisations: Department of Environmental Engineering, Residual Resource Engineering, Tongji University
Pages: 1816-1827
Publication date: 2011
Peer-reviewed: Yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 4.04 SJR 1.62 SNIP 1.364
Web of Science (2012): Impact factor 3.648
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 4.08 SJR 1.668 SNIP 1.481
Web of Science (2011): Impact factor 3.946
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.551 SNIP 1.354
Web of Science (2010): Impact factor 3.7
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.498 SNIP 1.358
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.248 SNIP 1.283
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.363 SNIP 1.356
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.467 SNIP 1.437
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.135 SNIP 1.23
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.105 SNIP 1.245
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.052 SNIP 1.228
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.117 SNIP 1.263
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.059 SNIP 1.16
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 1.428 SNIP 1.529
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 1.494 SNIP 1.531
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Research output: Research - peer-review ; Journal article – Annual report year: 2011

Metangas kan blive en genvej til brintsamfundet

General information
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Organisations: Department of Environmental Engineering, Residual Resource Engineering, Vestforsyning
Contributors: Angelidaki, I., Luo, G., Lyhne, P.
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Publication information
Micro-aerobic, anaerobic and two-stage condition for ethanol production by Enterobacter aerogenes from biodiesel-derived crude glycerol

The microbial production of ethanol from biodiesel-derived crude glycerol by Enterobacter aerogenes TISTR1468, under micro-aerobic and anaerobic conditions, was investigated. The experimental results showed that micro-aerobic conditions were more favorable for cellular growth (4.0 g/L DCW), ethanol production (20.7 g/L) as well as the ethanol yield (0.47 g/g glycerol) than anaerobic conditions (1.2 g/L DCW, 6.3 g/L ethanol and 0.72 g/g glycerol, respectively). Crude glycerol (100 g/L) was consumed completely with the rate of 1.80 g/L/h. Two-stage fermentation (combination of micro-aerobic and anaerobic condition) exhibited higher ethanol production (24.5 g/L) than using one-stage fermentation (either micro-aerobic or anaerobic condition). The two-stage configuration, exhibited slightly higher crude glycerol consumption rate (1.81 g/L/h), as well as ethanol yield (0.56 g/g) than the one-stage configuration. Therefore, two-stage process was selected for ethanol production from E. aerogenes TISTR1468 in scale-up studies.

Microwave pretreatment of rape straw for bioethanol production: Focus on energy efficiency

The energy efficiency of microwave-assisted dilute sulfuric acid pretreatment of rape straw for the production of ethanol was investigated. Different microwave energy inputs and solid loadings were tested to find economic pretreatment conditions. The lowest energy consumption was observed when solid loading and energy input were fixed at 50% (w/w) and 54kJ (900W for 1min), respectively, and amounted to 5.5 and 10.9kJ to produce 1g of glucose after enzymatic hydrolysis and 1g ethanol after fermentation, respectively. In general, 1g ethanol can produce about 30kJ of energy, and therefore, the energy input for the pretreatment was only 35% of the energy output. The approach developed in this study resulted in 92.9% higher energy savings for producing 1g ethanol when compared with the results of microwave pretreatments previously reported.
Nitrate as an Oxidant in the Cathode Chamber of a Microbial Fuel Cell for Both Power Generation and Nutrient Removal Purposes

Nitrate ions were used as the oxidant in the cathode chamber of a microbial fuel cell (MFC) to generate electricity from organic compounds with simultaneous nitrate removal. The MFC using nitrate as oxidant could generate a voltage of 111 mV (1,000 Ω) with a plain carbon cathode. The maximum power density achieved was 7.2 mW m⁻² with a 470 Ω resistor. Nitrate was reduced from an initial concentration of 49 to 25 mg (NO₃⁻–N) L⁻¹ during 42-day operation. The daily removal rate was 0.57 mg (NO₃⁻–N) L⁻¹ day⁻¹ with a voltage generation of 96 mV. In the presence of Pt catalyst dispersed on cathode, the cell voltage was significantly increased up to 450 mV and the power density was 117.7 mW m⁻², which was 16 times higher than the value without Pt catalyst. Significant nitrate removal was also observed with a daily removal rate of 2 mg (NO₃⁻–N) L⁻¹ day⁻¹, which was 3.5 times higher compared with the operation without catalyst. Nitrate was reduced to nitrite and ammonia in the liquid phase at a ratio of 0.6% and 51.8% of the total nitrate amount. These results suggest that nitrate can be successfully used as an oxidant for power generation without aeration and also nitrate removal from water in MFC. However, control of the process would be needed to reduce nitrate to only nitrogen gas, and avoid further reduction to ammonia.

General information
State: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering
Contributors: Fang, C., Min, B., Angelidaki, I.
Pages: 464-474
Publication date: 2011
Peer-reviewed: Yes

Publication information
Journal: Applied Biochemistry and Biotechnology
Volume: 164
Issue number: 4
ISSN (Print): 0273-2289
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.02 SJR 0.571 SNIP 0.8
Web of Science (2017): Impact factor 1.797
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.81 SJR 0.579 SNIP 0.749
Web of Science (2016): Impact factor 1.751
Web of Science (2016): Indexed yes
Performance and microbial community analysis of two-stage process with extreme thermophilic hydrogen and thermophilic methane production from hydrolysate in UASB reactors

The two-stage process for extreme thermophilic hydrogen and thermophilic methane production from wheat straw hydrolysate was investigated in up-flow anaerobic sludge bed (UASB) reactors. Specific hydrogen and methane yields of 89ml-H2/g-VS (190ml-H2/g-sugars) and 307ml-CH4/g-VS, respectively were achieved simultaneously with the overall VS removal efficiency of 81% by operating with total hydraulic retention time (HRT) of 4 days. The energy conversion efficiency was dramatically increased from only 7.5% in the hydrogen stage to 87.5% of the potential energy from hydrolysate, corresponding to total energy of 13.4kJ/g-VS. Dominant hydrogen-producing bacteria in the H2-UASB reactor were Thermoanaerobacter wiegelii, Caldanaerobacter subteraneus, and Caloramator fervidus. Meanwhile, the CH4-UASB reactor was dominated with methanogens of Methanosarcina mazei and Methanothermobacter defluvii. The results from this study suggest the two stage anaerobic process can be effectively used for energy recovery and for stabilization of hydrolysate at anaerobic conditions.

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Kongjan, P., O-Thong, S., Angelidaki, I.
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Publication date: 2011
Peer-reviewed: Yes

Publication information
Journal: Bioresource Technology
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Issue number: 5
ISSN (Print): 0960-8524
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 6.28 SJR 2.029 SNIP 1.799
Web of Science (2017): Impact factor 5.807
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.94 SJR 2.215 SNIP 1.932
Web of Science (2016): Impact factor 5.651
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.47 SJR 2.243 SNIP 1.897
Web of Science (2015): Impact factor 4.917
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.3 SJR 2.399 SNIP 2.087
Web of Science (2014): Impact factor 4.494
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 5.97 SJR 2.405 SNIP 2.477
Web of Science (2013): Impact factor 5.039
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.25 SJR 2.334 SNIP 2.461
Web of Science (2012): Impact factor 4.75
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 5.56 SJR 2.308 SNIP 2.507
Simultaneous organic carbon, nutrients removal and energy production in a photomicrobial fuel cell (PFC)

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Zhang, Y., Noori, J. S., Angelidaki, I.
Pages: 4340-4346
Publication date: 2011
Peer-reviewed: Yes

Publication information
Journal: Energy & Environmental Science
Volume: 4
Issue number: 10
ISSN (Print): 1754-5692
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 30.87 SJR 14.59 SNIP 4.819
Web of Science (2017): Impact factor 30.067
Submersible microbial fuel cell for electricity production from sewage sludge

A submersible microbial fuel cell (SMFC) was utilized to treat sewage sludge and simultaneously generate electricity. Stable power generation (145± 5 mW/m2, 470 Ω) was produced continuously from raw sewage sludge for 5.5 days. The maximum power density reached 190±5 mW/m2. The corresponding total chemical oxygen demand (TCOD) removal efficiency was 78.1±0.2% with initial TCOD of 49.7 g/L. The power generation of SMFC was depended on the sludge concentration, while dilution of the raw sludge resulted in higher power density. The maximum power density was saturated at sludge concentration of 17 g-TCOD/L, where 290 mW/m2 was achieved. When effluents from an anaerobic digester that was fed with raw sludge were used as substrate in the SMFC, a maximum power density of 318 mW/m2, and a final TCOD removal of 71.9±0.2% were achieved. These results have practical implications for development of an effective system to treat sewage sludge and simultaneously recover energy.

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering, Technical University of Denmark
Contributors: Zhang, Y., Olias, L. G., Kongjan, P., Angelidaki, I.
Pages: 50-55
Publication date: 2011
Submersible microbial fuel cell sensor for monitoring microbial activity and BOD in groundwater: Focusing on impact of anodic biofilm on sensor applicability

A sensor, based on a submersible microbial fuel cell (SUMFC), was developed for in situ monitoring of microbial activity and biochemical oxygen demand (BOD) in groundwater. Presence or absence of a biofilm on the anode was a decisive factor for the applicability of the sensor. Fresh anode was required for application of the sensor for microbial activity measurement, while biofilm-colonized anode was needed for utilizing the sensor for BOD content measurement. The current density of SUMFC sensor equipped with a biofilm-colonized anode showed linear relationship with BOD content, to up to 250 mg/L (∼233 ± 1 mA/m2), with a response time of

General information

State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Zhang, Y., Angelidaki, I.
Pages: 2339-2347
Publication date: 2011
Peer-reviewed: Yes

Publication information

Journal: Biotechnology and Bioengineering (Print)
Volume: 108
Issue number: 10
ISSN (Print): 0006-3592
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 4.07 SJR 1.372 SNIP 1.186
Web of Science (2017): Impact factor 3.952
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.14 SJR 1.447 SNIP 1.178
Web of Science (2016): Impact factor 4.481
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 4.44 SJR 1.632 SNIP 1.355
Thermophilic Biohydrogen Production

Dark fermentative hydrogen production at thermophilic conditions is an attractive process for biofuel production. From a thermodynamic point of view, higher temperatures favor biohydrogen production. Highest hydrogen yields are always associated with acetate, or with mixed acetate-butyrate type fermentation. On the contrary, the hydrogen yield decreases with increasing concentrations of lactate, ethanol or propionate. Major factors affecting dark fermentative biohydrogen production are organic loading rate (OLR), pH, hydraulic retention time (HRT), dissolved hydrogen and dissolved carbon dioxide concentrations, and soluble metabolic profile (SMP). A number of thermophilic and extreme thermophilic cultures (pure and mixed) have been studied for biohydrogen production from different feedstocks - pure substrates and waste/wastewaters. Variety of process technologies (operational conditions such as temperature and pH, fermentation modes and reactor types applied) are currently utilized at lab and pilot scale, for biohydrogen production. Although the process has strong potential for the production of energy from organic residues and wastes, the major challenge is to determine whether the economics and reliability of dark fermentative hydrogen production are sufficiently attractive for commercial application to be installed. Furthermore, storage and utilization of the produced hydrogen still faces challenges.

General information
State: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering
Contributors: Karakashev, D. B., Angelidaki, I.
Number of pages: 672
Publication date: 2011

Host publication information
Title of host publication: Biofuels: Alternative Feedstocks and Conversion Processes
Publisher: Academic Press
Editors: Pandey, A., Larroche, C., Ricke, S. C., Dussap, C., Gnansounou, E.
ISBN (Print): 978-0-12-385099-7
Source: orbit
Source-ID: 275885
Research output: Research → Book chapter – Annual report year: 2011

Use of extremophilic bacteria for second generation bioethanol production

The pursuit of ways to obtain viable alternatives to fossil fuels has been one of the main subjects in microbial biotechnology research in the last decade. Of all the possible fuel candidates, bioethanol is one of the most relevant, especially when considered for the transport sector. Its production from food crops, such as corn (starch) or sugar cane (sucrose) is already an established process, with the USA and Brazil supplying 86% of the market. The major challenge remains in the use of different waste sources – agricultural, forestry, animal and household waste - as a feedstock. The recalcitrance of these materials and their diverse sugar composition make the industrial yeast strains currently used unsuitable for a second generation bioethanol production process.

One of the alternative strategies is the use of extreme thermophilic microorganisms. Currently, selected members from the genera Clostridium, Thermoanaerobacter, Geobacillus and Thermoanaerobacterium are among the best candidates. A new strain of Thermoanaerobacter, closely related to T. italicus and T. mathranii, has achieved 0.43 g ethanol/g xylose, which is 83% of the theoretical yield of ethanol based on xylose and the highest value for a wild type strain reported so far. However, productivity and titer values comparable to a first generation process are yet to be achieved. Metabolic engineering to redirect the metabolism from mixed-product fermentation to ethanol production is one of the solutions proposed to improve the performance of extreme thermophilic bacteria.

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Number of pages: 1
Publication date: 2011
Peer-reviewed: Yes
Event: Abstract from 2011 Symposium The Danish Microbiological Society, Copenhagen, Denmark.
Electronic versions:
1.pdf

Bibliographical note
Oral presentation
Source: dtu
Source-ID: u::5883
Research output: Research - peer-review → Conference abstract for conference – Annual report year: 2012
Biogas production from food-processing industrial wastes by anaerobic digestion

General information
State: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering
Contributors: Fang, C., Angelidaki, I., Boe, K.
Publication date: Dec 2010

Publication information
Place of publication: Kgs. Lyngby, Denmark
Publisher: Technical University of Denmark (DTU)
Original language: English
Electronic versions:
WWW version
URLs:
Source: orbit
Source-ID: 274142
Research output: Research › Ph.D. thesis – Annual report year: 2010

Biohydrogen production from sugar rich substrates using the dark fermentation process

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Kongjan, P., Angelidaki, I., Min, B.
Publication date: Aug 2010

Publication information
Place of publication: Kgs. Lyngby, Denmark
Publisher: Technical University of Denmark (DTU)
Original language: English
Electronic versions:
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URLs:
Source: orbit
Source-ID: 265585
Research output: Research › Ph.D. thesis – Annual report year: 2010

Improved anaerobic digestion of energy crops and agricultural residues

General information
State: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering
Contributors: Bruni, E., Angelidaki, I.
Number of pages: 40
Publication date: Jun 2010

Publication information
Place of publication: Kgs. Lyngby, Denmark
Publisher: Technical University of Denmark (DTU)
ISBN (Print): 978-88-792654-00-7
Original language: English
Electronic versions:
WWW version
Source: orbit
Source-ID: 265130
Research output: Research › Ph.D. thesis – Annual report year: 2010
Biohydrogen production from wheat straw hydrolysate by dark fermentation using extreme thermophilic mixed culture

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Kongian, P., O-Thong, S., Kotay, S. M., Min, B., Angelidaki, I.
Pages: 899-908
Publication date: 2010
Peer-reviewed: Yes

Publication information
Journal: Biotechnology and Bioengineering (Print)
Volume: 105
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ISSN (Print): 0006-3592
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 4.07 SJR 1.372 SNIP 1.186
Web of Science (2017): Impact factor 3.952
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.14 SJR 1.447 SNIP 1.178
Web of Science (2016): Impact factor 4.481
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 4.44 SJR 1.632 SNIP 1.355
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 4.16 SJR 1.612 SNIP 1.395
Web of Science (2014): Impact factor 4.126
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Biorefinery concept as a sustainable way to produce energy and chemicals from agricultural products

General information
State: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering
Contributors: Angelidaki, I.
Number of pages: 60
Comparative study of mechanical, hydrothermal, chemical and enzymatic treatments of digested biofibers to improve biogas production

Publication information
Journal: Bioresource Technology
Volume: 101
Issue number: 22
ISSN (Print): 0960-8524
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 6.28 SJR 2.029 SNIP 1.799
Web of Science (2017): Impact factor 5.807
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.94 SJR 2.215 SNIP 1.932
Web of Science (2016): Impact factor 5.651
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.47 SJR 2.243 SNIP 1.897
Web of Science (2015): Impact factor 4.917
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.3 SJR 2.399 SNIP 2.087
Web of Science (2014): Impact factor 4.494
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 5.97 SJR 2.405 SNIP 2.477
Web of Science (2013): Impact factor 5.039
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.25 SJR 2.334 SNIP 2.461
Web of Science (2012): Impact factor 4.75
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Effect of xylose and nutrients concentration on ethanol production by a newly isolated extreme thermophilic Thermoanaerobacter sp.

General information
State: Published
Organisations: Department of Environmental Engineering
Publication date: 2010

Host publication information
Title of host publication: The 12th World Congress on Anaerobic Digestion 2010. Water Science and Technology, 31 October – 4 November, 2010, Guadalajara, Mexico
Volume: CD-ROM
Publisher: IWA International Water Association
Source: orbit
Source-ID: 268906
Research output: Research - peer-review › Article in proceedings – Annual report year: 2010

Electricity Generation from Organic Matters in Biocatalyst-Based Microbial Fuel Cells (MFCs)
Microbial fuel cells (MFCs) are a novel technology for converting organic matter directly to electricity via biocatalytic reactions by microorganisms. MFCs can also be used for wastewater treatment by the oxidations of organic pollutants during the electricity generation. Several factors for optimum power generation in MFC have been investigated at previous
studies. A submersible microbial fuel cell (SMFC), which is a novel configuration, was developed by immersing an anode electrode and a cathode chamber in an anaerobic reactor. Domestic wastewater without any amendments was used as the medium and the inoculum in the experiments. The SMFC could successfully generate a stable voltage of 0.428±0.003V with a fixed 470Ω resistor from acetate. From the polarization test, the maximum power density of 204mWm^{-2} was obtained at current density of 595mAm^{-2} (external resistance = 180Ω). The power generation showed a saturation-type relationship as a function of wastewater strength, with a maximum power density (P_{max}) of 218mWm^{-2} and a saturation constant (K_s) of 244 mg L^{-1}. We also achieved a successful power generation (123 mW/m2) from wheat straw hydrolysate in a two chamber microbial fuel cells (MFCs). These results demonstrate that MFC has a great potential for a sustainable power generation and wastewater treatment with a better understanding and optimization of microbial electricity generation.

**General information**
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering, Tsinghua University
Contributors: Min, B., Zhang, Y., Angelidaki, I.
Publication date: 2010
Peer-reviewed: Yes
Electronic versions:
ENV2010-001.pdf
Source: orbit
Source-ID: 285659
Research output: Research - peer-review > Conference abstract for conference – Annual report year: 2010

**Engineered heat treated methanogenic granules: A promising biotechnological approach for extreme thermophilic biohydrogen production**

**General information**
State: Published
Organisations: Department of Environmental Engineering
Pages: 9577-9586
Publication date: 2010
Peer-reviewed: Yes

**Publication information**
Journal: Bioresource Technology
Volume: 101
Issue number: 24
ISSN (Print): 0960-8524
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 6.28 SJR 2.029 SNIP 1.799
Web of Science (2017): Impact factor 5.807
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.94 SJR 2.215 SNIP 1.932
Web of Science (2016): Impact factor 5.651
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.47 SJR 2.243 SNIP 1.897
Web of Science (2015): Impact factor 4.917
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.3 SJR 2.399 SNIP 2.087
Web of Science (2014): Impact factor 4.494
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Extreme thermophilic biohydrogen production from wheat straw hydrolysate using mixed culture fermentation: Effect of reactor configuration

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Kongjan, P., Angelidaki, I.
Pages: 7789-7796
Publication date: 2010
Peer-reviewed: Yes
Long-chain fatty acids inhibition and adaptation process in anaerobic thermophilic digestion: Batch tests, microbial community structure and mathematical modelling

Biomass samples taken during the continuous operation of thermophilic anaerobic digestors fed with manure and exposed to successive inhibitory pulses of long-chain fatty acids (LCFA) were characterized in terms of specific metabolic activities and 16S rDNA DGGE profiling of the microbial community structure. Improvement of hydrogenotrophic and acidogenic (beta-oxidation) activity rates was detected upon successive LCFA pulses, while different inhibition effects over specific anaerobic trophic groups were observed. Bioreactor recovery capacity and biomass adaptation to LCFA inhibition were verified. Population profiles of eubacterial and archaeal 16S rDNA genes revealed that no significant shift on microbial community composition took place upon biomass exposure to LCFA. DNA sequencing of predominant DGGE bands showed close phylogenetic affinity to ribotypes characteristic from specific beta-oxidation bacterial genera (Syntrophomonas and Clostridium), while a single predominant syntrophic archaeae was related with the genus Methanosarcina. The hypothesis that biomass adaptation was fundamentally of physiological nature was tested using mathematical modelling, taking the IWA ADM1 as general model. New kinetics considering the relation between LCFA inhibitory substrate concentration and specific biomass content, as an approximation to the adsorption process, improved the model fitting and provided a better insight on the physical nature of the LCFA inhibition process. (C) 2009 Elsevier Ltd. All rights reserved.
Possibilities of anaerobic digestion in the Arctic

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Jørgensen, M. W., Angelidaki, I.
Publication date: 2010

Host publication information
Title of host publication: The 12th World Congress on Anaerobic Digestion (AD12). Water Science and Technology, 31 October – 4 November, 2010, Guadalajara, Mexico
Volume: CD-ROM
Publisher: IWA
Source: orbit
Source-ID: 271141
Research output: Research - peer-review › Article in proceedings – Annual report year: 2010

Production of bioethanol from wheat straw: An overview on pretreatment, hydrolysis and fermentation

General information
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Organisations: Department of Environmental Engineering
Pages: 4744-4753
Publication date: 2010
Peer-reviewed: Yes

Publication information
Journal: Bioresource Technology
Volume: 101
Issue number: 13
ISSN (Print): 0960-8524
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 6.28 SJR 2.029 SNIP 1.799
Web of Science (2017): Impact factor 5.807
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.94 SJR 2.215 SNIP 1.932
Web of Science (2016): Impact factor 5.651
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.47 SJR 2.243 SNIP 1.897
Web of Science (2015): Impact factor 4.917
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.3 SJR 2.399 SNIP 2.087
Web of Science (2014): Impact factor 4.494
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 5.97 SJR 2.405 SNIP 2.477
Web of Science (2013): Impact factor 5.039
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.25 SJR 2.334 SNIP 2.461
Web of Science (2012): Impact factor 4.75
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 5.56 SJR 2.308 SNIP 2.507
Web of Science (2011): Impact factor 4.98
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.089 SNIP 2.344
Web of Science (2010): Impact factor 4.365
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.915 SNIP 2.236
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.736 SNIP 2.74
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.403 SNIP 2.396
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.314 SNIP 2.003
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.278 SNIP 1.98
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.19 SNIP 1.655
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.942 SNIP 1.665
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.908 SNIP 1.294
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.537 SNIP 1.2
State indicators for monitoring the anaerobic digestion process

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Boe, K., Batstone, D. J., Steyer, J., Angelidaki, I.
Pages: 5973-5980
Publication date: 2010
Peer-reviewed: Yes

Publication information
Journal: Water Research
Volume: 44
ISSN (Print): 0043-1354
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 7.55 SJR 2.601 SNIP 2.358
Web of Science (2017): Impact factor 7.051
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 7.49 SJR 2.663 SNIP 2.563
Web of Science (2016): Impact factor 6.942
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 6.63 SJR 2.665 SNIP 2.482
Web of Science (2015): Impact factor 5.991
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 6.13 SJR 2.946 SNIP 2.702
Web of Science (2014): Impact factor 5.528
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 6.02 SJR 2.956 SNIP 2.676
Web of Science (2013): Impact factor 5.323
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.15 SJR 2.914 SNIP 2.442
Web of Science (2012): Impact factor 4.655
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 5.43 SJR 2.862 SNIP 2.355
Web of Science (2011): Impact factor 4.865
ISI indexed (2011): ISI indexed yes
Steam treatment of digested biofibers for increasing biogas production

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Bruni, E., Jensen, A., Angelidaki, I.
Pages: 7668-7671
Publication date: 2010
Peer-reviewed: Yes

Publication information
Journal: Bioresource Technology
Volume: 101
Issue number: 19
ISSN (Print): 0960-8524
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 6.28 SJR 2.029 SNIP 1.799
Web of Science (2017): Impact factor 5.807
Web of Science (2017): Indexed yes

DOIs:
10.1016/j.watres.2010.07.043
Source: orbit
Source-ID: 271665
Research output: Research - peer-review › Journal article – Annual report year: 2010
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.94 SJR 2.215 SNIP 1.932
Web of Science (2016): Impact factor 5.651
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.47 SJR 2.243 SNIP 1.897
Web of Science (2015): Impact factor 4.917
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.3 SJR 2.399 SNIP 2.087
Web of Science (2014): Impact factor 4.494
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 5.97 SJR 2.405 SNIP 2.477
Web of Science (2013): Impact factor 5.039
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.25 SJR 2.334 SNIP 2.461
Web of Science (2012): Impact factor 4.75
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 5.56 SJR 2.308 SNIP 2.507
Web of Science (2011): Impact factor 4.98
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.089 SNIP 2.344
Web of Science (2010): Impact factor 4.365
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.915 SNIP 2.236
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.736 SNIP 2.74
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.403 SNIP 2.396
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.314 SNIP 2.003
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.278 SNIP 1.98
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.19 SNIP 1.655
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.942 SNIP 1.665
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.908 SNIP 1.294
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.537 SNIP 1.2
Scopus rating (2000): SJR 0.653 SNIP 1.023
Scopus rating (1999): SJR 0.659 SNIP 1.033

Original language: English
Submersible microbial fuel cell for electricity production from sewage sludge

A submersible microbial fuel cell (SMFC) was utilized to treat sewage sludge and simultaneously generate electricity. Stable power generation (145±5 mW/m²) was produced continuously from raw sewage sludge for 5.5 days. The corresponding total chemical oxygen demand (TCOD) removal efficiency was 78.1±0.2% with an initial TCOD of 49.7 g/L. The power generation of SMFC was dependent on the sludge concentration. The maximum power density generated from raw sludge reached 190±5 mW/m². Dilution of the raw sludge resulted in higher power density. The power density was saturated at a sludge concentration of 17 g-TCOD/L, where the maximum power density of 290 mW/m² was achieved. When effluents from an anaerobic digester were used as substrate in the SMFC, a maximum power density of 318 mW/m² and a final TCOD removal of 71.9±0.2% was achieved. These results have practical implications for the development of an effective system to treat sewage sludge and simultaneously recover energy.

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering, Technical University of Denmark
Contributors: Zhang, Y., Olias, L. G., Kongjan, P., Angelidaki, I.
Publication date: 2010

Host publication information
Title of host publication: The 12th World Congress on Anaerobic Digestion (AD12). Water Science and Technology: CD-ROM
Publisher: IWA International Water Association
Keywords: Sewage sludge, TCOD removal efficiency, Submersible microbial fuel cell, Anaerobic digestion, Electricity generation
Source: orbit
Source-ID: 286761
Research output: Research - peer-review → Article in proceedings – Annual report year: 2011

Systematic investigation of the effect of feedstock composition, and filamentous bacteria cells on foaming in manure anaerobic digestion systems

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Pacheco, F., O-Thong, S., Boe, K., Angelidaki, I.
Publication date: 2010

Host publication information
Title of host publication: The 12th World Congress on Anaerobic Digestion (AD12). Water Science and Technology, 31 October – 4 November, 2010, Guadalajara, Mexico
Volume: CD-ROM
Publisher: IWA
Source: orbit
Source-ID: 271142
Research output: Research - peer-review → Article in proceedings – Annual report year: 2010

Thermophilic anaerobic co-digestion of pretreated empty fruit bunches with palm oil mill effluent for efficient biogas production

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: O-Thong, S., Fang, C., Angelidaki, I.
Publication date: 2010

Host publication information
Title of host publication: The 12th World Congress on Anaerobic Digestion (AD12). Water Science and Technology, 31 October – 4 November, 2010, Guadalajara, Mexico
Xylose fermentation to biofuels (hydrogen and ethanol) by extreme thermophilic (70 C) mixed culture

Combined biohydrogen and bioethanol (CHE) production from xylose was achieved by an extreme thermophilic (70 degrees C) mixed culture. Effect of initial pH, xylose, peptone, FeSO4, NaHCO3, yeast extract, trace mineral salts, vitamins, and phosphate buffer concentrations on bioethanol and biohydrogen yield was investigated in batch experiments. Results obtained showed that initial pH, concentration of xylose, peptone, and FeSO4 significantly affected biohydrogen and bioethanol production, while the concentration of NaHCO3 was only significant for bioethanol production. By changing cultivation conditions the culture could be directed to mainly produce ethanol with maximum ethanol yield of 1.60 mol ethanol/mol-xylose corresponding to 95.8% of the theoretical ethanol yield based on degradation of xylose through ethanologenic pathway, or mainly hydrogen with maximum hydrogen yield of 1.84 mol H2/mol-xylose corresponding to 55% of the theoretical hydrogen yield based on acetate metabolic pathway. An empirical model was established to reveal the quantitative effect of factors significant for biohydrogen (quadratic model) production and for bioethanol (linear model) production. Changes in hydrogen/ethanol yields observed were due to the shift of the metabolic pathway between ethanol or hydrogen production, rather than changes in bacterial community composition at genus level. Thermoanaerobacter related bacteria were found to be the dominant hydrogen/ethanol producers. (C) 2010 Professor T. Nejat Veziroglu. Published by Elsevier Ltd. All rights reserved.
Anaerobic digestion of slaughterhouse by-products

Anaerobic digestion of animal by-products was investigated in batch and semi-continuously fed, reactor experiments at 55 degrees C and for some experiments also at 37 degrees C. Separate or mixed by-products from pigs were tested. The methane potential measured by batch assays for meat- and bone flour, fat, blood, hair, meat, ribs, raw waste were: 225, 497, 487, 561, 582, 575, 359, 619 dm(3) kg(-1) respectively, corresponding to 50-100% of the calculated theoretical methane potential. Dilution of the by-products had a positive effect on the specific methane yield with the highest dilutions giving the best results. High concentrations of long-chain fatty acids and ammonia in the by-products were found to inhibit the biogas process at concentrations higher than 5 g lipids dm(-3) and 7 gN dm(-3) respectively, corresponding to 50-100% of the calculated theoretical methane potential. Pretreatment (pasteurization: 70 degrees C, sterilization: 133 degrees C, and alkali hydrolysis (NaOH)) had no effect on achieved methane yields. Mesophilic digestion was more stable than thermophilic digestion, and higher methane yield was noticed at high waste concentrations. The lower yield at thermophilic temperature and high waste concentration was due to ammonia inhibition. Co-digestion of 5% pork by-products mixed with pig manure at 37 degrees C showed 40% higher methane production compared to digestion of manure alone.

General information

State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Hejnfelt, A., Angelidaki, I.
Anammox for ammonia removal from pig manure effluents: Effect of organic matter content on process performance

The anammox process, under different organic loading rates (COD), was evaluated using a semi-continuous UASB reactor at 37 degrees C. Three different substrates were used: initially, synthetic wastewater, and later, two different pig manure effluents (after UASB-post-digestion and after partial oxidation) diluted with synthetic wastewater. High ammonium removal was achieved, up to 92.1 +/- 4.9% for diluted UASB-post-digested effluent (95 mg COD L-1) and up to 98.5 +/- 0.8% for diluted partially oxidized effluent (121 mg COD L-1). Mass balance clearly showed that an increase in organic loading (from 95 mg COD L-1 to 237 mg COD L-1 and from 121 mg COD L-1 to 290 mg COD L-1 for the UASB-post-digested effluent and the partially oxidized effluent, respectively) negatively affected the anammox process and facilitated heterotrophic denitrification. Partial oxidation as a pre-treatment method improved ammonium removal at high organic matter concentration. Up to threshold organic load concentration of 142 mg COD L-1 of UASB-post-digested effluent and 242 mg COD L-1 of partially oxidized effluent, no effect of organic loading on ammonia removal was registered (ammonium removal was above 80%). However, COD concentrations above 237 mg L-1 (loading rate of 112 mg COD L-1 day(-1)) for post-digested effluent and above 290 mg L-1 (loading rate of 136 mg COD L-1 day(-1)) for partially oxidized effluent resulted in complete cease of ammonium removal. Results obtained showed that, denitrification and anammox process were simultaneously occurring in the reactor. Denitrification became the dominant ammonium removal process when the COD loading was increased.

General information

State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Salces, B. M., García, M. C., Karakashev, D. B., Angelidaki, I.
Pages: 2171-2175
Publication date: 2009
Peer-reviewed: Yes

Publication information

Journal: Bioresource Technology
Volume: 100
Issue number: 7
ISSN (Print): 0960-8524
Ratings:
   BFI (2018): BFI-level 2
   Web of Science (2018): Indexed yes
   BFI (2017): BFI-level 2
   Scopus rating (2017): CiteScore 6.28 SJR 2.029 SNIP 1.799
   Web of Science (2017): Impact factor 5.807
   Web of Science (2017): Indexed yes
   BFI (2016): BFI-level 2
A strict anaerobic extreme thermophilic hydrogen-producing culture enriched from digested household waste

The aim of this study was to enrich, characterize and identify strict anaerobic extreme thermophilic hydrogen (H-2) producers from digested household solid wastes. A strict anaerobic extreme thermophilic H-2 producing bacterial culture was enriched from a lab-scale digester treating household wastes at 70 degrees C. The enriched mixed culture consisted of two rod-shaped bacterial members growing at an optimal temperature of 80 degrees C and an optimal pH 8.1. The culture was able to utilize glucose, galactose, mannose, xylose, arabinose, maltose, sucrose, pyruvate and glycerol as carbon sources. Growth on glucose produced acetate, H-2 and carbon dioxide. Maximal H-2 production rate on glucose was 1.1 mmol l(-1) h(-1) with a maximum H-2 yield of 1.9 mole H-2 per mole glucose. 16S ribosomal DNA clone library analyses showed that the culture members were phylogenetically affiliated to the genera Bacillus and Clostridium. Relative abundance of the culture members, assessed by fluorescence in situ hybridization, were 87 +/- 5% and 13 +/- 5% for Bacillus and Clostridium, respectively. An extreme thermophilic, strict anaerobic, mixed microbial culture with H-2-producing potential was enriched from digested household wastes. This study provided a culture with a potential to be applied in reactor systems for extreme thermophilic H-2 production from complex organic wastes.
Bioaugmentation of an upflow biofilm biohydrogen producing reactors under extreme-thermophilic condition (70 degree C) for improvement of the hydrogen yield and start up time

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Number of pages: 311
Publication date: 2009
Bioethanol, biohydrogen and biogas production from wheat straw in a biorefinery concept

The production of bioethanol, biohydrogen and biogas from wheat straw was investigated within a biorefinery framework. Initially, wheat straw was hydrothermally liberated to a cellulose rich fiber fraction and a hemicellulose rich liquid fraction (hydrolysate). Enzymatic hydrolysis and subsequent fermentation of cellulose yielded 0.41 g-ethanol/g-glucose, while dark fermentation of hydrolysate produced 178.0 ml-H₂/g-sugars. The effluents from both bioethanol and biohydrogen processes were further used to produce methane with the yields of 0.324 and 0.381 m³/kg volatile solids (VS) added, respectively. Additionally, evaluation of six different wheat straw-to-biofuel production scenarios showed that either use of wheat straw for biogas production or multi-fuel production were the energetically most efficient processes compared to production of mono-fuel such as bioethanol when fermenting C₆ sugars alone. Thus, multiple biofuels production from wheat straw can increase the efficiency for material and energy and can presumably be more economical process for biomass utilization. (C) 2008 Elsevier Ltd. All rights reserved.
Biohydrogen production by anaerobic fermentation of waste: Final Project Report STVF 2058-03-0020

General information
State: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering
Contributors: Karakashev, D. B., Angelidaki, I.
Publication date: 2009

Publication information
Place of publication: Kgs. Lyngby
Publisher: Technical University of Denmark. Department of Environmental Science and Engineering
Original language: English
Source: orbit
Source-ID: 246003
Biohydrogen production from xylose at extreme thermophilic temperatures (70 degrees C) by mixed culture fermentation

Biohydrogen production from xylose at extreme thermophilic temperatures (70 degrees C) was investigated in batch and continuous-mode operation. Biohydrogen was successfully produced from xylose by repeated batch cultivations with mixed culture received from a biohydrogen reactor treating household solid wastes at 70 degrees C. The highest hydrogen yield of 1.62 +/- 0.02 mol-H2/Mol-xylose(consumed) was obtained at initial xylose concentration of 0.5 g/L with synthetic medium amended with 1 g/L of yeast extract. Lower hydrogen yield was achieved at initial xylose concentration higher than 2 g/L. Addition of yeast extract in the cultivation medium resulted in significant improvement of hydrogen yield. The main metabolite products during xylose fermentation were acetate, ethanol, and lactate. The specific growth rates were able to fit the experimental points relatively well with Haldane equation assuming substrate inhibition, and the following kinetic parameters were obtained: the maximum specific growth rate (mu(max)) was 0.17h(-1), the half-saturation constant (K-s) was 0.75 g/L, and inhibition constant (K) was 3.72 g/L of xylose. Intermittent N2 sparging could enhance hydrogen production when high hydrogen partial pressure (>0.14 atm) was present in the headspace of the batch reactors. Biohydrogen could be successfully produced in continuously stirred reactor (CSTR) operated at 72-h hydraulic retention time (HRT) with 1 g/L of xylose as substrate at 70 degrees C. The hydrogen production yield achieved in the CSTR was 1.36 +/- 0.03 mol-H2/Mol-xylose(consumed), and the production rate was 62 +/- 2 ml/d.L-reactor. The hydrogen content in the methane-free mixed gas was approximately 31 +/- 1%, and the rest was carbon dioxide. The main intermediate by-products from the effluent were acetate, formate, and ethanol at 4.25 +/- 0.10, 3.01 +/- 0.11, and 2.59 +/- 0.16 mM, respectively.

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Kongjan, P., Min, B., Angelidaki, I.
Pages: 1414-1424
Publication date: 2009
Peer-reviewed: Yes

Publication information
Journal: Water Research
Volume: 43
Issue number: 5
ISSN (Print): 0043-1354
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 7.55 SJR 2.601 SNIP 2.358
Web of Science (2017): Impact factor 7.051
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 7.49 SJR 2.663 SNIP 2.563
Web of Science (2016): Impact factor 6.942
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 6.63 SJR 2.665 SNIP 2.482
Web of Science (2015): Impact factor 5.991
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 6.13 SJR 2.946 SNIP 2.702
Web of Science (2014): Impact factor 5.528
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 6.02 SJR 2.956 SNIP 2.676
Web of Science (2013): Impact factor 5.323
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Biorefineries: converting biomass into valuable products

General information
State: Published
Organisations: Department of Environmental Engineering, Biosystems Division. Management, Biosystems Division, Risø National Laboratory for Sustainable Energy
Contributors: Angelidaki, I., Pilegaard, K.
Pages: 82-96
Publication date: 2009

Host publication information
Title of host publication: Engineering challenges: energy, climate chance & health
Biorefinery for sustainable fuel production and high value added products from energy crops

General information
State: Published
Organisations: Urban Water Engineering, Department of Environmental Engineering
Contributors: Angelidaki, I.
Number of pages: 63
Publication date: 2009

Host publication information
Title of host publication: IBIO. BIT's 2nd annual world congress of industrial biotechnology 2009, Seoul, South Korea, April 5-7, 2009
Place of publication: Dalian, China
Publisher: BIT Life Sciences Inc.
Source: orbit
Source-ID: 241951
Research output: Research - peer-review » Conference abstract in proceedings – Annual report year: 2009

Defining the biomethane potential (BMP) of solid organic wastes and energy crops: a proposed protocol for batch assays
The application of anaerobic digestion technology is growing worldwide because of its economic and environmental benefits. As a consequence, a number of studies and research activities dealing with the determination of the biogas potential of solid organic substrates have been carrying out in the recent years. Therefore, it is of particular importance to define a protocol for the determination of the ultimate methane potential for a given solid substrates. In fact, this parameter determines, to a certain extent, both design and economic details of a biogas plant. Furthermore, the definition of common units to be used in anaerobic assays is increasingly requested from the scientific and engineering community. This paper presents some guidelines for biomethane potential assays prepared by the Task Group for the Anaerobic Biodegradation, Activity and Inhibition Assays of the Anaerobic Digestion Specialist Group of the International Water Association. This is the first step for the definition of a standard protocol.

General information
State: Published
Organisations: Department of Environmental Engineering
Pages: 927-934
Publication date: 2009
Peer-reviewed: Yes

Publication information
Journal: Water Science and Technology
Volume: 59
Issue number: 5
ISSN (Print): 0273-1223
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.34 SJR 0.429 SNIP 0.574
Web of Science (2017): Impact factor 1.247
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.3 SJR 0.404 SNIP 0.637
Web of Science (2016): Impact factor 1.197
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.19 SJR 0.464 SNIP 0.594
Web of Science (2015): Impact factor 1.064
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.14 SJR 0.585 SNIP 0.683
Web of Science (2014): Impact factor 1.106
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 1.3 SJR 0.571 SNIP 0.701
Web of Science (2013): Impact factor 1.212
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 1.13 SJR 0.597 SNIP 0.659
Web of Science (2012): Impact factor 1.102
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 1.25 SJR 0.594 SNIP 0.631
Web of Science (2011): Impact factor 1.122
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.529 SNIP 0.597
Web of Science (2010): Impact factor 1.056
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.592 SNIP 0.693
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 0.583 SNIP 0.694
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.736 SNIP 0.766
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.696 SNIP 0.789
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.767 SNIP 0.841
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.875 SNIP 0.897
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.882 SNIP 0.897
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.877 SNIP 0.894
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.758 SNIP 0.967
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 0.887 SNIP 0.866
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 0.885 SNIP 0.91
Effect of post-digestion temperature on serial CSTR biogas reactor performance

The effect of post-digestion temperature on a lab-scale serial continuous-flow stirred tank reactor (CSTR) system performance was investigated. The system consisted of a main reactor operated at 55 degrees C with hydraulic retention time (HRT) of 15 days followed by post-digestion reactors with HRT of 5.3 days. Three post-digestion temperatures (55 degrees C, 37 degrees C and 15 degrees C) were compared in terms of biogas production, process stability, microbial community and methanogenic activity. The results showed that the post-digesters operated at 55 degrees C, 37 degrees C and 15 degrees C gave extra biogas production of 11.7%, 8.4% and 1.2%, respectively. The post-digester operated at 55 degrees C had the highest biogas production and was the most stable in terms of low VFA concentrations. The specific methanogenic activity tests revealed that the main reactor and the post-digester operated at 55 degrees C and 37 degrees C had very active acidogens and methanogens. In contrast, very low methanogenic activity was observed at 15 degrees C.

General information
State: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering
Pages: 669-676
Publication date: 2009
Peer-reviewed: Yes

Publication information
Journal: Water Research
Volume: 43
Issue number: 3
ISSN (Print): 0043-1354
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 7.55 SJR 2.601 SNIP 2.358
Web of Science (2017): Impact factor 7.051
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 7.49 SJR 2.663 SNIP 2.563
Web of Science (2016): Impact factor 6.942
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 6.63 SJR 2.665 SNIP 2.482
Web of Science (2015): Impact factor 5.991
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 6.13 SJR 2.946 SNIP 2.702
Web of Science (2014): Impact factor 5.528
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 6.02 SJR 2.956 SNIP 2.676
Web of Science (2013): Impact factor 5.323
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.15 SJR 2.914 SNIP 2.442
Effect of pulse and continuous addition of oleate on microbial communities involved in anaerobic digestion process

General information
State: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering
Contributors: Baserba, M., Karakashev, D. B., Angelidaki, I.
Publication date: 2009

Host publication information
Title of host publication: ASPD5 - 5th IWA Activated Sludge Population Dynamics Specialist Conference - Microbial Population Dynamics in Biological Wastewater Treatment, 24-27 May 2009, Aalborg, Denmark
Volume: CD-ROM
Place of publication: Aalborg
Source: orbit

Effect of pulse and continuous addition of oleate on microbial communities involved in anaerobic digestion process
Effect of reactor configuration on biogas production from wheat straw hydrolysate

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Kaparaju, P. L., Serrano, M., Angelidaki, I.
Pages: 6317-6323
Publication date: 2009
Peer-reviewed: Yes

Publication information
Journal: Bioresource Technology
Volume: 100
Issue number: 24
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Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 6.28 SJR 2.029 SNIP 1.799
Web of Science (2017): Impact factor 5.807
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.94 SJR 2.215 SNIP 1.932
Web of Science (2016): Impact factor 5.651
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.47 SJR 2.243 SNIP 1.897
Web of Science (2015): Impact factor 4.917
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.3 SJR 2.399 SNIP 2.087
Web of Science (2014): Impact factor 4.494
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 5.97 SJR 2.405 SNIP 2.477
Web of Science (2013): Impact factor 5.039
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.25 SJR 2.334 SNIP 2.461
Web of Science (2012): Impact factor 4.75
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 5.56 SJR 2.308 SNIP 2.507
Web of Science (2011): Impact factor 4.98
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.089 SNIP 2.344
Web of Science (2010): Impact factor 4.365
Web of Science (2010): Indexed yes
Engineered heat treated methanogenic granules (EHTG): a promising biotechnological approach for high rate extreme thermophilic (70 degrees C) biohydrogen production in expanded granular sludge bed (EGSB) reactors

General information
State: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering, Urban Water Engineering, University of Minho
Pages: S250-S251
Publication date: 2009
Peer-reviewed: Yes

Publication information
Journal: New Biotechnology
Volume: 25
ISSN (Print): 1871-6784
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 3.66 SJR 0.967 SNIP 1.14
Web of Science (2017): Impact factor 3.733
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.67 SJR 1.08 SNIP 1.262
Web of Science (2016): Impact factor 3.813
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 3.07 SJR 1.073 SNIP 1.055
Engineered heat treated methanogenic granules (ETHG): a promising biotechnological approach for high rate extreme thermophilic (70 degree C) biohydrogen production in expanded granular sludge bed (EGSB) reactor

General information
State: Published
Organisations: Department of Environmental Engineering
Pages: S250
Publication date: 2009
Peer-reviewed: Yes

Publication information
Journal: New Biotechnology
Ex-situ bioremediation of polycyclic aromatic hydrocarbons in sewage sludge

Polycyclic aromatic hydrocarbons (PAH) are regarded as environmental pollutants. A promising approach to reduce PAH pollution is based on the implementation of the natural potential of some microorganisms to utilize hydrocarbons. In this study Proteiniphilum acetatigenes was used for bioaugmentation of sewage sludge to improve the PAH removal. Bioaugmentation experiments were performed in parallel semi-continuously fed reactors started up with digested primary and secondary sludge. Three bioaugmentation approaches were investigated: A1, addition of bacteria once during starting up; A2, addition of bacteria at the beginning and then every 2nd day and A3, addition of encapsulated bacteria once during starting up. Removal of PAH was found to be both biotic and abiotic. All three approaches had a positive effect of the biological removal of PAH. Highest biological removal of individual PAH (up to 80%) was observed using continuous addition (approach A2) of the bacteria to the reactors. In general, the effect of bioaugmentation was higher in the reactors fed with primary sludge compared to the reactors fed with mixed sludge. Bioaugmentation resulted in biological removal of low molecular weight PAH in the reactors fed with primary sludge using all three approaches while clear biological removal of the medium- and high molecular weight PAH only was observed if the bacteria were added continuously (approach A2).

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Electricity generation from wheat straw hydrolysate and the microbial ecology of electricity producing microbial communities developed in two chamber microbial fuel cells (MFCs) were investigated. Power density reached 123 mW/m² with an initial hydrolysate concentration of 1000 mg-COD/L while Coulombic efficiencies (CEs) ranged from 37.1 to 15.5% corresponding to the initial hydrolysate concentrations from 250 to 2000 mg-COD/L. The suspended bacteria found were different from the bacteria immobilized in the biofilm, and they played different roles in electricity generation from hydrolysate. Bacteria in the biofilm were consortia with sequences similar to Bacteroidetes (40% of sequences), Alphaproteobacteria (20%), Bacilli (20%), Deltaproteobacteria (10%), and Gammaproteobacteria (10%), while suspended consortia were predominated by Bacilli (22.2%). Results from this study can contribute to improve understanding and optimizing the electricity generation in microbial fuel cells.
High yield simultaneous biohydrogen and bioethanol production under extreme thermophilic (70 degree C) mixed culture environment

General information
State: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering
Contributors: Zhao, C., Karakashev, D. B., Tomas, A., Angelidaki, I.
Publication date: 2009

Host publication information
Title of host publication: FEMS 2009. 3rd Congress of European Microbiologists, Gothenburg, Sweden, June 28 - July 2, 2009 : Microbes and man-interdependence and future challenges
Volume: Abstracts. CD-ROM.
Place of publication: Geneve, Switzerland
Publisher: Kenes International
Source: orbit
Source-ID: 247056
Research output: Research - peer-review » Conference abstract in proceedings – Annual report year: 2009

High yield simultaneous hydrogen and ethanol production under extreme-thermophilic (70 degrees C) mixed culture environment

General information
State: Published
Organisations: Department of Environmental Engineering
Pages: 5657-5665
Publication date: 2009
Peer-reviewed: Yes

Publication information
Volume: 34
Issue number: 14
ISSN (Print): 0360-3199
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 4.1 SJR 1.116 SNIP 1.267
Microbial community structure of biohydrogen production process in extreme thermophilic conditions

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Alves, J., Abreu, A., Pereira, M., Karakashev, D. B., Angelidaki, I., Alves, M.
Publication date: 2009

Host publication information
Title of host publication: FEMS 2009. 3rd Congress of European Microbiologists, Gothenburg, Sweden, June 28 - July 2, 2009: Microbes and man-interdependence and future challenges
Volume: Abstracts. CD-ROM
Place of publication: Geneve, Switzerland
Publisher: Kenes International
Source: orbit
Source-ID: 247051
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2009

Optimising af biogasproduktionen

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Ellegaard, L., Angelidaki, I.
Pages: 12-14
Publication date: 2009
Peer-reviewed: No

Publication information
Journal: Forskning i Bioenergi
Issue number: 30
ISSN (Print): 1604-6331
Ratings:
ISI indexed (2013): ISI indexed no
ISI indexed (2012): ISI indexed no
ISI indexed (2011): ISI indexed no
Original language: Danish
Source: orbit
Source-ID: 257353
Research output: Research › Journal article – Annual report year: 2009

Optimisation of biogas production from manure through serial digestion: Lab-scale and pilot-scale studies

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Kaparaju, P. L., Ellegaard, L., Angelidaki, I.
Pages: 701-709
Publication date: 2009
Peer-reviewed: Yes

Publication information
Journal: Bioresource Technology
Volume: 100
Issue number: 2
ISSN (Print): 0960-8524
Ratings:
BFI (2018): BFI-level 2
Optimization of H2SO4-catalyzed hydrothermal pretreatment of rapeseed straw for bioconversion to ethanol: Focusing on pretreatment at high solids content

A central composite design of response surface method was used to optimize H2SO4-catalyzed hydrothermal pretreatment of rapeseed straw, in respect to acid concentration (0.5-2%), treatment time (5-20 min) and solid content (10-20%) at 180 degrees C. Enzymatic hydrolysis and fermentation were also measured to evaluate the optimal pretreatment conditions for maximizing ethanol production. The results showed that acid concentration and treatment time were more significant than solid content for optimization of xylose release and cellulose recovery. Pretreatment with 1% sulfuric acid and 20% solid content for 10 min at 180 degrees C was found to be the most optimal condition for pretreatment of rapeseed straw for ethanol production. After pretreatment at the optimal condition and enzymatic hydrolysis, 75.12% total xylan and 63.17% total glucan were converted to xylose and glucose, respectively. Finally, 66.79% of theoretical ethanol yielded after fermentation.

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Xuebin, L., Zhang, Y., Angelidaki, I.
Pages: 3048-3053
Publication date: 2009
Peer-reviewed: Yes

Publication information
Journal: Bioresource Technology
Volume: 100
Issue number: 12
ISSN (Print): 0960-8524
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 6.28 SJR 2.029 SNIP 1.799
Web of Science (2017): Impact factor 5.807
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.94 SJR 2.215 SNIP 1.932
Web of Science (2016): Impact factor 5.651
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.47 SJR 2.243 SNIP 1.897
Web of Science (2015): Impact factor 4.917
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.3 SJR 2.399 SNIP 2.087
Web of Science (2014): Impact factor 4.494
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 5.97 SJR 2.405 SNIP 2.477
Web of Science (2013): Impact factor 5.039
ISI indexed (2013): ISI indexed yes
Screening *Escherichia coli*, *Enterococcus faecalis*, and *Clostridium perfringens* as Indicator Organisms in Evaluating Pathogen-Reducing Capacity in Biogas Plants

This study was conducted to identify an indicator organism(s) in evaluating the pathogen-reducing capacity of biogas plants. Fresh cow manure containing 10(4) to 10(5) colony forming unit (CFU) per milliliter of *Escherichia coli* and *Enterococcus faecalis* along with an inoculated *Clostridium perfringens* strain were exposed to 37°C degrees C for 15 days, 55°C degrees C for 48 h, and 70°C degrees C for 24 h. *C. perfringens* was the most heat-resistant organism followed by *E. faecalis*, while *E. coli* was the most heat-sensitive organism. *E. coli* was reduced below detection limit at all temperatures with log(10) reductions of 4.94 (10 s), 4.37 (40 min), and 2.6 (5 days) at 70°C degrees C, 55°C degrees C, and 37°C degrees C, respectively. Maximum log(10) reductions for *E. faecalis* were 1.77 at 70°C degrees C (1 day), 1.7 at 55°C degrees C (2 days) and 3.13 at 37°C degrees C (15 days). For *C. perfringens*, maximum log(10) reduction at 37°C degrees C was 1.35 log(10) units (15 days) compared to less than 1 unit at 55 and 70°C degrees C. Modeling results showed that *E. faecalis* and *C. perfringens* had higher amount of heat-resistant fraction than *E. coli*. Thus, *E. faecalis* and *C. perfringens* can be used as indicator organisms to evaluate pathogen-reducing capacity in biogas plants at high temperatures of 55°C degrees C.
C and 70A degrees C while at 37A degrees C E. coli could also be included as indicator organism.
Serial CSTR digester configuration for improving biogas production from manure

A new configuration of manure digesters for improving biogas production has been investigated in laboratory scale. A single thermophilic continuous-flow stirred tank reactor (CSTR) operated with a hydraulic retention time (HRT) of 15 days was compared to a serial CSTR configuration with volume distribution ratio of 80/20 and 90/10, and total HRT of 15 days. The results showed that the serial CSTR could obtain 11% higher biogas yield compared to the single CSTR. The increased biogas yield in the serial CSTR was mainly from the second reactor, which accounted for 16% and 12% of total biogas yield in the 90/10 and 80/20 configuration, respectively. VFA concentration in the serial CSTR was high in the first reactor but very low in the second reactor. The results from organic pulse load test showed that the second reactor in serial CSTR helped utilizing VFA produced from overloading in the first reactor, which improved the effluent quality and conversion efficiency of the serial CSTR.

General information
State: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering
Contributors: Boe, K., Angelidaki, I.
Pages: 166-172
Publication date: 2009
Peer-reviewed: Yes

Publication information
Journal: Water Research
Volume: 43
Issue number: 1
ISSN (Print): 0043-1354
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 7.55 SJR 2.601 SNIP 2.358
Web of Science (2017): Impact factor 7.051
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 7.49 SJR 2.663 SNIP 2.563
Web of Science (2016): Impact factor 6.942
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 6.63 SJR 2.665 SNIP 2.482
Web of Science (2015): Impact factor 5.991
Strategies for recovering inhibition caused by long chain fatty acids on anaerobic thermophilic biogas reactors

Long chain fatty acids (LCFA) concentrations over 1.0 g L\(^{-1}\) were inhibiting manure thermophilic digestion, in batch and semi-continuous experiments, resulting in a temporary cease of the biogas production. The aim of the work was to test and evaluate several recovery actions, such as reactor feeding patterns, dilution and addition of adsorbents, in order to determine the most appropriate strategy for fast recovery of the reactor activity in manure based plants inhibited by LCFA. Dilution with active inoculum for increasing the biomass/LCFA ratio, or addition of adsorbents for adsorbing the LCFA and reducing the bioavailable LCFA concentration, were found to be the best recovery strategies, improving the recovery time from 10 to 2 days, in semi-continuously fed systems. Moreover, acclimatization was introduced by repeated inhibition and process recovery. The subsequent exposure of the anaerobic biomass to an inhibitory concentration of LCFA improved the recovery ability of the system, indicated as increasing degradation rates from 0.04 to 0.16 g COD_CH4/g VS day. The incubation time between subsequent pulses, or discontinuous LCFA pulses, seems to be a decisive process parameter to tackle LCFA inhibition in manure anaerobic co-digestion. © 2009 Elsevier Ltd. All rights reserved
The effect of different substrates and humic acid on power generation in microbial fuel cell operation

General information
State: Published
Organisations: Bioenergy and Biomass, Biosystems Division, Risø National Laboratory for Sustainable Energy, Electroceramics, Fuel Cells and Solid State Chemistry Division, Residual Resource Engineering, Department of Environmental Engineering
Contributors: Thygesen, A., Poulsen, F. W., Min, B., Angelidaki, I., Thomsen, A. B.
Pages: 1186-1191
Publication date: 2009
Peer-reviewed: Yes

Publication information
Journal: Bioresource Technology
Volume: 100
Issue number: 3
ISSN (Print): 0960-8524
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 6.28 SJR 2.029 SNIP 1.799
Web of Science (2017): Impact factor 5.807
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.94 SJR 2.215 SNIP 1.932
Web of Science (2016): Impact factor 5.651
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.47 SJR 2.243 SNIP 1.897
Web of Science (2015): Impact factor 4.917
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.3 SJR 2.399 SNIP 2.087
Web of Science (2014): Impact factor 4.494
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 5.97 SJR 2.405 SNIP 2.477
Web of Science (2013): Impact factor 5.039
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.25 SJR 2.334 SNIP 2.461
Web of Science (2012): Impact factor 4.75
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 5.56 SJR 2.308 SNIP 2.507
Web of Science (2011): Impact factor 4.98
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.089 SNIP 2.344
Web of Science (2010): Impact factor 4.365
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.915 SNIP 2.236
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.736 SNIP 2.74
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.403 SNIP 2.396
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.314 SNIP 2.003
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.278 SNIP 1.98
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.19 SNIP 1.655
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.942 SNIP 1.665
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.908 SNIP 1.294
Web of Science (2002): Indexed yes
Bio-hydrogen production by dark fermentation from organic wastes and residues

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering, Residual Resource Engineering
Contributors: Liu, D., Angelidaki, I., Zeng, R. J., Min, B.
Number of pages: 46
Publication date: Jul 2008

Publication information
Place of publication: Kgs. Lyngby
Publisher: DTU Environment
ISBN (Print): 978-87-91855-52-8
Original language: English
Electronic versions:
WWW version
Source: orbit
Source-ID: 228054
Research output: Research › Ph.D. thesis – Annual report year: 2008

16S rRNA-targeted probes for specific detection of Thermoanaerobacterium spp., Thermoanaerobacterium thermosaccharolyticum, and Caldicellulosiruptor spp. by fluorescent in situ hybridization in biohydrogen producing systems

16S rRNA gene targeted oligonucleotide probes for specific detection of genera Thermoanaerobacterium (Tbm1282), Caldicellulosiruptor (Ccs432), and specie Thermoanaerobacterium thermosaccharolyticum (Tbmthsacc184) were designed and used to monitor the spatial distribution of hydrogen producing bacteria in sludge and granules from anaerobic reactors. The designed probes were checked for their specificity and then validated using fluorescence in situ hybridization with target microorganisms and non-target microorganisms. Thermoanaerobacterium spp., T. thermosaccharolyticum and Caldicellulosiruptor spp. were detected with the probes designed with coverage of 75%, 100% and 93%, respectively. Thermophilic (60 °C) hydrogen producing reactors, one fed with sucrose and another, fed with palm oil mill effluent comprised of following major groups of hydrogen producers: Thermoanaerobacterium spp. (49% and 36%), T. thermosaccharolyticum (16% and 10%), phylum Firmicutes (low G+C) gram positive bacteria (15% and 27%). Extreme-thermophilic (70 °C) hydrogen producing reactors, one with xylose and another, fed with lignocellulosic hydrolysate comprised of following major groups of hydrogen producers: Caldicellulosiruptor spp. (40.5% and 20.5%), phylum Firmicutes (low G+C) gram positive bacteria (17% and 20%), Archaea (7% and 8.5%), and Thermoanaerobacterium spp. (0% and 5%). Results obtained, showed good applicability of the probes Tbm1282, Tbmthsacc184 and Ccs432 for specific detection and quantification of thermophilic and extreme-thermophilic hydrogen producers in complex environments.

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Pages: 6082-6091
Publication date: 2008
Peer-reviewed: Yes

Publication information
Volume: 33
Issue number: 21
ISSN (Print): 0360-3199
Ratings:
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Anaerobic biodegradation of fluoranthene under methanogenic conditions in presence of surface-active compounds

Bacillus cereus isolated from municipal wastewater treatment plant was used as a model strain to assess the efficiency of two anionic surfactants, a chemical surfactant and a biosurfactant during fluoranthene biodegradation under anaerobic methanogenic conditions. The surfactants selected for the study were linear alkyl benzene sulphonates (LAS) and rhamnolipid-biosurfactant complex from Pseudomonas sp. PS-17. Biodegradation of fluoranthene was monitored by GC/MS for a period up to 12th day. No change in the fluoranthene concentration was registered after 7th day. The presence of LAS enhanced the cell growth as well as the fluoranthene biodegradation. The rhamnolipid-biosurfactant at both used concentrations inhibited the cell growth and had no effect on the biodegradation rate. It was shown that LAS did not affect the microbial cell permeability and its positive effect on fluoranthene biodegradation was most likely as a result of the increased fluoranthene solubility. The results indicate that LAS can be considered as a promising agent for facilitation of the process of anaerobic polycyclic aromatic hydrocarbons (PAH) biodegradation under methanogenic conditions.

General information
State: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering, Bulgarian Academy of Sciences
Pages: 123-127
Publication date: 2008
Peer-reviewed: Yes

Publication information
Journal: Journal of Hazardous Materials
Volume: 153
Issue number: 1-2
ISSN (Print): 0304-3894
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 6.75 SJR 1.787 SNIP 1.96
Web of Science (2017): Impact factor 6.434
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 6.31 SJR 1.742 SNIP 2.061
Web of Science (2016): Impact factor 6.065
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 5.54 SJR 1.633 SNIP 1.931
Web of Science (2015): Impact factor 4.836
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 5.21 SJR 1.814 SNIP 2.258
Web of Science (2014): Impact factor 4.529
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 5.09 SJR 1.822 SNIP 2.43
Web of Science (2013): Impact factor 4.331
ISI indexed (2013): ISI indexed yes
Biofuel production: A new biorefinery for sustainable energy from crops: conversion of lignocellulose to bioethanol, biohydrogen and biomethane

General information
State: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering
Contributors: Angelidaki, I., Kongjan, P.
Publication date: 2008
Peer-reviewed: No
Event: Abstract from indo-Swedish International Conference on Biotechnology for Sustainable Development, National Chemical Laboratory, Pune, India.
Electronic versions:
ENV2008-063.pdf
Biohydrogen production from glucose in upflow biofilm reactors with plastic carriers under extreme thermophilic conditions (70°C)

Biohydrogen could efficiently be produced in glucose-fed biofilm reactors filled with plastic carriers and operated at 70°C. Batch experiments were, in addition, conducted to enrich and cultivate glucose-fed extremethermophilic hydrogen producing microorganisms from a biohydrogen CSTR reactor fed with household solid waste. Kinetic analysis of the biohydrogen enrichment cultures show that substrate (glucose) likely inhibited hydrogen production when its concentration was higher than 1 g/L. Different start up strategies were applied for biohydrogen production in biofilm reactors operated at 70°C, and fed with synthetic medium with glucose as the only carbon and energy source. A biofilm reactor, started up with plastic carriers, that were previously inoculated with the enrichment cultures, resulted in higher hydrogen yield (2.21 mol H2/mol glucose consumed) but required longer start up time (1 month), while a biofilm reactor directly inoculated with the enrichment cultures reached stable state much faster (8 days) but with very low hydrogen yield (0.69 mol H2/mol glucose consumed). These results indicate that hydraulic pressure is necessary for successful immobilization of bacteria on carriers, while there is the risk of washing out specific high yielding bacteria. © 2008 Wiley Periodicals, Inc.
Biohydrogen production from household solid waste (HSW) at extreme-thermophilic temperature (70 degrees C) - Influence of pH and acetate concentration

Hydrogen production from household solid waste (HSW) was performed via dark fermentation by using an extreme-thermophilic mixed culture, and the effect of pH and acetate on the biohydrogen production was investigated. The highest hydrogen production yield was $257 \pm 25$ mL/gVS(added) at the optimum pH of 7.0. Acetate was proved to be inhibiting the dark fermentation process at neutral pH, which indicates that the inhibition was caused by total acetate concentration not by undissociated acetate. Initial inhibition was detected at acetate concentration of 50 mM, while the hydrogen fermentation was seriously inhibited at acetate concentration of 200 mM. At 200 mM acetate concentration, the hydrogen yield was $36 \pm 25$ mL/gVS(added), which was almost 7 times lower than the yield of $254 \pm 13$ mL/gVS(added), which was achieved at lower acetate concentration (5-25 mM). Additional to the negative effect on the hydrogen yield, acetate was resulting in the longer lag phase during batch fermentations. The lag phase was more than 100 h at acetate concentration of more than 150 mM, while it was only 3-4 h at 5-25 mM acetate.

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Liu, D., Min, B., Angelidaki, I.
Scopus rating (2006): SJR 1.061 SNIP 2.202
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.116 SNIP 1.825
Scopus rating (2004): SJR 1.232 SNIP 1.626
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.996 SNIP 1.289
Scopus rating (2002): SJR 0.748 SNIP 1.156
Scopus rating (2001): SJR 0.488 SNIP 1.197
Scopus rating (2000): SJR 0.384 SNIP 0.83
Scopus rating (1999): SJR 0.376 SNIP 0.882
Original language: English
Keywords: Hydrogen production, Extreme-thermophilic condition, Inhibition, Household solid waste, Dark fermentation
DOIs:
10.1016/j.ijhydene.2008.08.059
Source: orbit
Source-ID: 243670
Research output: Research - peer-review › Journal article – Annual report year: 2008

Biorefinery: The only way for sustainable biofuel production from energy crops; conversion of lignocellulose to bioethanol, biohydrogen and biomethane

General information
State: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering
Contributors: Angelidaki, I., Kongjan, P.
Publication date: 2008
Peer-reviewed: No
Electronic versions:
ENV2008-159.pdf
Source: orbit
Source-ID: 224322
Research output: Research › Conference abstract for conference – Annual report year: 2008

Codigestion of manure and industrial organic waste at centralized biogas plants: process imbalances and limitations
The present study focuses on process imbalances in Danish centralized biogas plants treating manure in combination with industrial waste. Collection of process data from various full-scale plants along with a number of interviews showed that imbalances occur frequently. High concentrations of ammonia or long chain fatty acids is in most cases expected to be the cause of microbial inhibitions/imbalances while foaming in the prestorage tanks and digesters is the most important practical process problem at the plants. A correlation between increased residual biogas production (suboptimal process conditions) and high fractions of industrial waste in the feedstock was also observed. The process imbalances and suboptimal conditions are mainly allowed to occur due to 1) inadequate knowledge about the waste composition, 2) inadequate knowledge about the waste degradation characteristics, 3) inadequate process surveillance, especially with regard to volatile fatty acids, and 4) insufficient pre-storage capacity causing inexpedient mixing and hindering exact dosing of the different waste products.

General information
State: Published
Organisations: Bioenergy and Biomass, Biosystems Division, Risø National Laboratory for Sustainable Energy, Residual Resource Engineering, Department of Environmental Engineering
Contributors: Bangsø Nielsen, H., Angelidaki, I.
Pages: 1521-1528
Publication date: 2008
Peer-reviewed: Yes

Publication information
Journal: Water Science and Technology
Volume: 58
Issue number: 7
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Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.34 SJR 0.429 SNIP 0.574
Web of Science (2017): Impact factor 1.247
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.3 SJR 0.404 SNIP 0.637
Web of Science (2016): Impact factor 1.197
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.19 SJR 0.464 SNIP 0.594
Web of Science (2015): Impact factor 1.064
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.14 SJR 0.585 SNIP 0.683
Web of Science (2014): Impact factor 1.106
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 1.3 SJR 0.571 SNIP 0.701
Web of Science (2013): Impact factor 1.212
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 1.13 SJR 0.597 SNIP 0.659
Web of Science (2012): Impact factor 1.102
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 1.25 SJR 0.594 SNIP 0.631
Web of Science (2011): Impact factor 1.122
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.529 SNIP 0.597
Web of Science (2010): Impact factor 1.056
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.592 SNIP 0.693
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 0.583 SNIP 0.694
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.736 SNIP 0.766
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.696 SNIP 0.789
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.767 SNIP 0.841
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.875 SNIP 0.897
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.882 SNIP 0.897
Web of Science (2003): Indexed yes
Codigestion of manure and organic waste at centralized biogas plants: Process imbalances and limitations

General information
State: Published
Organisations: Bioenergy and Biomass, Biosystems Division, Risø National Laboratory for Sustainable Energy, Residual Resource Engineering, Department of Environmental Engineering
Contributors: Bangsø Nielsen, H., Angelidaki, I.
Publication date: 2008

Host publication information
Title of host publication: Proceedings
Publisher: ADMED-IWA
Source-ID: 231820
Research output: Research › Article in proceedings – Annual report year: 2008

Defining the biomethane potential (BMP) of solid organic wastes: a proposed protocol for batch assays

General information
State: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering, University of Minho, University of Verona, University of Glamorgan, Lomonosov Moscow State University, Institute of Chemical Technology in Prague, University of Montevideo, University of Santiago de Compostela, Wageningen University & Research
Publication date: 2008

Host publication information
Title of host publication: 5th International Symposium of anaerobic digestion of solid waste and energy crops
Source-ID: 317705
Research output: Research › Article in proceedings – Annual report year: 2008

Defining the biomethane potential (BMP) of solid organic wastes: a proposed protocol for batch assays

General information
State: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering
Publication date: 2008
Peer-reviewed: Yes
Source-ID: 235440
Research output: Research › Conference abstract for conference – Annual report year: 2008
Effect of humic acids on electricity generation integrated with xylose degradation in microbial fuel cells

Pentose and humic acids (HA) are the main components of hydrolysates, the liquid fraction produced during thermohydrolysis of lignocellulosic material. Electricity generation integrated with xylose (typical pentose) degradation as well as the effect of HA on electricity production in microbial fuel cells (MFCs) was examined. Without HA addition the maximum power density increased from 39.5 mW/m² to 83 mW/m² when initial xylose concentrations increased from 1.5 to 30 mM, while coulombic efficiency ranged from 13.5% to 52.4% for xylose concentrations of 15 and 0.5 mM, respectively. Compared to controls where HAs were not added, addition of commercial HA resulted in increase of power density and coulombic efficiency, which ranged from 7.5% to 67.4% and 24% to 92.6%, respectively. Digested manure wastewater (DMW) was tested as potential mediator for power generation due to its content of natural HA, and although it could produce higher coulombic efficiency namely 32.2% than the control of 18.3%, showed lower power density which was approx. 57 mW/m² in comparison to power density of the control which was 69 mW/m². Presence of commercial HA or DMW in the anode chamber resulted in faster xylose degradation and formation of more oxidized products (acetate and formate) as well as less reduced products (lactate and ethanol) compared to the controls. The reduced power generation in the presence of DMW was attributed to the presence of bacterial inhibitors such as phenolic compounds. Therefore, new feedstocks for MFCs, containing both mediators and substrates, such as lignocellulose hydrolysates should be considered for their applicability in MFCs. Biotechnol. Bioeng. 2008;100: 413-422. © 2008 Wiley Periodicals, Inc.
Effect of temperature and active biogas process on passive separation of digested manure

The objective of the study was to identify the optimum time interval for effluent removal after temporarily stopping stirring in otherwise continuously stirred tank reactors. Influence of temperature (10 and 55 degrees C) and active biogas process on passive separation of digested manure, where no outside mechanical or chemical action was used, within the reactor was studied in three vertical settling columns (100 cm deep). Variations in solids and microbial distribution at top, middle and bottom layers of column were assessed over a 15 day settling period. Results showed that best solids separation was achieved when digested manure was allowed to settle at 55 degrees C with active biogas process (pre-incubated at 55 degrees C) compared to separation at 55 degrees C without active biogas process (autoclaved at 120 degrees C, for 20 min) or at 10 degrees C with active biogas process. Maximum solids separation was noticed 24 h after settling in column incubated at 55 degrees C, with active biogas process. Microbiological analyses revealed that proportion of Archaea and Bacteria, absent in the autoclaved material, varied with incubation temperature, time and sampling depth. Short rod shaped bacteria dominated at 55 degrees C, while long rod shaped bacteria dominated at 10 degrees C. Methanosarcinaceae were seen more abundant in the surface layer at 55 degrees C while it was seen more common in the top and bottom layers at 10 degrees C. Thus, passive separation of digester contents within the reactor can be used effectively as an operating strategy to optimize biogas production by increasing the solids and biomass retention times. A minimum of 1-2 h "non-stirring" period appears to be optimal time before effluent removal in plants where extraction is batch-wise 2-4 times a day.
Effects of mixing on methane production during thermophilic anaerobic digestion of manure: Lab-scale & pilot-scale studies

The effect of mixing on anaerobic digestion of manure was evaluated in lab-scale and pilot-scale experiments at 55 °C. The effect of continuous (control), minimal (mixing for 10 min prior to extraction/feeding) and intermittent mixing (withholding mixing for 2 h prior to extraction/feeding) on methane production was investigated in three lab-scale continuously stirred tank reactors. On comparison to continuous mixing, intermittent and minimal mixing strategies improved methane productions by 1.3% and 12.5%, respectively. Pilot-scale studies also supported the lab-scale results with an average 7% increase in biogas yields during intermittent mixing compared to continuous mixing. The effect of mixing intensities (minimal, gentle or vigorous) in batch assays at 55 °C showed that when the process was overloaded by high substrate to inoculum ratio (40/60), gentle (35 times per minute) or minimal mixing (10 min mixing before feeding) was advantageous compared to vigorous mixing (110 times per minute). On the other hand, under low substrate to inoculum ratio (10/90), gentle mixing was the best. The study thus indicated that mixing schemes and intensities have some effect on anaerobic digestion of manures.
Effects of pH and hydraulic retention time on hydrogen production versus methanogenesis during anaerobic fermentation of organic household solid waste under extreme-thermophilic temperature (70ºC)

Two continuously stirred tank reactors were operated with household solid waste at 70°C, for hydrogen and methane production. The individual effect of hydraulic retention time (HRT as 1, 2, 3, 4, and 6 days) at pH 7 or pH (5, 5.5, 6, 6.5, 7) at 3-day HRT was investigated on the hydrogen production versus methanogenesis. It was found that at pH 7, the maximum hydrogen yield was 107 mL-H2/g VSadded (volatile solid added) but no stable hydrogen production was obtained as after some time methanogenesis was initiated at all tested HRTs. This demonstrated that sludge retention time alone was not enough for washing out the methanogens at pH 7 under extreme-thermophilic conditions. Oppositely, we showed that keeping the pH level at 5.5 was enough to inhibit methane and produce hydrogen stably at 3-day HRT. However, the maximum stable hydrogen yield was low at 21 mL-H2/g VSadded. Biotechnol. Bioeng. 2008;100: 1108-1114. © 2008 Wiley Periodicals, Inc.

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Liu, D., Zeng, R. J., Angelidaki, I.
Pages: 1108-1114
Publication date: 2008
Peer-reviewed: Yes

Publication information
Journal: Biotechnology and Bioengineering (Print)
Volume: 100
Issue number: 6
ISSN (Print): 0006-3592
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BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 4.07 SJR 1.372 SNIP 1.186
Web of Science (2017): Impact factor 3.952
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.14 SJR 1.447 SNIP 1.178
Web of Science (2016): Impact factor 4.481
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 4.44 SJR 1.632 SNIP 1.355
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 4.16 SJR 1.612 SNIP 1.395
Web of Science (2014): Impact factor 4.126
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 4.44 SJR 1.637 SNIP 1.427
Web of Science (2013): Impact factor 4.164
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 4.04 SJR 1.62 SNIP 1.364
Web of Science (2012): Impact factor 3.648
Electricity generation integrated with xylose degradation was investigated in a two-chamber mediator-less microbial fuel cell (MFC). Voltage output followed saturation kinetics as a function of xylose concentration for concentration below 9.7 mM, with a predicted maximum of 86 mV (6.3 mW m\(^{-2}\) or 116 mW m\(^{-3}\)) and half-saturation constant (K\(s\)) of 0.29 mM. Xylose concentrations from 0.5 mM to 1.5 mM resulted in coulombic efficiencies and maximum voltage ranging from 41\(\pm\)1.6\% to 36\(\pm\)1.2\% and 55\(\pm\)2.0 mV to 70\(\pm\)3.0 mV respectively. Xylose degradation rate increased with increasing xylose concentration up to 9.7 mM and the predicted maximum degradation rate was 0.13 mM h\(^{-1}\) and K\(s\) of 3.0 mM. Stirring by nitrogen in the anode chamber led to 99\(\pm\)2.3 mV maximum voltage (8.4\(\pm\)0.4 mW m\(^{-2}\) or 153\(\pm\)7.1 mW m\(^{-3}\)) and 5.9\(\pm\)0.3\% coulombic efficiency at MFC running time 180 h, which were respectively 17\(\pm\)1.2\% and 37\(\pm\)1.8\%, higher than those without stirring. The COD removal under stirring was 22.1\(\pm\)0.3\%, which was slightly lower than that of 23.7\(\pm\)0.4\% under no stirring. However, stirring resulted in 59% lower xylose degradation rate. This work demonstrates that xylose can be used in the MFC for electricity production. Comparatively higher electricity generation and coulombic efficiency can be obtained by adjusting initial xylose concentration and applying stirring in the anode chamber.
Enrichment and adaptation of extreme-thermophilic (70°C) hydrogen producing bacteria to organic household solid waste by repeated batch cultivation

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Liu, D., Zeng, R. J., Angelidaki, I.
Pages: 6492-6497
Publication date: 2008
Peer-reviewed: Yes

Publication information
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Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 4.1 SJR 1.116 SNIP 1.267
Web of Science (2017): Impact factor 4.229
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.74 SJR 1.145 SNIP 1.315
Web of Science (2016): Impact factor 3.582
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3.46 SJR 1.27 SNIP 1.314
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.54 SJR 1.207 SNIP 1.484
Web of Science (2014): Impact factor 3.313
Web of Science (2014): Indexed yes
High-rate continuous hydrogen production by Thermoanaerobacterium thermosaccharolyticum PSU-2 immobilized on heat-pretreated methanogenic granules

Biohydrogen production from Thermoanaerobacterium thermosaccharolyticum strain PSU-2 was examined in upflow anaerobic sludge blanket (UASB) reactor and carrier-free upflow anaerobic reactor (UA), both fed with sucrose and operating at 60 degrees C. Heat-pretreated methanogenic granules were used as carrier to immobilize T. thermosaccharolyticum strain PSU-2 in UASB reactor operated at a hydraulic retention time (HRT) ranging from 0.75 to 24h and corresponding sucrose loading rate from 58.5 to 2.4 mmol sucrose l(-1)h(-1). In comparison with hydrogen production rate of 12.1 mmol H(2)l(-1)h(-1) obtained by carrier-free reactor upflow anaerobic (UA) system, a greatly improved hydrogen production rate up to 152 mmol H(2)l(-1)h(-1) was demonstrated by the granular cells in UASB system. The biofilm of T. thermosaccharolyticum strain PSU-2 developed on treated methanogenic granules in UASB reactor substantially enhanced biomass retention (3 times), and production of hydrogen (12 times) compared to carrier-free reactor. It appears to be the most preferred process for highly efficient dark fermentative hydrogen production from sugar containing wastewater under thermophilic conditions. (C) 2008 International Association for Hydrogen Energy.
Importance of temperature and anodic medium composition on microbial fuel cell (MFC) performance

The performance of a microbial fuel cell (MFC) was investigated at different temperatures and anodic media. A lag phase of 30 h occurred at 30°C which was half that at room temperature (22°C). The maximum power density at 30°C was 70 mW/m² and at 22°C was 43 mW/m². At 15°C, no successful operation was observed even after several loadings for a long period of operation. Maximum power density of 320 mW/m² was obtained with wastewater medium containing phosphate buffer (conductivity: 11.8 mS/cm), which was approx. 4 times higher than the value without phosphate additions (2.89 mS/cm).

General information

State: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering
Contributors: Min, B., Romàn, Ó., Angelidaki, I.
Pages: 1213-1218
Publication date: 2008
Peer-reviewed: Yes

Publication information

Journal: Biotechnology Letters
Volume: 30
Issue number: 7
ISSN (Print): 0141-5492
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.88 SJR 0.621 SNIP 0.695
Web of Science (2017): Impact factor 1.846
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.89 SJR 0.628 SNIP 0.725
Web of Science (2016): Impact factor 1.73
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.66 SJR 0.598 SNIP 0.664
Web of Science (2015): Impact factor 1.639
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.75 SJR 0.636 SNIP 0.811
In this study, we identified the influence of wastewater characteristics on the theoretical and practical methane potential using different food industrial wastewaters as substrates. Ten composite wastewater samples from five industries were investigated. The ultimate practical methane yields (Bo) were compared to the theoretical methane yields (Bo,th) in order to evaluate the biodegradability of the tested wastewaters and the influence of their physico-chemical characteristics. The analytical method applied to quantify the wastewaters’ organic content proved to influence the estimation of their theoretical yields. The substrate:inoculum ratio as well as the dilution factor of the wastewaters influenced the ultimate practical methane yields differently in each of the wastewaters assessed. Substrate chemical oxygen demand (COD)
concentrations did not present any influence on ultimate practical methane yields; on the other hand, it was found that they were affected positively by concentrations of total inorganic carbon when wastewaters were 25% and 50% diluted and affected negatively by concentrations of total acetate when wastewaters were undiluted. Carbohydrate and protein concentrations affected negatively the maximum achieved practical methane yields.

**General information**
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Maya Altamira, L., Baun, A., Angelidaki, I., Schmidt, J. E.
Pages: 2195-2203
Publication date: 2008
Peer-reviewed: Yes

**Publication information**
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BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 7.55 SJR 2.601 SNIP 2.358
Web of Science (2017): Impact factor 7.051
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 7.49 SJR 2.663 SNIP 2.563
Web of Science (2016): Impact factor 6.942
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 6.63 SJR 2.665 SNIP 2.482
Web of Science (2015): Impact factor 5.991
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 6.13 SJR 2.946 SNIP 2.702
Web of Science (2014): Impact factor 5.528
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 6.02 SJR 2.956 SNIP 2.676
Web of Science (2013): Impact factor 5.323
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.15 SJR 2.914 SNIP 2.442
Web of Science (2012): Impact factor 4.655
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 5.43 SJR 2.862 SNIP 2.355
Web of Science (2011): Impact factor 4.865
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.592 SNIP 2.192
Web of Science (2010): Impact factor 4.546
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
A submersible microbial fuel cell (SMFC) was developed by immersing an anode electrode and a cathode chamber in an anaerobic reactor. Domestic wastewater was used as the medium and the inoculum in the experiments. The SMFC could successfully generate a stable voltage of 0.428 ± 0.003 V with a fixed 470 Ω resistor from acetate. From the polarization test, the maximum power density of 204 mW m−2 was obtained at current density of 595 mA m−2 (external resistance = 180 Ω). The power generation showed a saturation-type relationship as a function of wastewater strength, with a maximum power density (Pmax) of 218 mW m−2 and a saturation constant (Ks) of 244 mg L−1. The main limitations for achieving higher electricity production in the SMFC were identified as the high internal resistance at the electrolyte and the inefficient electron transfer at the cathode electrode. As the current increased, a large portion of voltage drop was caused by the ohmic (electrolyte) resistance of the medium present between two electrodes, although the two electrodes were closely positioned (about 3 cm distance; internal resistance = 35 ± 2 Ω). The open circuit potential (0.393 V vs. a standard hydrogen electrode) of the cathode was much smaller than the theoretical value (0.804 V). Besides, the short circuit potential of the cathode electrode decreased during the power generation in the SMFC. These results demonstrate that the SMFC could successfully generate electricity from wastewater, and has a great potential for electricity production from existing anaerobic reactors or other anaerobic environments such as sediments. The advantage of the SMFC is that no special anaerobic chamber (anode chamber) is needed, as existing anaerobic reactors can be used, where the cathode chamber and anode electrode are immersed.

**Innovative microbial fuel cell for electricity production from anaerobic reactors**

A submersible microbial fuel cell (SMFC) was developed by immersing an anode electrode and a cathode chamber in an anaerobic reactor. Domestic wastewater was used as the medium and the inoculum in the experiments. The SMFC could successfully generate a stable voltage of 0.428 ± 0.003 V with a fixed 470 Ω resistor from acetate. From the polarization test, the maximum power density of 204 mW m−2 was obtained at current density of 595 mA m−2 (external resistance = 180 Ω). The power generation showed a saturation-type relationship as a function of wastewater strength, with a maximum power density (Pmax) of 218 mW m−2 and a saturation constant (Ks) of 244 mg L−1. The main limitations for achieving higher electricity production in the SMFC were identified as the high internal resistance at the electrolyte and the inefficient electron transfer at the cathode electrode. As the current increased, a large portion of voltage drop was caused by the ohmic (electrolyte) resistance of the medium present between two electrodes, although the two electrodes were closely positioned (about 3 cm distance; internal resistance = 35 ± 2 Ω). The open circuit potential (0.393 V vs. a standard hydrogen electrode) of the cathode was much smaller than the theoretical value (0.804 V). Besides, the short circuit potential of the cathode electrode decreased during the power generation in the SMFC. These results demonstrate that the SMFC could successfully generate electricity from wastewater, and has a great potential for electricity production from existing anaerobic reactors or other anaerobic environments such as sediments. The advantage of the SMFC is that no special anaerobic chamber (anode chamber) is needed, as existing anaerobic reactors can be used, where the cathode chamber and anode electrode are immersed.

**General information**

State: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering, Urban Water Engineering
Contributors: Min, B., Angelidaki, I.
Pages: 641-647
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Peer-reviewed: Yes

**Publication information**

Journal: Journal of Power Sources
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ISSN (Print): 0378-7753
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 7 SJR 2.202 SNIP 1.536
Web of Science (2017): Impact factor 6.945
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 6.22 SJR 1.944 SNIP 1.5
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 6.34 SJR 1.9 SNIP 1.667
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 6.3 SJR 1.964 SNIP 2.042
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 5.63 SJR 1.975 SNIP 2.137
Web of Science (2013): Impact factor 5.211
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 5.04 SJR 2.282 SNIP 2.006
Web of Science (2012): Impact factor 4.675
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 5.13 SJR 2.227 SNIP 2.172
Web of Science (2011): Impact factor 4.951
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 2.294 SNIP 1.972
Web of Science (2010): Impact factor 4.29
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 2.105 SNIP 1.785
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.96 SNIP 1.713
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.587 SNIP 1.488
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.802 SNIP 2.223
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.656 SNIP 1.809
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.85 SNIP 1.805
Scopus rating (2003): SJR 1.66 SNIP 1.57
Scopus rating (2002): SJR 2.385 SNIP 1.409
Innovative process scheme for removal of organic matter, phosphorus and nitrogen from pig manure

Disposal of pig manure often requires treatment with respect to environmental legislations. In this study different processes for reduction of the organic matter (anaerobic digestion, effluent separation by decanter centrifugation, membrane microfiltration, post-digestion in upflow anaerobic sludge blanket (UASB) reactor, partial oxidation), nitrogen (oxygen-limited autotrophic nitrification-denitrification, OLAND) and phosphorus (phosphorus removal by precipitation as struvite, PRS) from pig manure were tested. Results obtained showed that microfiltration was unsuitable for pig manure treatment. PRS treated effluent was negatively affecting the further processing of the pig manure in UASB, and was therefore not included in the final process flow scheme. In a final scheme (PIGMAN concept) combination of the following successive process steps was used: thermophilic anaerobic digestion with sequential separation by decanter centrifuge, post-digestion in UASB reactor, partial oxidation and finally OLAND process. This combination resulted in reduction of the total organic, nitrogen and phosphorus contents by 96%, 88%, and 81%, respectively.

General information
State: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering
Contributors: Karakashev, D. B., Schmidt, J. E., Angelidaki, I.
Pages: 4083-4090
Publication date: 2008
Peer-reviewed: Yes

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Journal: Water Research
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Issue number: 15
ISSN (Print): 0043-1354
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 7.55 SJR 2.601 SNIP 2.358
Web of Science (2017): Impact factor 7.051
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 7.49 SJR 2.663 SNIP 2.563
Web of Science (2016): Impact factor 6.942
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 6.63 SJR 2.665 SNIP 2.482
Web of Science (2015): Impact factor 5.991
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 6.13 SJR 2.946 SNIP 2.702
Web of Science (2014): Impact factor 5.528
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 6.02 SJR 2.956 SNIP 2.676
Web of Science (2013): Impact factor 5.323
ISI indexed (2013): ISI indexed yes
MICROBIAL FUEL CELL
A novel microbial fuel cell construction for the generation of electrical energy. The microbial fuel cell comprises: (i) an anode electrode, (ii) a cathode chamber, said cathode chamber comprising an inlet through which an influent enters the cathode chamber, an outlet through which an effluent depart the cathode chamber, a cathode electrode and an electrolyte permeable membrane, wherein both the anode electrode and the cathode chamber are to be submersed into an anaerobic environment to generate electrical energy.

General information
State: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering
Contributors: Angelidaki, I., Min, B.
Microbial fuel cells with acetate, glucose and xylose using humic acid as mediator

General information
State: Published
Organisations: Bioenergy and Biomass, Biosystems Division, Risø National Laboratory for Sustainable Energy, Electroceramics, Fuel Cells and Solid State Chemistry Division, Residual Resource Engineering, Department of Environmental Engineering
Contributors: Thygesen, A., Poulsen, F. W., Min, B., Angelidaki, I., Thomsen, A. B.
Publication date: 2008
Peer-reviewed: No
Event: Poster session presented at 1. International symposium on microbial fuel cells, State College, USA.
Keywords: Bio energy, Microbial energy technology
Source: orbit
Source-ID: 266123
Research output: Research › Patent – Annual report year: 2008

Monitoring and control of the biogas process based on propionate concentration using online VFA measurement
Simple logic control algorithms were tested for automatic control of a lab-scale CSTR manure digester. Using an online VFA monitoring system, propionate concentration in the reactor was used as parameter for control of the biogas process. The propionate concentration was kept below a threshold of 10 mM by manipulating the feed flow. Other online parameters such as pH, biogas production, total VFA, and other individual VFA were also measured to examine process performance. The experimental results showed that a simple logic control can successfully prevent the reactor from overload, but with fluctuations of the propionate level due to the nature of control approach. The fluctuation of propionate concentration could be reduced, by adding a lower feed flow limit into the control algorithm to prevent undershooting of propionate response. It was found that use of the biogas production as a main control parameter, rather than propionate can give a more stable process, since propionate was very persistent and only responded very slowly to the decrease of the feed flow which lead to high fluctuation of biogas production. Propionate, however, was still an excellent parameter to indicate process stress under gradual overload and thus recommended as an alarm in the control algorithm.

General information
State: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering
Contributors: Boe, K., Steyer, J., Angelidaki, I.
Pages: 661-666
Publication date: 2008
Peer-reviewed: Yes

Publication information
Journal: Water Science and Technology
Volume: 57
Issue number: 5
ISSN (Print): 0273-1223
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.34 SJR 0.429 SNIP 0.574
Web of Science (2017): Impact factor 1.247
Web of Science (2017): Indexed yes
Strategies for optimizing recovery of the biogas process following ammonia inhibition

General information
State: Published
Organisations: Bioenergy and Biomass, Biosystems Division, Risø National Laboratory for Sustainable Energy, Residual Resource Engineering, Department of Environmental Engineering
Contributors: Bangsø Nielsen, H., Angelidaki, I.
Pages: 7995-8001
Publication date: 2008
Peer-reviewed: Yes

Publication information
Journal: Bioresource Technology
Volume: 99
ISSN (Print): 0960-8524
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 6.28 SJR 2.029 SNIP 1.799
Web of Science (2017): Impact factor 5.807
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.94 SJR 2.215 SNIP 1.932
Web of Science (2016): Impact factor 5.651
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.47 SJR 2.243 SNIP 1.897
Web of Science (2015): Impact factor 4.917
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.3 SJR 2.399 SNIP 2.087
Web of Science (2014): Impact factor 4.494
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 5.97 SJR 2.405 SNIP 2.477
Web of Science (2013): Impact factor 5.039
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.25 SJR 2.334 SNIP 2.461
Web of Science (2012): Impact factor 4.75
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 5.56 SJR 2.308 SNIP 2.507
Web of Science (2011): Impact factor 4.98
ISI indexed (2011): ISI indexed yes
Thermophilic fermentative hydrogen production by the newly isolated Thermoanaerobacterium thermosaccharolyticum PSU-2

A thermophilic H(2)-producing bacterial strain was isolated from a biohydrogen reactor fed with palm oil mill effluent (POME) and identified as Thermoanaerobacterium thermosaccharolyticum using 16S rRNA gene analysis. The isolated bacterium, designated as T thermosaccharolyticum PSU-2, showed a high yield and production rate of H(2). Temperature optimum, pH optimum and substrate utilization for H(2) production were investigated in batch conditions. All of tested substrate was utilized for H(2) production, while sucrose, xylose and starch were the preferred substrates. The strain produced H(2) within a wide range of pH (4.5-8) and temperature (45-7 degrees C), with the optimal temperature 60 degrees C and optimal initial pH about 6.25. Maximum of H(2) production rate was registered from hour 8 to hour 16 in late exponential phase. The H(2) production was drastically reduced in a prolonged fermentation (24 h) and stopped at pH 4.5 due to the accumulation of organic acids. The maximum H(2) production yield and rate at sucrose concentration of 20 g(l)(-1), pH 6.25 and temperature 60 degrees C were 2.53 mol H(2) mol(-1) hexose and 12.12 mmol H(2) l(-1) h(-1), respectively. Organic nitrogen amended medium improved the H(2) production with 68% compared to inorganic nitrogen amended medium. The strain performed ethanol-acetate type fermentation in inorganic nitrogen amended medium, while it performed butyrate-acetate type fermentation in organic nitrogen amended medium. (C) 2008 International Association for Hydrogen Energy. Published by Elsevier Ltd. All rights reserved.

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Pages: 1204-1214
Publication date: 2008
Peer-reviewed: Yes
Anaerobic Biodegradation, Activity and Inhibition (ABAI) Task Group Meeting 9th to 10th October 2006, in Prague

General information
State: Published
Organisations: Department of Environmental Engineering
Number of pages: 25
Publication date: 2007

Publication information
Place of publication: Kgs. Lyngby
Publisher: Institute of Environment & Resources, Technical University of Denmark
ISBN (Print): 978-87-91855-44-3
Original language: English
Electronic versions:
MR2007-147.pdf
Source: orbit
Source-ID: 202846
Research output: Research › Report – Annual report year: 2007

Anaerobic biotechnological approaches for production of liquid energy carriers from biomass
In recent years, increasing attention has been paid to the use of renewable biomass for energy production. Anaerobic biotechnological approaches for production of liquid energy carriers (ethanol and a mixture of acetone, butanol and ethanol) from biomass can be employed to decrease environmental pollution and reduce dependency on fossil fuels. There are two major biological processes that can convert biomass to liquid energy carriers via anaerobic biological breakdown of organic matter: ethanol fermentation and mixed acetone, butanol, ethanol (ABE) fermentation. The specific product formation is determined by substrates and microbial communities available as well as the operating conditions applied. In this review, we evaluate the recent biotechnological approaches employed in ethanol and ABE fermentation. Practical applicability of different technologies is discussed taking into account the microbiology and biochemistry of the processes.

General information
State: Published
Organisations: Department of Environmental Engineering, Risø National Laboratory for Sustainable Energy
Contributors: Karakashev, D. B., Thomsen, A. B., Angelidaki, I.
Pages: 1005-1012
Publication date: 2007
Peer-reviewed: Yes

Publication information
Journal: Biotechnology Letters
Volume: 29
Issue number: 7
ISSN (Print): 0141-5492
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.88 SJR 0.621 SNIP 0.695
Web of Science (2017): Impact factor 1.846
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.89 SJR 0.628 SNIP 0.725
Web of Science (2016): Impact factor 1.73
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.66 SJR 0.598 SNIP 0.664
Web of Science (2015): Impact factor 1.639
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.75 SJR 0.636 SNIP 0.811
Web of Science (2014): Impact factor 1.591
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 2.03 SJR 0.723 SNIP 0.94
Web of Science (2013): Impact factor 1.736
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 2.03 SJR 0.748 SNIP 0.949
Web of Science (2012): Impact factor 1.853
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 1.97 SJR 0.725 SNIP 0.913
Web of Science (2011): Impact factor 1.683
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.703 SNIP 0.895
Web of Science (2010): Impact factor 1.768
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.704 SNIP 0.811
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.635 SNIP 0.781
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.536 SNIP 0.723
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.546 SNIP 0.719
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.468 SNIP 0.679
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.456 SNIP 0.616
Scopus rating (2003): SJR 0.441 SNIP 0.631
Scopus rating (2002): SJR 0.505 SNIP 0.651
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.526 SNIP 0.85
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 0.663 SNIP 0.788
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 0.599 SNIP 0.838
Anaerobic digestion of solid material: multidimensional modelling of continuous-flow reactor with non-uniform influent concentration distributions

A new multidimensional (3 and 2D) anaerobic digestion model for cylindrical reactor with non-uniform influent concentration distributions was developed to study the way in which mixing intensity affects the efficiency of continuous-flow anaerobic digestion. Batch experiments reported and simulated earlier by Vavilin and Angelidaki (2005) were used to modernize a kinetic scheme and to obtain the corresponding kinetic coefficients. In the new models, hydrolytic microorganisms were included using Contois kinetics for the hydrolysis/acidogenesis degradation of municipal solid waste (MSW). Monod kinetics was applied for description of methanogenesis. Both hydrolytic and methanogenic microorganisms were assumed to be inhibited by high volatile fatty acids (VFA) concentration. According to the new distributed models, the mixing level reduction expressed by increasing dimensionless Peclet number may improve the continuous flow reactor performance at the relatively low influent methanogenic biomass concentration. In the continuously stirred tank reactor (CSTR) there are two steady states with and without methane production at slightly different values of initial methanogenic biomass concentration. In the system, the threshold methanogenic biomass concentration existed because of inhibition by high VFA concentration. High methanogenic biomass concentration is required for efficient anaerobic digestion of MSW in order to avoid possible inhibition due to high VFA build-up. Thus, CSTR configuration might have unstable dynamics at high organic loading as shown in earlier experiments carried out by Stroot et al. (2001). A gradual increase of organic loading during the start up of a completely mixed digester causing an accumulation of methanogenic biomass is a solution to prevent a probable digester failure. According to the distributed models a plug-flow reactor with non-uniform influent concentration distributions where methanogenic and hydrolytic microorganisms are separated has significant methane production and solids removal at the relatively low influent methanogenic biomass concentration. © 2006 Wiley Periodicals, Inc.
An innovative online VFA monitoring system for the anerobic process, based on headspace gas chromatography

General information
State: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering, Urban Water Engineering
Contributors: Boe, K., Batstone, D. J., Angelidaki, I.
Biohydrogen production from glucose in upflow biofilm reactors with plastic carriers under hyperthermophilic condition (70°C)

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Zheng, H., Zeng, R. J., Angelidaki, I.
Publication date: 2007
Peer-reviewed: Yes
Event: Poster session presented at 11th IWA World Congress on Anaerobic Digestion, Brisbane, Australia.
Source: orbit
Source-ID: 208991
Research output: Research - peer-review › Poster – Annual report year: 2007

Biorefinery for sustainable biofuel production from energy crops; conversion of lignocellulose to bioethanol, biohydrogen and biomethane

General information
State: Published
Organisations: Department of Environmental Engineering, Bioenergy and Biomass, Biosystems Division, Risø National Laboratory for Sustainable Energy
Contributors: Angelidaki, I., Kongjan, P., Thomsen, M. H., Thomsen, A. B.
Publication date: 2007

Host publication information
Title of host publication: Bioenergy for our future : 11th IWA world congress on anaerobic digestion (AD11) held in Brisbane, Australia 23-27 September 2007
Volume: Session PP8A - Bioenergy 2. CD-ROM
Place of publication: Brisbane
Source: orbit
Source-ID: 208996
Research output: Research - peer-review › Article in proceedings – Annual report year: 2007
Effect of post-treatments on biodegradability and methane recovery from fibres separated from thermophilically digested cow manure

**General information**
State: Published
Organisations: Department of Environmental Engineering
Contributors: Kaparaju, P. L., Angelidaki, I.
Publication date: 2007
Peer-reviewed: Yes
Event: Poster session presented at 11th IWA World Congress on Anaerobic Digestion, Brisbane, Australia.
Source: orbit
Source-ID: 209000
Research output: Research - peer-review › Poster – Annual report year: 2007

Effect of temperature and anodic medium on power generation in microbial fuel cells (MFCs)

**General information**
State: Published
Organisations: Department of Environmental Engineering
Contributors: Min, B., Romàn, O., Angelidaki, I.
Publication date: 2007
Peer-reviewed: Yes
Event: Poster session presented at 11th IWA World Congress on Anaerobic Digestion, Brisbane, Australia.
Source: orbit
Source-ID: 208998
Research output: Research - peer-review › Poster – Annual report year: 2007

Enrichment and adaptation of extreme-thermophilic (70°C) H2 producing bacteria to organic household solid waste by repeated batch cultivations

**General information**
State: Published
Organisations: Department of Environmental Engineering
Contributors: Lui, D., Zeng, R. J., Angelidaki, I.
Publication date: 2007

**Host publication information**
Title of host publication: Bioenergy for our future : 11th IWA world congress on anaerobic digestion (AD11) held in Brisbane, Australia 23-27 September 2007
Volume: Session PP7A - Biohydrogen 2. CD-ROM
Place of publication: Brisbane
Source: orbit
Source-ID: 208997
Research output: Research - peer-review › Article in proceedings – Annual report year: 2007

Genetablering af biogasprocessen

**General information**
State: Published
Organisations: Bioenergy and Biomass, Biosystems Division, Risø National Laboratory for Sustainable Energy, Residual Resource Engineering, Department of Environmental Engineering
Contributors: Bangsø Nielsen, H., Angelidaki, I.
Pages: 10-13
Publication date: 2007
Peer-reviewed: Unknown

**Publication information**
Journal: Forskning i Bioenergi
Volume: 4
Issue number: 22
ISSN (Print): 1604-6331
Ratings:
ISI indexed (2013): ISI indexed no
High-rate hydrogen production in up-flow anaerobic sludge blanket (UASB) using immobilized hermoanaerobacterium thermosaccharolyticum strain PSU-2 with treated methanogenic granules

General information
State: Published
Organisations: Department of Environmental Engineering
Publication date: 2007
Peer-reviewed: Yes
Event: Poster session presented at 11th IWA World Congress on Anaerobic Digestion, Brisbane, Australia.
Source: orbit
Source-ID: 231812
Research output: Communication › Journal article – Annual report year: 2007

Homoacetogenesis as the alternative pathway for H₂ sink during thermophilic anaerobic degradation of butyrate under suppressed methanogenesis

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Siriwongrungson, V., Zeng, R. J., Angelidaki, I.
Pages: 4204-4210
Publication date: 2007
Peer-reviewed: Unknown

Publication information
Journal: Water Research
Volume: 41
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 7.55 SJR 2.601 SNIP 2.358
Web of Science (2017): Impact factor 7.051
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 7.49 SJR 2.663 SNIP 2.563
Web of Science (2016): Impact factor 6.942
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 6.63 SJR 2.665 SNIP 2.482
Web of Science (2015): Impact factor 5.991
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 6.13 SJR 2.946 SNIP 2.702
Web of Science (2014): Impact factor 5.528
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 6.02 SJR 2.956 SNIP 2.676
Web of Science (2013): Impact factor 5.323
ISI indexed (2013): ISI indexed yes
Monitoring and control of the biogas process based on propionate concentration using online VFA measurement

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Boe, K., Steyer, J., Angelidaki, I.
Publication date: 2007

Host publication information
Title of host publication: Bioenergy for our future : 11th IWA world congress on anaerobic digestion (AD11) held in Brisbane, Australia 23-27 September 2007
Volume: Session PP9A - Instrumentation and control. CD-ROM
Place of publication: Brisbane
Optimization of biogas production by co-digesting whey with diluted poultry manure

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Gelegenis, J., Georgakakis, D., Angelidaki, I., Mavris, V.
Pages: 2147-2160
Publication date: 2007
Peer-reviewed: Yes

Publication information
Journal: Renewable Energy
Volume: 32
ISSN (Print): 0960-1481
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 5.38 SJR 1.847 SNIP 2.008
Web of Science (2017): Impact factor 4.9
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.83 SJR 1.661 SNIP 2.05
Web of Science (2016): Impact factor 4.357
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 4.51 SJR 1.767 SNIP 2.085
Web of Science (2015): Impact factor 3.404
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 4.51 SJR 1.925 SNIP 2.621
Web of Science (2014): Impact factor 3.476
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 4.63 SJR 1.989 SNIP 2.719
Web of Science (2013): Impact factor 3.361
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 3.97 SJR 1.787 SNIP 2.699
Web of Science (2012): Impact factor 2.989
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 3.9 SJR 1.634 SNIP 2.349
Web of Science (2011): Impact factor 2.978
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.459 SNIP 2.215
Web of Science (2010): Impact factor 2.58
Web of Science (2010): Indexed yes
Optimization of biogas production from manure: Final project report EFP-04

The main objective of the project was to improve biogas production from manures. This objective was addressed by investigating 1) the effect of different reactor configurations, 2) operational procedures, aiming to selectively retain/return degradable material in the reactor and 3) different posttreatments to improve the degradability of the undegraded material. Both lab-scale and pilot-scale experiments were carried out at the Institute of Environment & Resources, Technical University of Denmark. In the first experiment, the effect of serial digestion on process performance and methane production was compared to a conventional single CSTR process at 55°C. The total working volume (5 l) between the two methanogenic reactors of serial CSTR process was varied by distributing the volume between the first and second reactor at 90/10, 80/20, 70/30, 50/50, 30/70 or 10/90%. Results showed that serial CSTR process at 90/10, 80/20, 70/30, 50/50 or 30/70% volume distribution could produce 11-17.8% more biogas compared to single CSTR process under similar operating conditions. The increased biogas production was mainly from the second reactor of the serial process, which accounted for 16-18% of the total biogas production. At 10/90 ratio, no significant increase in biogas production was noticed. Both single and serial CSTR processes were stable when operated 90/10, 80/20, 70/30 or 50/50% volume distributions and also during an organic pulse load (19.6 to 65.3 g/l reactor volume). Results from pilot-scale studies showed that serial digestion with 77/23% volume distribution produced 1.9-6.1% more biogas compared to that obtained during one-step CSTR operation. However, temperature was found to have a strong influence on the methane production and process performance of the second reactor of a serial CSTR process.

In the second experiment, the effect of temperature (10 & 55°C) and microbial activity on passive separation of digested cow manure was investigated in vertical columns (100 cm) with an aim to improve solids retention time within the reactor and improve biogas production. Results showed that greatest degree and rates of passive separation took place when the temperature during the settling was maintained at 55°C and after 24 hrs of incubation. Higher temperature and lower viscosity, and probable higher biological activity aided the separation process at 55°C than at 10°C. The effect of continuous mixing (control), mixing for 10 min per day (minimal mixing) and withholding mixing for 2 hrs prior to feeding (intermittent mixing) on biogas production was evaluated in three lab-scale CSTRs. Results showed that minimal and intermittent mixing improved biogas productions by 12.5% and 1.3% respectively over continuous mixing. Intermittent mixing also resulted in stratification of solids with higher solids content in the top and bottom layers compared to middle layer. Similar result was also noticed in pilot-scale plant when intermittent mixing was sequenced with continuous mixing. Biogas yields improved from 2.5 to 14.6% when the reactor was operated under intermittent mixing compared to continuous mixing. The effect of mixing intensities (minimal, gentle or vigorous) in batch assays at 55°C showed that when the process was overloaded by high substrate to inoculum ratio (40/60), gentle (35 times per minute) or minimal mixing (10
minutes mixing before feeding) was advantageous compared to vigorous mixing (110 times per minute). On the other hand, under low substrate to inoculum ratio (10/90), gentle mixing was the best. The study thus indicated that mixing schemes and intensities have some effect on anaerobic digestion of manures. In the third experiment, the effect of eight different post-treatments on improving the biogas production of fibres separated from thermophilically digested cow manure was studied in batches at 55°C. Results showed that only partial aerobic treatment (air flow rate at 0.28 l/min g total solids) and grinding (mortar and pestle) improved methane yields while chemical treatments (NaOH or CaO at 40g/kgVS) resulted in more or less similar methane yields to that of untreated fibres. Treatments such as microwave irradiation (300-700 W), conventional boiling and wet oxidation (195°C, 12 bar of O2 for 10 min.) improved the soluble chemical oxygen demand content while ultrasound irradiation did not affect the fibres’ SCOD content. Thus, the present results showed that biogas production from manure can be improved from 7% to 18% by either adopting serial digestion of manure, mixing the reactor intermittently with a 2 hour mixer blocking prior to feeding or by partial aerobic treatment or grinding of the fibers separated from the digested manure. However, the optimal volume distributed between the two methanogenic reactors in serial digestion could be either 70/30 or 50/50% and/or effluent should be removed from the middle layer after 2 hrs of settling. The improved methane recovery with the tested posttreatment needs further investigation with respect to the costs, efforts and energy inputs.

Optimization of biogas production from olive-oil mill wastewater, by codigesting with diluted poultry-manure

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Gelegenis, J., Georgakakis, D., Angelidaki, I., Chistopoulou, N., Goumenaki, M.
Pages: 646-663
Publication date: 2007
Peer-reviewed: Yes

Electronic versions:
MR2007_255.pdf
Source: orbit
Source-ID: 208946
Research output: Research › Report – Annual report year: 2007

Optimization of biogas production from olive-oil mill wastewater, by codigesting with diluted poultry-manure

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Gelegenis, J., Georgakakis, D., Angelidaki, I., Chistopoulou, N., Goumenaki, M.
Pages: 646-663
Publication date: 2007
Peer-reviewed: Yes

Electronic versions:
MR2007_255.pdf
Source: orbit
Source-ID: 208946
Research output: Research › Report – Annual report year: 2007
Re-establishing the biogas process
Removal of residual organic matter, phosphates and ammonium from thermophilically digested pig manure

The development of biogas in Sweden and Denmark

Online monitoring and control of the biogas process
Acetate oxidation is the dominant methanogenic pathway from acetate in the absence of Methanosetaeae. The oxidation of acetate to hydrogen, and the subsequent conversion of hydrogen and carbon dioxide to methane, has been regarded largely as a niche mechanism occurring at high temperatures or under inhibitory conditions. In this study, 13 anaerobic reactors and sediment from a temperate anaerobic lake were surveyed for their dominant methanogenic population by using fluorescent in situ hybridization and for the degree of acetate oxidation relative to aceticlastic conversion by using radiolabeled [2-C-14]acetate in batch incubations. When Methanosetaeae were not present, acetate oxidation was the dominant methanogenic pathway. Aceticlastic conversion was observed only in the presence of Methanosetaeae.
Biohydrogen production in granular up-flow anaerobic sludge blanket (UASB) reactors with mixed cultures under hyperthermophilic temperature (70 degree C)

**General information**
- **State:** Published
- **Organisations:** Department of Environmental Engineering, Urban Water Engineering
- **Contributors:** Kotsopoulos, T., Zeng, R. J., Angelidaki, I.
- **Pages:** 296-302
- **Publication date:** 2006
- **Peer-reviewed:** Yes

**Publication information**
- **Journal:** Biotechnology and Bioengineering
- **Volume:** 94
- **Issue number:** 2
- **ISSN (Print):** 0006-3592
- **Ratings:**
  - BFI (2018): BFI-level 1
  - Web of Science (2018): Indexed yes
  - BFI (2017): BFI-level 1
  - Scopus rating (2017): CiteScore 4.07 SJR 1.372 SNIP 1.186
  - Web of Science (2017): Impact factor 3.952
  - Web of Science (2017): Indexed yes
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<th>BFI Rating</th>
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<td>2009</td>
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<td>BFI-level 2</td>
<td>SJR 1.467 SNIP 1.437</td>
<td>Indexed yes</td>
</tr>
<tr>
<td>2006</td>
<td>BFI-level 2</td>
<td>SJR 1.135 SNIP 1.23</td>
<td>Indexed yes</td>
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<td>2005</td>
<td>BFI-level 2</td>
<td>SJR 1.105 SNIP 1.245</td>
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<td>2004</td>
<td>BFI-level 2</td>
<td>SJR 1.052 SNIP 1.228</td>
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<td>2003</td>
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<td>SJR 1.117 SNIP 1.263</td>
<td>Indexed yes</td>
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<td>2002</td>
<td>BFI-level 2</td>
<td>SJR 1.059 SNIP 1.16</td>
<td>Indexed yes</td>
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<td>2001</td>
<td>BFI-level 2</td>
<td>SJR 1.428 SNIP 1.529</td>
<td>Indexed yes</td>
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Enhanced biogas recovery by applying post-digestion in large-scale centralized biogas plants

The main objective of this study was to investigate the degradation efficiency of centralized biogas plants and provide guidance for the design of more efficient digester and post-digestion systems. These centralized biogas plants in Denmark digest manure together with organic waste from the food industry to generate biogas, which is used for electricity and thermal energy. A total of 20 such plants are currently active in Denmark, most of which were included in the investigation. From the plants, samples were obtained from various steps of the process. Samples were analysed and the residual biogas potential determined by batch post-digestion at various temperature levels. Results were correlated with plant characteristics and production statistics in order to judge the efficiency of various digestion concepts. A simplified model based on a two-step biogas production process was developed and experimental data were used to determine kinetic constants. Experimental results and analysis combined with model simulations showed that the residual biogas potential in the main digestion step effluent is originating mainly from undegraded particulate matter in the biomass. For thermophilic plants 93% of the residual biogas potential was originating from particulate matter and 88% for the mesophilic biogas plants. This indicates that the residual biogas potential is mainly due to insufficient retention time in the main digestion step for hydrolysis of particulate material and that the hydrolysis step is the methane yield limiting factor, while conversion of soluble material such as VFA is the rate limiting factor critical for achieving a stable process.

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Angelidaki, I., Hejnfelt, A., Ellegaard, L.
Pages: 237-244
Publication date: 2006
Peer-reviewed: Yes

Publication information
Journal: Water Science and Technology
Volume: 54
Issue number: 2
ISSN (Print): 0273-1223
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.34 SJR 0.429 SNIP 0.574
Web of Science (2017): Impact factor 1.247
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.3 SJR 0.404 SNIP 0.637
Web of Science (2016): Impact factor 1.197
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.19 SJR 0.464 SNIP 0.594
Web of Science (2015): Impact factor 1.064
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.14 SJR 0.585 SNIP 0.683
Web of Science (2014): Impact factor 1.106
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 1.3 SJR 0.571 SNIP 0.701
Web of Science (2013): Impact factor 1.212
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
Evaluation of different lab-scale configurations for pig manure treatment (anaerobic codigestion, removal of organic matter and nutrients): A sustainable solution for pig manure treatment: Environmental compliance with the Integrated Pollution Prevention and Control directive (PIGMAN)

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Karakashev, D. B., Angelidaki, I.
Publication date: 2006

Publication information
Place of publication: Kgs. Lyngby

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Angelidaki, I., Karakashev, D. B.
Number of pages: 50
Publication date: 2006

H2/CO2-aetogenesis pathway in anaerobic butyrate degradation with digested manure as inoculum at 55 degree C

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Siri Wongrungson, V., Zeng, R. J., Angelidaki, I.
Number of pages: 8
Publication date: 2006

Hydrogen and methane production from household solid waste in the two-stage fermentation process
A two-stage process combined hydrogen and methane production from household solid waste was demonstrated working successfully. The yield of 43 mL H-2/g volatile solid (VS) added was generated in the first hydrogen production stage and the methane production in the second stage was 500 mL CH4/g VS added. This figure was 21% higher than the methane yield from the one-stage process, which was run as control. Sparging of the hydrogen reactor with methane gas resulted in doubling of the hydrogen production. PH was observed as a key factor affecting fermentation pathway in hydrogen production stage. The optimum PH range for hydrogen production in this system was in the range from 5 to 5.5. The short hydraulic retention time (2 days) applied in the first stage was enough to separate acidogenesis from methanogenesis. No additional control for preventing methanogenesis in the first stage was necessary. Furthermore, this study also provided direct evidence in the dynamic fermentation process that, hydrogen production increase was reflected by acetate to butyrate ratio increase in liquid phase. (c) 2006 Elsevier Ltd. All rights reserved.

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Lui, D., Liu, D., Zeng, R. J., Angelidaki, I.
Pages: 2230-2236
Publication date: 2006
Peer-reviewed: Yes

Publication information
Journal: Water Research
Identifiability study of the proteins degradation model, based on ADM1, using simultaneous batch experiments

The objective of the present study is to analyse kinetic and stoichiometric parameter values of gelatine anaerobic degradation at thermophilic range, based on an experiment designed to elucidate if volatile fatty acids (VFA) are inhibitors of the hydrolysis process. Results showed that VFA are not inhibiting the hydrolysis process. The ADM1 model adequately expressed the consecutive steps of hydrolysis and acidogenesis, with estimated kinetic values corresponding to a fast acidogenesis and slower hydrolysis. The hydrolysis was found to be the rate limiting step of anaerobic degradation. Estimation of yield coefficients based on the relative initial slopes of VFA profiles obtained in a simple batch experiment produced satisfactory results. From the identification study, it was concluded that it is possible to determine univocally the related kinetic parameter values for protein degradation if the evolution of amino acids is measured in simultaneous batch experiments, with different initial protein and amino acids concentrations.

General information
State: Published
Organisations: Bioscience and Technology, Department of Systems Biology, Department of Environmental Engineering
Contributors: Flotats, X., Palatsi, J., Ahring, B. K., Angelidaki, I.
Number of pages: 9
Pages: 31-39
Publication date: 2006
Peer-reviewed: Yes

Publication information
Journal: Water Science and Technology
Volume: 54
Issue number: 4
ISSN (Print): 0273-1223
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.34 SJR 0.429 SNIP 0.574
Web of Science (2017): Impact factor 1.247
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.3 SJR 0.404 SNIP 0.637
Web of Science (2016): Impact factor 1.197
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.19 SJR 0.464 SNIP 0.594
Web of Science (2015): Impact factor 1.064
Web of Science (2015): Indexed yes
Lessons learnt from 15 years of ICA in anaerobic digesters

Anaerobic digestion plants are highly efficient wastewater treatment processes with inherent energy production. Despite these advantages, many industries are still reluctant to use them because of their instability confronted with changes in operating conditions. There is therefore great potential for application of instrumentation, control and automation (ICA) in the field of anaerobic digestion. This paper will discuss the requirements (in terms of on-line sensors needed, modelling efforts and mathematical complexity) but also the advantages and drawbacks of different control strategies that have been applied to AD high rate processes over the last 15 years.

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Steyer, J., Bernard, O., Batstone, D. J., Angelidaki, I.
Pages: 25-33
Publication date: 2006
Peer-reviewed: Yes

Publication information
Journal: Water Science and Technology
Volume: 53
Issue number: 4-5
ISSN (Print): 0273-1223
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.34 SJR 0.429 SNIP 0.574
Web of Science (2017): Impact factor 1.247
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.3 SJR 0.404 SNIP 0.637
Web of Science (2016): Impact factor 1.197
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.19 SJR 0.464 SNIP 0.594
Web of Science (2015): Impact factor 1.064
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.14 SJR 0.585 SNIP 0.683
Web of Science (2014): Impact factor 1.106
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 1.3 SJR 0.571 SNIP 0.701
Web of Science (2013): Impact factor 1.212
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 1.13 SJR 0.597 SNIP 0.659
Web of Science (2012): Impact factor 1.102
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 1.25 SJR 0.594 SNIP 0.631
Web of Science (2011): Impact factor 1.122
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.529 SNIP 0.597
Operational strategies for thermophilic anaerobic digestion of organic fraction of municipal solid waste in continuously stirred tank reactors

Three operational strategies to reduce inhibition due to ammonia during thermophilic anaerobic digestion of source-sorted organic fraction of municipal solid waste (SS-OFMSW) rich in proteins were investigated. Feed was prepared by diluting SS-OFMSW (ratio of 1:4) with tap water or reactor process water with or without stripping ammonia. Three continuously stirred tank reactors were operated at 55 degrees C with 11.4 gVS d(-1) loading rate and 15 d retention time. Total ammonia nitrogen (TAN) level in the reactor fed with recirculated water alone was spiked to 3.5 and 5.5 g-N l(-1) through ammonium bicarbonate additions. Dilution of SS-OFMSW with fresh water showed a stable performance with volatile fatty acids of < 1g l(-1) and methane yield of 0.40 m(3) kg(-1) volatile solids (VS). Use of recirculated process water after stripping ammonia showed even better performance with a methane yield of 0.43 m(3) kg(-1)VS. Recirculation of process water alone on the other hand, resulted in process inhibition at both TAN levels of 3.5 and 5.5 g-N l(-1). However, after a short period, the process recovered and adapted to the tested TAN levels. Thus, use of recirculated process water after stripping ammonia would not only evade potential inhibition due to ammonia but could avoid the use of fresh water for dilution of high solids protein-rich SS-OFMSW.

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Angelidaki, I., Cui, J., Chen, X., Kaparaju, P. L.
Pages: 855-861
Publication date: 2006
Peer-reviewed: Yes

Publication information
Journal: Environmental Technology
Volume: 27
Issue number: 8
Thermophilic anaerobic digestion of source-sorted organic fraction of household municipal solid waste: start-up procedure for continuously stirred tank reactor

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Angelidaki, I., Chen, X., Cui, J., Kaparaju, P. L., Ellegaard, L.
Pages: 2621-2628
Publication date: 2006
Peer-reviewed: Yes

Publication information
Journal: Water Research
Volume: 40
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 7.55 SJR 2.601 SNIP 2.358
Web of Science (2017): Impact factor 7.051
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 7.49 SJR 2.663 SNIP 2.563
Web of Science (2016): Impact factor 6.942
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 6.63 SJR 2.665 SNIP 2.482
Web of Science (2015): Impact factor 5.991
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 6.13 SJR 2.946 SNIP 2.702
Web of Science (2014): Impact factor 5.528
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 6.02 SJR 2.956 SNIP 2.676
Web of Science (2013): Impact factor 5.323
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.15 SJR 2.914 SNIP 2.442
Web of Science (2012): Impact factor 4.655
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 5.43 SJR 2.862 SNIP 2.355
Anaerobic degradation of solid material: Importance of initiation centers for methanogenesis, mixing intensity, and 2D distributed model

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Vavilin, V., Angelidaki, I.
Pages: 113-122
Publication date: 2005
Peer-reviewed: Yes

Publication information
Journal: Biotechnology and Bioengineering (Print)
Volume: 89
Issue number: 1
ISSN (Print): 0006-3592
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 4.07 SJR 1.372 SNIP 1.186
Web of Science (2017): Impact factor 3.952
Anaerobic degradation of urban waste

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Angelidaki, I.
Pages: 1-12
Publication date: 2005

Host publication information
Title of host publication: 2005 Taiwan International Seminar on Urban Waste Treatment, Reuse, and Management, Taipei on October 30-31, 2005
Volume: Session 7
Place of publication: Taipei
Publisher: Department of Environmental Protection, Taipei City Government
Source: orbit
Source-ID: 182939
Research output: Research › Article in proceedings – Annual report year: 2005

Biogasreaktorer i serie kan give op til 15 procent mere gas

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Angelidaki, I., Ellegaard, L.
Pages: 2-3
Publication date: 2005
Peer-reviewed: Unknown

Publication information
Journal: Forskning i Bioenergi
Volume: 2
Issue number: 9
ISSN (Print): 1604-6331
Ratings:
ISI indexed (2013): ISI indexed no
ISI indexed (2012): ISI indexed no
ISI indexed (2011): ISI indexed no
Original language: Danish
Source: orbit
Source-ID: 189171
Research output: Communication › Journal article – Annual report year: 2005

Development of new ecotoxicity tests adapted to organic wastes to be recycled in agriculture

General information
State: Published
Organisations: Department of Environmental Engineering
Number of pages: 448
Publication date: 2005
Peer-reviewed: Yes
Event: Poster session presented at BOKU waste conference : Waste management in the focus of controversial interests, Vienna, Austria, 4-6 April,
Effect of operating conditions and reactor configuration on efficiency of full-scale biogas plants

A study on 18 full-scale centralized biogas plants was carried out in order to find significant operational factors influencing productivity and stability of the plants. It was found that the most plants were operating relatively stable with volatile fatty acids (VFA) concentration below 1.5 g/l. VFA concentration increase was observed in occasions with dramatic overloading or other disturbances such as operational temperature changes. Ammonia was found to be a significant factor for stability. A correlation between increased residual biogas production and high ammonia was found. When ammonia was higher than approx. 4 g-N/l the degradation efficiency of the plant decreased and as a consequence, the residual methane potential was high. Decrease of the residual methane potential with increasing hydraulic retention time was found. Digestion temperature was very important for effective post-digestion. Post-digestion for recovering the residual methane potential at temperatures below 15 degrees C was very inefficient.

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Angelidaki, I., Boe, K., Ellegaard, L.
Pages: 189-194
Publication date: 2005
Peer-reviewed: Yes

Publication information
Journal: Water Science and Technology
Volume: 52
Issue number: 1-2
ISSN (Print): 0273-1223
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.34 SJR 0.429 SNIP 0.574
Web of Science (2017): Impact factor 1.247
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.3 SJR 0.404 SNIP 0.637
Web of Science (2016): Impact factor 1.197
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.19 SJR 0.464 SNIP 0.594
Web of Science (2015): Impact factor 1.064
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.14 SJR 0.585 SNIP 0.683
Web of Science (2014): Impact factor 1.106
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 1.3 SJR 0.571 SNIP 0.701
Web of Science (2013): Impact factor 1.212
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 1.13 SJR 0.597 SNIP 0.659
Web of Science (2012): Impact factor 1.102
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Effects of process stability on anaerobic biodegradation of LAS in UASB reactors

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering
Contributors: Christiansen, T. L., Toräng, L., Batstone, D. J., Schmidt, J. E., Angelidaki, I.
Pages: 759-765
Publication date: 2005
Peer-reviewed: Yes

Publication information
Journal: Biotechnology and Bioengineering (Print)
Volume: 89
Issue number: 7
ISSN (Print): 0006-3592
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
Scopus rating (2017): CiteScore 4.07 SJR 1.372 SNIP 1.186
Web of Science (2017): Impact factor 3.952
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.14 SJR 1.447 SNIP 1.178
Web of Science (2016): Impact factor 4.481
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 4.44 SJR 1.632 SNIP 1.355
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 4.16 SJR 1.612 SNIP 1.395
Web of Science (2014): Impact factor 4.126
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 4.44 SJR 1.637 SNIP 1.427
Web of Science (2013): Impact factor 4.164
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 4.04 SJR 1.62 SNIP 1.364
Web of Science (2012): Impact factor 3.648
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 4.08 SJR 1.668 SNIP 1.481
Web of Science (2011): Impact factor 3.946
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.551 SNIP 1.354
Web of Science (2010): Impact factor 3.7
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.498 SNIP 1.358
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.248 SNIP 1.283
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.363 SNIP 1.356
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.467 SNIP 1.437
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.135 SNIP 1.23
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.105 SNIP 1.245
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.052 SNIP 1.228
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.117 SNIP 1.263
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.059 SNIP 1.16
Web of Science (2001): Indexed yes
Hydrogen and methane production from household solid waste in the two-stage fermentation process

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Lui, D., Liu, D., Zeng, R. J., Angelidaki, I.
Publication date: 2005
Peer-reviewed: Yes
Event: Poster session presented at 4th International Symposium on Anaerobic Digestion of Solid Waste, Copenhagen, Denmark.

Identifiability study of the proteins degradation model, based on ADM1, using simultaneous batch experiments

General information
State: Published
Organisations: Department of Biotechnology, Department of Environmental Science and Engineering, University of Lleida
Contributors: Flotats, X., Palatsi, J., Ahring, B. K., Angelidaki, I.
Publication date: 2005

Host publication information
Title of host publication: Proceedings of the 1st International Workshop on the IWA Anaerobic Digestion Model No.1 (ADM1)
Keywords: Proteins, Gelatine, Hydrolysis, Acidogenesis, Amino acids, Kinetics, Anaerobic digestion
Research output: Research › Article in proceedings – Annual report year: 2005

Influence of environmental conditions on methanogenic compositions in anaerobic biogas reactors

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Karakashev, D., Batstone, D. J., Angelidaki, I.
Pages: 331-338
Publication date: 2005
Peer-reviewed: Yes

Publication information
Journal: Applied and Environmental Microbiology
Volume: 71
Issue number: 1
ISSN (Print): 0099-2240
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.99
Web of Science (2017): Impact factor 3.633
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 4.08
Web of Science (2016): Impact factor 3.807
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 4.14 SJR 1.891 SNIP 1.308
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 4.02 SJR 1.857 SNIP 1.384
Web of Science (2014): Impact factor 3.668
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 4.25 SJR 1.899 SNIP 1.414
Web of Science (2013): Impact factor 3.952
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 4.29 SJR 1.975 SNIP 1.429
Web of Science (2012): Impact factor 3.678
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 4.12 SJR 1.914 SNIP 1.455
Web of Science (2011): Impact factor 3.829
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.887 SNIP 1.436
Web of Science (2010): Impact factor 3.778
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.972 SNIP 1.528
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.156 SNIP 1.572
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 2.043 SNIP 1.647
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 2.054 SNIP 1.602
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 2.074 SNIP 1.653
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 2.108 SNIP 1.648
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 2.097 SNIP 1.821
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 2.046 SNIP 1.754
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.989 SNIP 1.736
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 1.957 SNIP 1.758
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 2.3 SNIP 1.732
Investigation of post digestion in large scale centralized biogas plants

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Angelidaki, I., Hejnfelt, A., Ellegaard, L.
Publication date: 2005
Peer-reviewed: Yes
Event: Poster session presented at 4th International Symposium on Anaerobic Digestion of Solid Waste, Copenhagen, Denmark.
Source: orbit
Source-ID: 182197
Research output: Research - peer-review › Poster – Annual report year: 2005

Investigation of post digestion in large scale centralized biogas plants: No. O604

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Angelidaki, I., Hejnfelt, A., Ellegaard, L.
Pages: 427-432
Publication date: 2005

Host publication information
Title of host publication: VIII Latin American Workshop and Symposium on Anaerobic Digestion, 2-5 October, 2005, Punta del Este, Uruguay : Proceedings
Place of publication: Montevideo, Uruguay
Publisher: Universidad de la República (UDELAR), Facultad de Ingeniería - Facultad de Química - Facultad de Ciencias
Source: orbit
Source-ID: 182884
Research output: Research › Article in proceedings – Annual report year: 2005

Modeling of thermophilic anaerobic digestion of sorted household solid waste

General information
State: Published
Organisations: Department of Environmental Engineering
Pages: 359-366
Publication date: 2005

Host publication information
Title of host publication: 4th International Symposium on Anaerobic Digestion of Solid Waste, Copenhagen, August 31 - September 2, 2005 : Volume 1 - Oral Presentations
Place of publication: Kgs. Lyngby
Publisher: BioCentrum-DTU
Editors: Ahring, B. K., Hartmann, H.
Source: orbit
Source-ID: 182193
Research output: Research - peer-review › Article in proceedings – Annual report year: 2005

Online headspace chromatographic method for measuring VFA in biogas reactor

General information
State: Published
Organisations: Department of Environmental Engineering
Operational strategies for thermophilic anaerobic digestion of organic fraction of municipal solid waste in continuously stirred tank reactors

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Angelidaki, I., Cui, J., Chen, X., Kaparaju, P.
Pages: 233-239
Publication date: 2005

Host publication information
Title of host publication: 4th International Symposium on Anaerobic Digestion of Solid Waste, Copenhagen, August 31 - September 2, 2005 : Volume 1 - Oral Presentations
Place of publication: Kgs. Lyngby
Publisher: BioCentrum-DTU
Source: orbit
Source-ID: 182191
Research output: Research - peer-review › Article in proceedings – Annual report year: 2005

Optimisation of serial-CSTR biogas reactors using modeling by ADM1

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Boe, K., Batstone, D. J., Angelidaki, I.
Pages: 219-221
Publication date: 2005

Host publication information
Title of host publication: The First International Workshop on the IWA Anaerobic Digestion Model No. 1 (ADM1), Lyngby, Denmark, September 2-4, 2005 : Proceedings
Place of publication: Kgs. Lyngby, Denmark
Publisher: IWA Publishing
Source: orbit
Source-ID: 182091
Research output: Research - peer-review › Article in proceedings – Annual report year: 2005

Start up of UASB system for hydrogen production with enriched cultures at hyper thermophilic conditions (70 gr. C)
Strategies for changing temperature from mesophilic to thermophilic conditions in anaerobic CSTR reactors treating sewage sludge

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Bouskova, A., Dohanyos, M., Schmidt, J. E., Angelidaki, I.
Pages: 1481-1488
Publication date: 2005
Peer-reviewed: Yes

Publication information
Journal: Water Research
Volume: 39
ISSN (Print): 0043-1354
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 7.55 SJR 2.601 SNIP 2.358
Web of Science (2017): Impact factor 7.051
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 7.49 SJR 2.663 SNIP 2.563
Web of Science (2016): Impact factor 6.942
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 6.63 SJR 2.665 SNIP 2.482
Web of Science (2015): Impact factor 5.991
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 6.13 SJR 2.946 SNIP 2.702
Web of Science (2014): Impact factor 5.528
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 6.02 SJR 2.956 SNIP 2.676
Web of Science (2013): Impact factor 5.323
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.15 SJR 2.914 SNIP 2.442
Web of Science (2012): Impact factor 4.655
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 5.43 SJR 2.862 SNIP 2.355
Anaerobic bioprocessing of sewage sludge, focusing on degradation of linear alkylbenzene sulfonates (LAS)

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Angelidaki, I., Toräng, L., Waul, C. K., Schmidt, J. E.
Pages: 115-122
Publication date: 2004
Peer-reviewed: Yes

Publication information
Journal: Water Science and Technology
Volume: 49
Issue number: 10
ISSN (Print): 0273-1223
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.34 SJR 0.429 SNIP 0.574
Web of Science (2017): Impact factor 1.247
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.3 SJR 0.404 SNIP 0.637
Web of Science (2016): Impact factor 1.197
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.19 SJR 0.464 SNIP 0.594
Web of Science (2015): Impact factor 1.064
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.14 SJR 0.585 SNIP 0.683
Web of Science (2014): Impact factor 1.106
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 1.3 SJR 0.571 SNIP 0.701
Web of Science (2013): Impact factor 1.212
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 1.13 SJR 0.597 SNIP 0.659
Web of Science (2012): Impact factor 1.102
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 1.25 SJR 0.594 SNIP 0.631
Web of Science (2011): Impact factor 1.122
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.529 SNIP 0.597
Web of Science (2010): Impact factor 1.056
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.592 SNIP 0.693
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 0.583 SNIP 0.694
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.736 SNIP 0.766
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.696 SNIP 0.789
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.767 SNIP 0.841
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.875 SNIP 0.897
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.882 SNIP 0.897
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.877 SNIP 0.894
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.758 SNIP 0.967
Web of Science (2001): Indexed yes
Anaerobic degradation of phthalic acid esters in sewage sludge

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Christensen, N., Wang, C., Batstone, D. J., Angelidaki, I., Schmidt, J. E.
Pages: 891-896
Publication date: 2004

Host publication information
Title of host publication: 10th World Congress - Anaerobic Digestion 2004
Volume: vol. 2
Place of publication: Montreal
Publisher: NRC & IWA
Keywords: Phthalates, Anaerobic, Sewage sludge, FISH
Source: orbit
Source-ID: 135661
Research output: Research - peer-review › Article in proceedings – Annual report year: 2004

Application of anaerobic digestion modeling

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Batstone, D. J., Angelidaki, I.
Pages: 44-45
Publication date: 2004
Peer-reviewed: No

Publication information
Journal: Ecological Engineering and Environment Protection
Issue number: 1
Original language: English
Source: orbit
Source-ID: 90493
Research output: Research › Journal article – Annual report year: 2004

Assessment of the anaerobic biodegradability of macropollutants

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Angelidaki, I., Sanders, W.
Pages: 117-129
Publication date: 2004
Peer-reviewed: Yes

Publication information
Journal: Reviews in Environmental Science and Biotechnology
Volume: 3
Issue number: 2
ISSN (Print): 1569-1705
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
Bio-hydrogen production by anaerobic fermentation of waste

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Christiansen, T. L., Liu, D., Liu, D., Cirauqui, B., Batstone, D. J., Angelidaki, I.
Pages: 2216-2219
Publication date: 2004

Host publication information
Title of host publication: Anaerobic Digestion : 10th World Congress, 29th August - 2 September 2004, Montreal, Proceedings
Effect of operating conditions and reactor configuration on efficiency of full-scale biogas plants

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Angelidaki, I., Boe, K., Ellegaard, L.
Pages: 275-280
Publication date: 2004

Host publication information
Title of host publication: Anaerobic Digestion: 10th World Congress, 29th August - 2 September 2004, Montreal, Proceedings
Volume: vol. 1
Place of publication: Montreal
Publisher: NRC & IWA
Source: orbit
Source-ID: 135649
Research output: Research - peer-review › Article in proceedings – Annual report year: 2004

Improved nitrogen removal in upflow anaerobic sludge blanket (UASB) reactors by incorporation of Anammox bacteria into the granular sludge

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Schmidt, J. E., Batstone, D. J., Angelidaki, I.
Pages: 69-76
Publication date: 2004
Peer-reviewed: Yes

Publication information
Journal: Water Science and Technology
Volume: 49
Issue number: 11-12
ISSN (Print): 0273-1223
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.34 SJR 0.429 SNIP 0.574
Web of Science (2017): Impact factor 1.247
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.3 SJR 0.404 SNIP 0.637
Web of Science (2016): Impact factor 1.197
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.19 SJR 0.464 SNIP 0.594
Web of Science (2015): Impact factor 1.064
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.14 SJR 0.585 SNIP 0.683
Web of Science (2014): Impact factor 1.106
Method for determination of methane potentials of solid organic waste

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Hansen, T. L., Schmidt, J. E., Angelidaki, I., Marca, E., Jansen, J., Mosbæk, H., Christensen, T. H.
Pages: 393-400
Nedbrydning af LAS under anaerobe forhold

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Løbner, T., Toräng, L., Angelidaki, I.
Pages: 13-15
Publication date: 2004
Peer-reviewed: Unknown

Publication information
Journal: Vand & Jord
Volume: 11
Issue number: 1
ISSN (Print): 0908-7761
Ratings:
ISI indexed (2013): ISI indexed no
ISI indexed (2012): ISI indexed no
ISI indexed (2011): ISI indexed no
Original language: Danish
Source: orbit
Source-ID: 43765
Research output: Communication › Journal article – Annual report year: 2004

Online headspace chromatographic method for measuring VFA in biogas reactor

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Boe, K., Batstone, D. J., Angelidaki, I.
Pages: 426-431
Publication date: 2004

Host publication information
Title of host publication: Anaerobic Digestion: 10th World Congress, 29th August - 2 September 2004, Montreal,
Proceedings
Volume: vol. 1
Place of publication: Montreal
Publisher: NRC & IWA
Source: orbit
Source-ID: 135658
Research output: Research - peer-review › Article in proceedings – Annual report year: 2004

Optimal strategy for changing temperature from mesophilic to thermophilic conditions in CSTR reactors treating sewage sludge
Removal of polycyclic aromatic hydrocarbons (PAHs) from sewage sludge by anaerobic degradation

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Christensen, N., Batstone, D. J., Angelidaki, I., Schmidt, J. E.
Publication date: 2004

Publication information
Journal: Water Science and Technology
Volume: 50
Issue number: 9
ISSN (Print): 0273-1223
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.34 SJR 0.429 SNIP 0.574
Web of Science (2017): Impact factor 1.247
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.3 SJR 0.404 SNIP 0.637
Web of Science (2016): Impact factor 1.197
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.19 SJR 0.464 SNIP 0.594
Web of Science (2015): Impact factor 1.064
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.14 SJR 0.585 SNIP 0.683
Web of Science (2014): Impact factor 1.106
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 1.3 SJR 0.571 SNIP 0.701
Web of Science (2013): Impact factor 1.212
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 1.13 SJR 0.597 SNIP 0.659
Web of Science (2012): Impact factor 1.102
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
Sewage sludge for safe recycling on agricultural land: biowaste

**General information**

State: Published
Organisations: Department of Environmental Engineering
Number of pages: 3
Pages: Paper 48
Publication date: 2004

**Host publication information**

Title of host publication: Proceedings of the 9th European Biosolids and Biowastes Conference Workshop and Exhibition 14-17 November 2004, Wakefield, West Yorkshire
Volume: CD-ROM
Place of publication: Leeds
Publisher: Aqua Enviro Technology
Keywords: Xenobiotics, Modelling, Life cycle analysis, Toxicity, Agricultural disposal, Biomarkers
Source: orbit
Source-ID: 135678
Research output: Research › Article in proceedings – Annual report year: 2004
A new VFA sensor technique for anaerobic reactor systems

A key parameter for understanding and controlling the anaerobic biogas process is the concentration of volatile fatty acids (VFA). However, this information has so far been limited to off-line measurements using labor-intensive methods. We have developed a new technique that has made it possible to monitor VFA online in one of the most difficult media: animal slurry or manure. A novel in situ filtration technique has made it possible to perform microfiltration inside a reactor system. This filter enables sampling from closed reactor systems without large-scale pumping and filters. Furthermore, due to its small size it can be placed in lab-scale reactors without disturbing the process. Using this filtration technique together with commercially available membrane filters we have constructed a VFA sensor system that can perform automatic analysis of animal slurry at a frequency as high as every 15 minutes. Reproducibility and recovery factors of the entire system have been determined. The VFA sensor has been tested for a period of more than 60 days with more than 1000 samples on both a full-scale biogas plant and lab-scale reactors. The measuring range covers specific measurements of acetate, propionate, iso-/n-butyrate and iso-/n-valerate ranging from 0.1 to 50 mM (6-3000 mg). The measuring range could readily be expanded to more components and both lower and higher concentrations if desired. In addition to the new VFA sensor system, test results from development and testing of the in situ filtration technique are being presented in this article.
Applications of the anaerobic digestion process

At the start of the new millennium waste management has become a political priority in many countries. One of the main problems today is to cope with an increasing amount of primary waste in an environmentally acceptable way. Biowastes, i.e., municipal, agricultural or industrial organic waste, as well as contaminated soils etc., have traditionally been deposited in landfills or even dumped into the sea or lakes without much environmental concern. In recent times, environmental standards of waste incineration and controlled land filling have gradually improved, and new methods of waste sorting and resource-energy recovery have been developed. Treatment of biowastes by anaerobic digestion processes is in many cases the optimal way to convert organic waste into useful products such as energy (in the form of biogas) and a fertilizer product. Other waste management options, such as land filling and incineration of organic waste has become less desirable, and legislation, both in Europe and elsewhere, tends to favor biological treatment as a way of recycling minerals and nutrients of organic wastes from society back to the food production and supply chain. Removing the relatively wet organic waste from the general waste streams also results in a better calorific value of the remainder for incineration, and a more stable fraction for land filling.

General information

State: Published
Organisations: Environmental Microbiology and Biotechnology, Department of Systems Biology
Contributors: Angelidaki, I., Ellegaard, L., Ahring, B. K.
Pages: 1-33
Publication date: 2003
Peer-reviewed: Yes

Publication information

Journal: Advances in Biochemical Engineering/Biotechnology
Volume: 82
ISSN (Print): 0724-6145
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.37 SJR 0.788 SNIP 1.431
Web of Science (2017): Impact factor 2.795
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.78 SJR 0.717 SNIP 0.856
Web of Science (2016): Impact factor 2.222
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.44 SJR 0.608 SNIP 0.603
Web of Science (2015): Impact factor 1.911
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.35 SJR 0.568 SNIP 0.563
Bioprocessing of sewage sludge for safe recycling on agricultural land: BIOWASTE

**General information**

State: Published
Organisations: Department of Environmental Engineering
Contributors: Schmidt, J. E., Angelidaki, I., Christensen, N., Batstone, D. J., Lyberatos, G., Stamatelatou, K., Lichtfouse, E., Metzger, L., Borghi, V., Montcada, E.
Publication date: 2003

**Host publication information**
Title of host publication: Understanding the complexity of environmental issues. A way to sustainability : SETAC Europe 13th annual meeting, Hamburg, Germany 27 April - 1 May 2003. Abstracts
Place of publication: Brussels
Publisher: SETAC
Source: orbit
Bioprocessing of sewage sludge for safe recycling on agricultural land

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Schmidt, J. E., Christensen, N., Angelidaki, I.
Pages: 193-203
Publication date: 2003

Host publication information
Title of host publication: ORBIT - Organic Recovery and Biological Treatment: Advance for a Sustainable Society. Proceedings
Volume: Part 1
Place of publication: Perth, Australia
Publisher: Murdoch University
Editors: Pullamanappalli, P., McComb, A., Diaz, L. F., Bidlingmaier, W.
Source: orbit
Source-ID: 135732
Research output: Research - peer-review > Article in proceedings – Annual report year: 2003

Bioprocessing of sewage sludge for safe recycling on agricultural land - BIOWASTE

General information
State: Published
Organisations: Department of Environmental Engineering
Pages: 531-538
Publication date: 2003

Host publication information
Place of publication: Trondheim
Publisher: IWA Publishing
Editor: Ødegaard, H.
Source: orbit
Source-ID: 135731
Research output: Research - peer-review > Article in proceedings – Annual report year: 2003

Biowaste - a new European project. Bioprocessing of sewage sludge for safe recycling on agricultural land - BIOWASTE

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Schmidt, J. E., Angelidaki, I., Christensen, N., Batstone, D. J., Lyberatos, G., Stamatelatou, K., Lichtfouse, E., Elbisser, B., Rogers, K., Sappin-Didier, V., Denaix, L., Metzger, L., Borghi, V., Montcada, E.
Pages: 3-4
Publication date: 2003
Peer-reviewed: Unknown

Publication information
Journal: European Association of Chemistry and the Environment. Newsletter
Issue number: 5
Original language: English
DOIs:
10.1007/s10311-003-0042-7
Source: orbit
Source-ID: 43916
Research output: Communication > Journal article – Annual report year: 2003
Chemical characteristics and methane potentials of source-separated and pre-treated organic municipal solid waste

A research project has investigated the biogas potential of pre-screened source-separated organic waste. Wastes from five Danish cities have been pre-treated by three methods: screw press; disc screen; and shredder and magnet. This paper outlines the sampling procedure used, the chemical composition of the wastes and the estimated methane potentials.

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Hansen, T. L., Svärd, Á., Angelidaki, I., Schmidt, J. E., Jansen, J., Christensen, T. H.
Pages: 205-208
Publication date: 2003
Peer-reviewed: Yes

Publication information
Journal: Water Science and Technology
Volume: 48
Issue number: 4
ISSN (Print): 0273-1223
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.34 SJR 0.429 SNIP 0.574
Web of Science (2017): Impact factor 1.247
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.3 SJR 0.404 SNIP 0.637
Web of Science (2016): Impact factor 1.197
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.19 SJR 0.464 SNIP 0.594
Web of Science (2015): Impact factor 1.064
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.14 SJR 0.585 SNIP 0.683
Web of Science (2014): Impact factor 1.106
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 1.3 SJR 0.571 SNIP 0.701
Web of Science (2013): Impact factor 1.212
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 1.13 SJR 0.597 SNIP 0.659
Web of Science (2012): Impact factor 1.102
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 1.25 SJR 0.594 SNIP 0.631
Web of Science (2011): Impact factor 1.122
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.529 SNIP 0.597
Codigestion of manure and organic wastes in centralized biogas plants. Status and future trends

**General information**
State: Published
Organisations: Department of Environmental Engineering
Contributors: Angelidaki, I., Ellegaard, L.
Pages: 95-105
Publication date: 2003
Peer-reviewed: Yes

**Publication information**
Journal: Applied Biochemistry and Biotechnology
Volume: 109
ISSN (Print): 0273-2289
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.02 SJR 0.571 SNIP 0.8
Web of Science (2017): Impact factor 1.797
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.81 SJR 0.579 SNIP 0.749
Web of Science (2016): Impact factor 1.751
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Dynamics of the anaerobic process: Effects of volatile fatty acids

A complex and fast dynamic response of the anaerobic biogas system was observed when the system was subjected to pulses of volatile fatty acids (VFAs). It was shown that a pulse of specific VFAs into a well-functioning continuous stirred tank reactor (CSTR) system operating on cow manure affected both CH4 yield, pH, and gas production and that a unique
reaction pattern was seen for the higher VFAs as a result of these pulses. In this study, two thermophilic laboratory reactors were equipped with a novel VFA-sensor for monitoring specific VFAs online. Pulses of VFAs were shown to have a positive effect on process yield and the levels of all VFA were shown to stabilize at a lower level after the biomass had been subjected to several pulses. The response to pulses of propionate or acetate was different from the response to butyrate, iso-butyrate, valerate, or iso-valerate. High concentrations of propionate affected the degradation of all VFAs, while a pulse of acetate affected primarily the degradation of iso-valerate or 2-methylbutyrate. Pulses of n-butyrate, iso-butyrate, and iso-valerate yielded only acetate, while degradation of n-valerate gave both propionate and acetate. Product sensitivity or inhibition was shown for the degradation of all VFAs tested. Based on the results, it was concluded that measurements of all specific VFAs are important for control purposes and increase and decrease in a specific VFA should always be evaluated in close relationship to the conversion of other VFAs and the history of the reactor process. It should be pointed out that the observed dynamics of VFA responses were based on hourly measurements, meaning that the response duration was much lower than the hydraulic retention time, which exceeds several days in anaerobic CSTR systems.

General information
State: Published
Organisations: Environmental Microbiology and Biotechnology, Department of Systems Biology
Contributors: Pind, P. F., Angelidaki, I., Ahring, B. K.
Pages: 791-801
Publication date: 2003
Peer-reviewed: Yes

Publication information
Journal: Biotechnology and Bioengineering
Volume: 82
Issue number: 7
ISSN (Print): 0006-3592
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 4.07 SJR 1.372 SNIP 1.186
Web of Science (2017): Impact factor 3.952
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.14 SJR 1.447 SNIP 1.178
Web of Science (2016): Impact factor 4.481
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 4.44 SJR 1.632 SNIP 1.355
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 4.16 SJR 1.612 SNIP 1.395
Web of Science (2014): Impact factor 4.126
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 4.44 SJR 1.637 SNIP 1.427
Web of Science (2013): Impact factor 4.164
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 4.04 SJR 1.62 SNIP 1.364
Web of Science (2012): Impact factor 3.648
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 4.08 SJR 1.668 SNIP 1.481
Web of Science (2011): Impact factor 3.946
Kinetics and modeling of anaerobic digestion process

Anaerobic digestion modeling started in the early 1970s when the need for design and efficient operation of anaerobic systems became evident. At that time not only was the knowledge about the complex process of anaerobic digestion inadequate but also there were computational limitations. Thus, the first models were very simple and consisted of a limited number of equations. During the past thirty years much research has been conducted on the peculiarities of the process and on the factors that influence it on the one hand while an enormous progress took place in computer science on the other. The combination of both parameters resulted in the development of more and more concise and complex models. In this chapter the most important models found in the literature are described starting from the simplest and oldest to the more recent and complex ones.

General information
State: Published
Organisations: Environmental Microbiology and Biotechnology, Department of Systems Biology
Contributors: Gavala, H. N., Angelidaki, I., Ahring, B. K.
Pages: 57-93
Publication date: 2003

Host publication information
Title of host publication: Biomethanation I
Place of publication: Berlin
Publisher: Springer
Editor: Ahring, B. K.
ISBN (Print): 978-3-540-44322-3
Kinetics of thermophilic, anaerobic oxidation of straight and branched chain butyrate and valerate

The degradation kinetics of normal and branched chain butyrate and valerate are important in protein-fed anaerobic systems, as a number of amino acids degrade to these organic acids. Including activated and primary wastewater sludge digesters, the majority of full-scale systems digest feeds with a significant or major fraction of COD as protein. This study assesses the validity of using a common kinetic parameter set and biological catalyst to represent butyrate, n-valerate, and i-valerate degradation in dynamic models. The i-valerate degradation stoichiometry in a continuous, mixed population system is also addressed, extending previous pure-culture and batch studies. A previously published mathematical model was modified to allow competitive uptake of i-valerate, and used to model a thermophilic manure digester operated over 180 days. The digester was periodically pulsed with straight and branched chain butyrate and valerate. Parameters were separately optimized to describe butyrate, i-valerate, and n-valerate degradation, as well as a lumped set optimized for all three substrates, and nonlinear, correlated parameter spaces estimated using an F distribution in the objective function (A Each parameter set occupied mutually exclusive parameter spaces, indicating that all were statistically different from each other. However, qualitatively, the influence on model outputs was similar, and the lumped set would be reasonable for mixed acid digestion. The main characteristic not represented by Monod kinetics was a delay in i-valerate uptake, and was compensated for by a decreased maximum uptake rate (k(m)). Therefore, the kinetics need modification if fed predominantly i-valerate. Butyrate (i- and n-) and n-valerate could be modeled using stoichiometry consistent with beta-oxidation degradation pathways. However, i-valerate produced acetate only, supporting the stoichiometry of a reaction determined by other researchers in pure culture. Therefore, lumping i-valerate stoichiometry with that of n-valerate will not allow good system representation, especially when the feed consists of proteins high in leucine (which produces i-valerate), and the modified model structure and stoichiometry as proposed here should be used. This requires no additional kinetic parameters and one additional dynamic concentration state variable (i-valerate) in addition to the variables in the base model. (C) 2003 Wiley Periodicals, Inc.
Monitoring and control of anaerobic reactors
The current status in monitoring and control of anaerobic reactors is reviewed. The influence of reactor design and waste composition on the possible monitoring and control schemes is examined. After defining the overall control structure, and possible control objectives, the possible process measurements are reviewed in detail. In the sequel, possible manipulated variables, such as the hydraulic retention time, the organic loading rate, the sludge retention time, temperature, pH and alkalinity are evaluated with respect to the two main reactor types: high-rate and low-rate. Finally, the different control approaches that have been used are comprehensively described. These include simple and adaptive controllers, as well as more recent developments such as fuzzy controllers, knowledge-based controllers and controllers based on neural networks.

General information
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Contributors: Pind, P. F., Angelidaki, I., Ahring, B. K., Stamatelatou, K., Lyberatos, G.
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ISBN (Print): 3-540-44321-5
(Advances in Biochemical Engineering and Biotechnology, Vol. 82).
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Research output: Research - peer-review > Book chapter – Annual report year: 2003

Monitoring and control of anaerobic reactors
The current status in monitoring and control of anaerobic reactors is reviewed. The influence of reactor design and waste composition on the possible monitoring and control schemes is examined. After defining the overall control structure, and possible control objectives, the possible process measurements are reviewed in detail. In the sequel, possible manipulated variables, such as the hydraulic retention time, the organic loading rate, the sludge retention time, temperature, pH and alkalinity are evaluated with respect to the two main reactor types: high-rate and low-rate. Finally, the different control approaches that have been used are comprehensively described. These include simple and adaptive controllers, as well as more recent developments such as fuzzy controllers, knowledge-based controllers and controllers based on neural networks.

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Publication date: 2003
Peer-reviewed: Yes

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Journal: Advances in Biochemical Engineering/Biotechnology
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BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.37 SJR 0.788 SNIP 1.431
Web of Science (2017): Impact factor 2.795
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.78 SJR 0.717 SNIP 0.856
Web of Science (2016): Impact factor 2.222
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.44 SJR 0.608 SNIP 0.603
Web of Science (2015): Impact factor 1.911
Parameter identification of thermophilic anaerobic degradation of valerate

The considered mathematical model of the decomposition of valerate presents three unknown kinetic parameters, two unknown stoichiometric coefficients, and three unknown initial concentrations for biomass. Applying a structural identifiability study, we concluded that it is necessary to perform simultaneous batch experiments with different initial conditions for estimating these parameters. Four simultaneous batch experiments were conducted at 55°C, characterized by four different initial acetate concentrations. Product inhibition of valerate degradation by acetate was considered. Practical identification was done optimizing the sum of the multiple determination coefficients for all measured state variables and for all experiments simultaneously. The estimated values of kinetic parameters and stoichiometric coefficients were characterized by the parameter correlation matrix, the confidence interval, and the student's t-test at 5% significance level with positive results except for the saturation constant, for which more experiments for improving its identifiability should be conducted. In this article, we discuss kinetic parameter estimation methods.
Process stability in laboratory continuous stirred tank reactors affect anaerobic degradation of LAS

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Toräng, L., Perez, M., Schmidt, J. E., Angelidaki, I.
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Title of host publication: ORBIT - Organic Recovery and Biological Treatment : Proceedings of the 4th International Conference of ORBIT Association on Biological Processing of Organics: Advance for a Sustainable Society
Volume: Part 2
Place of publication: Perth, Australia
Publisher: Murdoch University
Editors: Pullammanappallil, P., McComb, A., Diaz, L. F., Bidlingmaier, W.
Source: orbit
Source-ID: 135738
Research output: Research - peer-review › Article in proceedings – Annual report year: 2003

Traditional and innovative ways for treatment of municipal wastewater

General information
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Organisations: Department of Environmental Engineering
Contributors: Schmidt, J. E., Fitsios, E., Angelidaki, I.
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Peer-reviewed: No

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Volume: 4
ISSN (Print): 0065-3535
Original language: English
Source: orbit
Source-ID: 43914
Research output: Research › Journal article – Annual report year: 2003
Anaerobic biodegradability of macropollutants

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Angelidaki, I.
Pages: 13-29
Publication date: 2002

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Title of host publication: Workshop on harmonisation of anaerobic biodegradation, activity and inhibition assays, June 7-8, 2002, Lago d’Orta, Italy. Proceedings
Place of publication: Ispra, Italy
Publisher: Institute for Environment and sustainability, Joint Research Center, European Commission
Editors: Ligthart, J., Nieman, H.
Source: orbit
Source-ID: 135743
Research output: Research › Article in proceedings – Annual report year: 2002

Anaerobic biodegradation of spent sulphite liquor in a UASB reactor
Anaerobic biodegradation of fermented spent sulphite liquor, SSL, which is produced during the manufacture of sulphite pulp, was investigated. SSL contains a high concentration of lignin products in addition to hemicellulose and has a very high COD load (173 g COD l⁻¹). Batch experiments with diluted SSL and pretreated SSL indicated a potential of 12–22 l methane per litre SSL, which corresponds to 0.13–0.22 l methane g VS⁻¹ and COD removal of up to 37%. COD removal in a mesophilic upflow anaerobic sludge blanket, UASB, reactor ranged from 10% to 31% at an organic loading rate, OLR, of 10–51 g O₃ l⁻¹ d⁻¹ and hydraulic retention time from 3.7 to 1.5 days. The biogas productivity was 3 l (reactor d⁻¹), with a yield of 0.05 l gas g VS⁻¹. These results suggest that anaerobic digestion in UASB reactors may provide a new alternative for the treatment of SSL to other treatment strategies such as incineration. Although the total COD reduction achieved is limited, bioenergy is produced and readily biodegradable matter is removed causing less load on post-treatment installations.

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Peer-reviewed: Yes

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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 6.28 SJR 2.029 SNIP 1.799
Web of Science (2017): Impact factor 5.807
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.94 SJR 2.215 SNIP 1.932
Web of Science (2016): Impact factor 5.651
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.47 SJR 2.243 SNIP 1.897
Web of Science (2015): Impact factor 4.917
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.3 SJR 2.399 SNIP 2.087
Web of Science (2014): Impact factor 4.494
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 5.97 SJR 2.405 SNIP 2.477
Web of Science (2013): Impact factor 5.039
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.25 SJR 2.334 SNIP 2.461
Web of Science (2012): Impact factor 4.75
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 5.56 SJR 2.308 SNIP 2.507
Web of Science (2011): Impact factor 4.98
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.089 SNIP 2.344
Web of Science (2010): Impact factor 4.365
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.915 SNIP 2.236
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.736 SNIP 2.74
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.403 SNIP 2.396
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.314 SNIP 2.003
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.278 SNIP 1.98
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.19 SNIP 1.655
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.942 SNIP 1.665
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.908 SNIP 1.294
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.537 SNIP 1.2
Scopus rating (2000): SJR 0.653 SNIP 1.023
Scopus rating (1999): SJR 0.659 SNIP 1.033
Original language: English
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DOIs: 10.1016/S0960-8524(02)00021-4
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Anaerobic digestion in Denmark: Past, present and future

General information
State: Published
Anaerobic digestion model No. 1 (ADM1)

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Batstone, D. J., Keller, J., Angelidaki, I., Kalyuzhny, S., Pavlostathis, S., Rozzi, A., Sanders, W., Siegrist, H., Vavilin, V.
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Source-ID: 43323
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Anaerobic digestion of olive oil mill effluents together with swine manure in UASB reactors

Combined anaerobic digestion of olive oil mill effluent (OME) with swine manure, was investigated. In batch experiments was shown that for anaerobic degradation of OME alone nitrogen addition was needed. A COD:N ratio in the range of 65:1 to 126:1 was necessary for the optimal degradation process. Furthermore, it was found that methane productions rates during digestion of either swine manure alone or OME alone were much lower than the rates achieved when OME and manure were digested together. Admixing OME with manure at a concentration of 5 to 10% OME resulted in the highest methane production rates. Using upflow anaerobic sludge blanket (UASB) reactors, it was shown that codigestion of OME with swine manure (up to 50% OME) was successful with a COD reduction up to 75%. The process was adapted for degradation of OME with stepwise increase of the OME load to the UASB reactor. The results showed that the high content of ammonia in swine manure, together with content of other nutrients, make it possible to degrade OME without addition of external alkalinity and without addition of external nitrogen source. Anaerobic treatment of OME in UASB reactors resulted in reduction of simple phenolic compounds such as mequinol, phenyl ethyl alcohol and ethyl methyl phenol. After anaerobic treatment the concentration of these compounds was reduced between 75 and 100%. However, the concentration of some degradation products such as methyl phenol and ethyl phenol were detected in significantly higher concentrations after treatment, indicating that the process has to be further optimised to achieve satisfactory removal of all xenobiotic compounds.

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Organisations: Department of Environmental Engineering, Department of Systems Biology
Contributors: Angelidaki, I., Ahring, B. K., Deng, H., Schmidt, J. E.
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Web of Science (2017): Impact factor 1.247
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.3 SJR 0.404 SNIP 0.637
Web of Science (2016): Impact factor 1.197
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.19 SJR 0.464 SNIP 0.594
Web of Science (2015): Impact factor 1.064
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.14 SJR 0.585 SNIP 0.683
Web of Science (2014): Impact factor 1.106
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 1.3 SJR 0.571 SNIP 0.701
Web of Science (2013): Impact factor 1.212
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 1.13 SJR 0.597 SNIP 0.659
Web of Science (2012): Impact factor 1.102
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 1.25 SJR 0.594 SNIP 0.631
Web of Science (2011): Impact factor 1.122
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.529 SNIP 0.597
Web of Science (2010): Impact factor 1.056
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.592 SNIP 0.693
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 0.583 SNIP 0.694
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.736 SNIP 0.766
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.696 SNIP 0.789
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.767 SNIP 0.841
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.875 SNIP 0.897
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.882 SNIP 0.897
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 0.877 SNIP 0.894
Anaerobic treatment of sludge: focusing on reduction of LAS concentration in sludge

Anaerobic degradation of linear alkylbenzene sulfonates (LAS) was tested in continuous stirred tank reactors (CSTR). LAS12 was used as a model compound and was spiked on sewage sludge. The experiments clearly showed that transformation of LAS12 occurred under anaerobic conditions. The degree of transformation varied between 14% and 25%. HPLC analysis showed that disappearance of LAS12 was followed by the formation of a metabolite. The experiments indicated that there is a clear correlation between degradation of organic matter contained in sludge and transformation of LAS12. When the reduction degree of the organic matter increased from 22% to 28%, the transformation degree of LAS12 also increased, from 14% to 20%. Decreasing the total solids concentration of the influent sludge or increasing the spiked concentration of LAS12 did not alter the degree of LAS12 transformation significantly. A clear correlation between transformed and bioavailable LAS12 was found, indicating that it is merely the bioavailable fraction of LAS12 that is transformed by anaerobic digestion. The results from the present study are promising and indicate that a great potential for biological degradation of LAS is possible even at anaerobic conditions.
An innovative process for treatment of municipal wastewater with superior characteristics compared to traditional technologies

An innovative treatment process for municipal sewage, which results in low sludge production, low energy consumption, high COD removal and high energy and nutrients recovery, is described. The organic matter will primarily be removed through anaerobic degradation using high-flow reactors. For nitrogen removal, the anammox process and an innovative physico-chemical method, will be described. These separation technologies have showed promising prospects for cost effective removal of ammonia. For phosphorus removal, biological process will be used. On-line volatile fatty acids (VFA) monitoring and control will ensure optimum utilization of VFA's for P removal and biogas production. Thermal hydrolysis for treatment of residual sludge will be used for further decreasing the amount of excess sludge. Finally, socio-economic evaluation of the process relative to the traditional treatment concepts will be worked out.
A novel in-situ sampling and VFA sensor technique for anaerobic systems

A key information for understanding and controlling the anaerobic biogas process is the concentration of Volatile Fatty Acids (VFA). However, access to this information has so far been limited to off-line measurements by manual time and labour consuming methods. We have developed a new technique that has made it possible to monitor VFA on-line in one of the most difficult media: animal slurry or manure. A novel in-situ filtration technique has made it possible to perform microfiltration inside the reactor system. This filter enables sampling from closed reactor systems without large scale pumping and filtering. Using this filtration technique together with commercially available membrane filters we have constructed a VFA sensor system that can perform automatic analysis on animal slurry at a frequency as high as every 15 minutes. The VFA sensor has been tested for a period of more than 60 days with more than 1000 samples on both a fullscale biogas plant and lab-scale reactors. The measuring range covers specific measurements of acetate, propionate, iso-/n-butyrate and iso-/n-valerate from 0.1 to 50 mM (6–3,000 mg).

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Contributors: Pind, P. F., Angelidaki, I., Ahring, B. K.
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BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.34 SJR 0.429 SNIP 0.574
Web of Science (2017): Impact factor 1.247
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.3 SJR 0.404 SNIP 0.637
Web of Science (2016): Impact factor 1.197
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.19 SJR 0.464 SNIP 0.594
Web of Science (2015): Impact factor 1.064
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.14 SJR 0.585 SNIP 0.683
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Co-digestion of the organic fraction of municipal waste with other waste types

General information
State: Published
Organisations: Department of Systems Biology, Department of Environmental Engineering
Contributors: Hartmann, H., Angelidaki, I., Ahring, B. K.
Co-Digestion of the Organic Fraction of Municipal Waste With Other Waste Types

Several characteristics make anaerobic digestion of the organic fraction of municipal solid waste (OFMSW) difficult. By co-digestion of OFMSW with several other waste types it will be possible to optimize the anaerobic process by waste management. The co-digestion concept involves the treatment of several waste types in a single treatment facility. By combining many types of waste it will be possible to treat a wider range of organic waste types by the anaerobic digestion process (figure 1). Furthermore, co-digestion enables the treatment of organic waste with a high biogas potential that makes the operation of biogas plants more economically feasible (Ahring et al., 1992a). Thus, co-digestion gives a new attitude to the evaluation of waste: since anaerobic digestion of organic waste is both a waste stabilization method and an energy gaining process with production of a fertilizer, organic waste becomes a valuable resource. Co-digestion treatment has been successfully applied to several agricultural and industrial organic waste types in recent years. In Denmark, for example, the co-digestion concept has been successfully used since the mid 1980's for the treatment of livestock waste and industrial organic waste in Joint Biogas Plants (Danish Energy Agency, 1995). However, at present only 7% of the overall OFMSW treated by anaerobic digestion in Europe was done so by means of co-digestion (De Baere, 2000). In this chapter we will show that co-digestion of OFMSW has several benefits which can be used for establishing a wider application of the anaerobic treatment of OFMSW.

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Organisations: Department of Environmental Engineering, Bioscience and Technology, Department of Systems Biology
Contributors: Hartmann, H., Angelidaki, I., Ahring, B. K.
Pages: 181-200
Publication date: 2002

Innovative wastewater treatment process with reduced energy consumption and regeneration of nutrients

Treatment of municipal wastewater by anaerobic digestion was investigated. A new process is described here, where anaerobic digestion of municipal wastewater is the main step for removal of organic matter, resulting in much lower sludge production. Steps for removal nutrients are also included. The suggested process contains the following steps: 1) The organic matter is primarily removed through anaerobic degradation using high-rate reactors. 2) For nitrogen removal, the Anammox process or physico-chemical methods will be applied. 3) For phosphorus removal, biological process will be used. 4) On-line volatile fatty acids (VFA) monitoring and control will ensure optimum utilization of VFA’s for P removal and biogas production. 4) Thermal hydrolysis for treatment of residual sludge will be used for further decreasing the amount of excess sludge. Batch experiments showed that sewage could be inhibitory for the anaerobic process if digested undiluted. The highest methane potential was found with filtrated sewage, unfiltered sewage gave biogas potentials, which were 4-6 times lower, depending on the temperature. Size distribution of the granules showed that the biggest granules had the highest hydrolytic activity and no substrate limitation was observed for the used granules. Experiment with UASB reactors showed COD removal efficiencies between 49-82 for the total COD and 25-99 for the soluble COD. No significant differences were observed between reactor performance at 22 and 37 degree C.

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Organisations: Department of Environmental Engineering
Contributors: Schmidt, J. E., Fitsios, E., Angelidaki, I.
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New reactor configurations for optimised anaerobic treatment of slurry waste

Parameter identification of thermophilic anaerobic degradation of valerate

Parameter Identification of thermophilic anaerobic degradation of valerate
The IWA Anaerobic digestion model no 1. (ADM1)
The IWA Anaerobic Digestion Modelling Task Group was established in 1997 at the 8th World Congress on Anaerobic Digestion (Sendai, Japan) with the goal of developing a generalised anaerobic digestion model. The structured model includes multiple steps describing biochemical as well as physicochemical processes. The biochemical steps include disintegration from homogeneous particulates to carbohydrates, proteins and lipids; extracellular hydrolysis of these particulate substrates to sugars, amino acids, and long chain fatty acids (LCFA), respectively; acidogenesis from sugars and amino acids to volatile fatty acids (VFAs) and hydrogen; acetogenesis of LCFA and VFAs to acetate; and separate methanogenesis steps from acetate and hydrogen/CO2. The physico-chemical equations describe ion association and dissociation, and gas-liquid transfer. Implemented as a differential and algebraic equation (DAE) set, there are 26 dynamic state concentration variables, and 8 implicit algebraic variables per reactor vessel or element. Implemented as differential equations (DE) only, there are 32 dynamic concentration state variables.

General information
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Organisations: Department of Environmental Engineering
Contributors: Batstone, D. J., Keller, J., Angelidaki, I., Kalyuzhny, S., Pavlostathis, S., Rozzi, A., Sanders, W., Siegrist, H., Vavilin, V.
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Scopus rating (2017): CiteScore 1.34 SJR 0.429 SNIP 0.574
Web of Science (2017): Impact factor 1.247
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.3 SJR 0.404 SNIP 0.637
Web of Science (2016): Impact factor 1.197
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.19 SJR 0.464 SNIP 0.594
Web of Science (2015): Impact factor 1.064
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.14 SJR 0.585 SNIP 0.683
Web of Science (2014): Impact factor 1.106
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 1.3 SJR 0.571 SNIP 0.701
Web of Science (2013): Impact factor 1.212
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 1.13 SJR 0.597 SNIP 0.659
Web of Science (2012): Impact factor 1.102
ISI indexed (2012): ISI indexed yes
Anaerobic digestion of organic fraction of municipal solid waste with recirculation of process water

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Organisations: Department of Systems Biology, Department of Environmental Engineering
Contributors: Hartmann, H., Angelidaki, I., Ahring, B. K.
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Place of publication: Antwerpen
Publisher: Technologisch Instituut
Source: orbit
Source-ID: 135825
Research output: Research - peer-review › Article in proceedings – Annual report year: 2001
Anaerobic Digestion of the Organic Fraction of Municipal Solid Waste With Recirculation of Process Water
A new concept of a wet anaerobic digestion treatment of the organic fraction of municipal solid waste (OFMSW) is investigated. Once the waste is diluted with water, the entire liquid fraction of the effluent is recirculated and used as process water for dilution of the waste. This enables a well-mixed process without additional water supply. A methane yield of 400 and 445 ml/gVS from OFMSW was achieved in batch and reactor experiments, respectively. Reactor performance with 15 days retention time and an organic loading rate of 4.5 gVS/d was stable with low VFA concentrations and a VS reduction of 70-80% when treating 100% OFMSW, diluted by 1:5. Recirculation of a larger fraction of the effluent makes removal of ammonia necessary in order to avoid inhibition of the process. The present process did not show degradation of the plasticizer DEHP (bis-2-ethylhexyl-phthalate) under thermophilic conditions after a period of 140 days.

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Research output: Research - peer-review › Article in proceedings – Annual report year: 2001

Dynamic responses of the anaerobic process to pulses of acetate and propionate

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Contributors: Pind, P. F., Angelidaki, I., Ahring, B. K.
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Publication date: 2001

Host publication information
Title of host publication: 9th World Congress, Anaerobic Digestion 2001, 2-6 September, Antwerpen, Proceedings
Volume: Part 2
Place of publication: Antwerpen, Belgium
Publisher: Technologisch Instituut
Keywords: acetate degradation, propionate degradation, anaerobic dynamics
Source: orbit
Source-ID: 135838
Research output: Research - peer-review › Article in proceedings – Annual report year: 2001

Mechanisms of oleate inhibition of the anaerobic degradation in upflow anaerobic sludge blanket (UASB) reactors

General information
State: Published
Organisations: Department of Environmental Engineering, Department of Systems Biology
Contributors: Schmidt, J. E., Jungersen, G., Ahring, B. K., Angelidaki, I.
Pages: 317-323
Publication date: 2001

Host publication information
Title of host publication: 9th World Congress, Anaerobic Digestion 2001, 2-6 September, Antwerpen, Proceedings
Volume: Part 2
Place of publication: Antwerpen, Belgium
Publisher: Technologisch Instituut
Keywords: oleate, UASB reactor, inhibition mechanisms
Source: orbit
Source-ID: 135842
Research output: Research - peer-review › Article in proceedings – Annual report year: 2001
The effects of sustainable waste management policies on anaerobic digestion of organic solid waste

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Alexiou, I., Alexiou, G., De Berardino, S., Kalyuzhnyi, S., Angelidaki, I., Papadimitriu, E.
Publication date: 2001

Host publication information
Title of host publication: 9th World Congress, Anaerobic Digestion 2001, 2-6 September, Antwerpen, Proceedings, (Late papers)
Place of publication: Antwerpen, Belgium
Publisher: Technologisch Instituut
Keywords: waste management, organic waste, Agenda 21, sustainable development, policy
Source: orbit
Source-ID: 135804
Research output: Research › Article in proceedings – Annual report year: 2001

Anaerobic transformation of LAS in continuous stirred tank reactors treating sewage sludge

General information
State: Published
Organisations: Department of Biotechnology
Contributors: Angelidaki, I., Haagensen, F., Ahring, B. K.
Pages: 1551-1557
Publication date: 2000

Host publication information
Title of host publication: 5th World Surfactants Congress
Source: orbit
Source-ID: 177433
Research output: Research - peer-review › Article in proceedings – Annual report year: 2000

Degradation of organic contaminants found in organic waste

In recent years, great interest has arisen in recycling of the waste created by modern society. A common way of recycling the organic fraction is amendment on farmland. However, these wastes may contain possible hazardous components in small amounts, which may prevent their use in farming. The objective of our study has been to develop biological methods by which selected organic xenobiotic compounds can be biotransformed by anaerobic or aerobic treatment. Screening tests assessed the capability of various inocula to degrade two phthalates di-n-butylphthalate, and di(2-ethylhexyl)phthalate, five polycyclic aromatic hydrocarbons, linear alkylbenzene sulfonates and three nonylphenol ethoxylates under aerobic and anaerobic conditions. Under aerobic conditions, by selecting the appropriate inoculum most of the selected xenobiotics could be degraded. Aerobic degradation of di(2-ethylhexyl)phthalate was only possible with leachate from a landfill as inoculum. Anaerobic degradation of some of the compounds was also detected. Leachate showed capability of degrading phthalates, and anaerobic sludge showed potential for degrading, polycyclic aromatic hydrocarbons, linear alkylbenzene sulfonates and nonyl phenol ethoxylates. The results are promising as they indicate that a great potential for biological degradation is present, though the inoculum containing the microorganisms capable of transforming the recalcitrant xenobiotics has to be chosen carefully.

General information
State: Published
Organisations: Department of Biotechnology
Contributors: Angelidaki, I., Mogensen, A. S., Ahring, B. K.
Pages: 377-383
Publication date: 2000
Peer-reviewed: Yes

Publication information
Journal: Biodegradation
Volume: 11
Issue number: 6
ISSN (Print): 0923-9820
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.43 SJR 0.876 SNIP 0.922
Web of Science (2017): Impact factor 2.41
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.41 SJR 0.818 SNIP 1.072
Web of Science (2016): Impact factor 2.018
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 2.37 SJR 0.895 SNIP 1.071
Web of Science (2015): Impact factor 2.208
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 2.42 SJR 0.968 SNIP 1.208
Web of Science (2014): Impact factor 2.336
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 2.63 SJR 1.105 SNIP 1.447
Web of Science (2013): Impact factor 2.492
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 2.22 SJR 1.034 SNIP 1.197
Web of Science (2012): Impact factor 2.173
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 2.31 SJR 1.068 SNIP 1.103
Web of Science (2011): Impact factor 2.017
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.1 SNIP 0.989
Web of Science (2010): Impact factor 2.012
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.012 SNIP 1.19
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.969 SNIP 1.192
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.811 SNIP 1.101
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.977 SNIP 1.092
Scopus rating (2005): SJR 0.809 SNIP 0.953
Scopus rating (2004): SJR 0.868 SNIP 0.759
Scopus rating (2003): SJR 0.736 SNIP 0.849
Scopus rating (2002): SJR 0.771 SNIP 0.681
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.658 SNIP 0.953
Scopus rating (2000): SJR 0.905 SNIP 0.824
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 0.878 SNIP 0.69
Original language: English
Keywords: nonylphenol ethoxylates, LAS, phthalates, anaerobic degradation, screening, PAH
DOIs:
10.1023/A:1011643014990
Source: orbit
Source-ID: 177343
Increase of anaerobic degradation of particulate organic matter in full-scale biogas plants by mechanical maceration

Different concepts of implementation of mechanical pretreatment for enhancing the biogas potential from fibers in manure feedstock were evaluated by sampling before and after macerators at different biogas plants and from a fiber separation unit. An increase of the biogas potential of up to 25% by pretreatment of the whole feed in the macerator before the reactor was observed. Implementation concepts with a treatment of the fibers alone after separation from the manure showed to be not efficient due to a low recovery of organic matter in the fibers by the separation unit. The low operational costs of a macerator make it attractive to use this pretreatment method for a more complete degradation of particulate organic matter. Investigation of the size distribution of the fibers showed that a change in biogas potential was not correlated to a smaller size of the fibers. Results from the macerators indicate that the biodegradability of the fibers is rather enhanced by shearing which is not necessarily reflected by a change in fiber size.

General information
State: Published
Organisations: Department of Biotechnology
Contributors: Hartmann, H., Angelidaki, I., Ahring, B. K.
Pages: 145-153
Publication date: 2000
Peer-reviewed: Yes

Publication information
Journal: Water Science and Technology
Volume: 41
Issue number: 3
ISSN (Print): 0273-1223

Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.34 SJR 0.429 SNIP 0.574
Web of Science (2017): Impact factor 1.247
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.3 SJR 0.404 SNIP 0.637
Web of Science (2016): Impact factor 1.197
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.19 SJR 0.464 SNIP 0.594
Web of Science (2015): Impact factor 1.064
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.14 SJR 0.585 SNIP 0.683
Web of Science (2014): Impact factor 1.106
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 1.3 SJR 0.571 SNIP 0.701
Web of Science (2013): Impact factor 1.212
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 1.13 SJR 0.597 SNIP 0.659
Web of Science (2012): Impact factor 1.102
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 1.25 SJR 0.594 SNIP 0.631
Web of Science (2011): Impact factor 1.122
Linear alkylbenzene sulfonates: inhibition effect on acetate and propionate degradation during anaerobic digestion

General information
State: Published
Organisations: Department of Biotechnology
Contributors: Gavala, H. N., Haagensen, F., Mogensen, A. S., Angelidaki, I., Ahring, B. K.
Pages: 452-455
Publication date: 2000

Host publication information
Title of host publication: Proceedings of the 4th International Symposium on Environmental Biotechnology
Place of publication: Noordwijkerhout, The Netherlands
Source: orbit
Source-ID: 177435
Research output: Research - peer-review › Article in proceedings – Annual report year: 2000

Methods for increasing the biogas potential from the recalcitrant organic matter contained in manure
The biogas potential of manure could be significantly increased by treatment of the recalcitrant organic matter (biofibers) contained in the manure. Several treatment methods were tested. Mechanical maceration resulted in an average increase of the biogas potential of approximately 17% as shown by the continuous stirred reactor experiment. In general the smaller the fibers the higher the biogas potential was. The best results showed an approximately 20% increase of the biogas potential with fibers smaller than 0.35 mm as measured by batch experiments. The increase was approximately 16% with fibers of size 2 mm. Chemical treatment of the fibers with bases such as NaOH, NH4OH or a combination of bases also resulted in an increased methane potential. However, combination of maceration and chemical treatment did not result in a further increase of the methane potential. There was not any significant difference of the biogas potential from fibers in
the range 5–20 mm. Treatment of the fibers with hemicellulolytic or cellulolytic enzymes did not result in any significant increase of the methane potential. However, biological treatment of the fibers of the manure with the hemicellulose degrading bacterium B4 resulted in a significant increase of the biogas potential of manure. An increase of approximately 30 % in methane potential was achieved compared to controls.

General information
State: Published
Organisations: Department of Biotechnology
Contributors: Angelidaki, I., Ahring, B. K.
Pages: 189-194
Publication date: 2000
Peer-reviewed: Yes

Publication information
Journal: Water Science and Technology
Volume: 41
Issue number: 3
ISSN (Print): 0273-1223
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.34 SJR 0.429 SNIP 0.574
Web of Science (2017): Impact factor 1.247
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.3 SJR 0.404 SNIP 0.637
Web of Science (2016): Impact factor 1.197
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.19 SJR 0.464 SNIP 0.594
Web of Science (2015): Impact factor 1.064
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.14 SJR 0.585 SNIP 0.683
Web of Science (2014): Impact factor 1.106
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 1.3 SJR 0.571 SNIP 0.701
Web of Science (2013): Impact factor 1.212
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 1.13 SJR 0.597 SNIP 0.659
Web of Science (2012): Impact factor 1.102
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 1.25 SJR 0.594 SNIP 0.631
Web of Science (2011): Impact factor 1.122
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.529 SNIP 0.597
Web of Science (2010): Impact factor 1.056
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
A comprehensive model of anaerobic bioconversion of complex substrates to biogas

A dynamic model describing the anaerobic degradation of complex material, and codigestion of different types of wastes, was developed based on a model previously described (Angelidaki et al., 1993). In the model, the substrate is described by its composition of basic organic components, i.e., carbohydrates, lipids, and proteins, the concentration of intermediates such as volatile fatty acids and long-chain fatty acids, and important inorganic components, i.e., ammonia, phosphate, cations, and anions. This allows dynamic changes of the process during a shift of substrate composition to be simulated by changing the input substrate data. The model includes 2 enzymatic hydrolytic steps, 8 bacterial steps and involves 19 chemical compounds. The model also includes a detailed description of pH and temperature characteristics. Free ammonia, acetate, volatile fatty acids, (VFA) and long-chain fatty acids (LCFA) constitute the primary modulating factors in the model. The model was rested with success in lab-scale reactors codigesting manure with glycerol trioleate or manure with gelatin. Finally, the model was validated using results from a full-scale biogas plant codigesting manure together with a proteinous wastewater and with bentonite-bound oil, which is a waste with high content of lipids. (C) 1999 John Wiley & Sons, Inc. Biotechnol Bioeng 63: 363-372, 1999.

General information
State: Published
Organisations: Department of Biotechnology, Burmeister & Wain Scandinavian Contractor A/S
Contributors: Angelidaki, I., Ellegaard, L., Ahring, B. K.
Pages: 363-372
Publication date: 1999
Peer-reviewed: Yes

Publication information
Journal: Biotechnology and Bioengineering
Volume: 63
Issue number: 3
ISSN (Print): 0006-3592
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Anaerobic co-digestion of olive mill effluents together with different wastes

General information
State: Published
Organisations: Department of Applied Chemistry, Department of Biotechnology
Contributors: Schmidt, J. E., Angelidaki, I., Ahring, B. K.
Pages: 180-183
Publication date: 1999

Host publication information
Title of host publication: Anaerobic co-digestion of olive mill effluents together with different wastes
Source: orbit
Source-ID: 170979
Research output: Research - peer-review › Journal article – Annual report year: 1999

Degradation of organic contaminants found in organic sludge

General information
State: Published
Organisations: Department of Biotechnology
Contributors: Angelidaki, I., Ahring, B. K.
Pages: 40-50
Publication date: 1999

Host publication information
Title of host publication: Proceedings CD-ROM, AiEPS 99, July 4-8, 1999
Place of publication: Pietermaritzburg, South Africa
Publisher: African international environmental protection symposium
Source: orbit
Source-ID: 173221
Research output: Research - peer-review › Article in proceedings – Annual report year: 1999

Improved digestion of swine manure in thermophilic biogas reactors

General information
State: Published
Organisations: Department of Biotechnology
Contributors: Hansen, K. H., Angelidaki, I., Ahring, B. K.
Pages: 1805-1810
Publication date: 1999
Peer-reviewed: Yes

Publication information
Journal: Water Research
Volume: 33
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 7.55 SJR 2.601 SNIP 2.358
Anaerobic digestion of swine manure: Inhibition by ammonia

A stable anaerobic degradation of swine manure with ammonia concentration of 6 g-N/litre was obtained in continuously stirred tank reactors with a hydraulic retention time of 15 days, at Four different temperatures. Methane yields of 188, 141, 67 and 22 ml-CH4/g-VS were obtained at 37, 45, 55 and 60 degrees C, respectively. The yields were significantly lower than the potential biogas yield of the swine manure used (300 ml-CH4/g-VS). A free ammonia concentration of 1.1 g-N/litre or more was found to cause inhibition in batch cultures at pH 8.0 (reactor pH), and higher free ammonia concentrations resulted in a decreased apparent specific growth rate. Batch experiments with various mixtures of swine and cattle manure showed that the biogas process was inhibited when the swine-to-cattle manure ratio was higher than 25:75, corresponding to a free ammonia concentration of approximately 1.1 g-N/litre. Inhibition of the biogas process and, thereby, a reduction of the methane yield followed a four-stage pattern: below a threshold of 1.1 g-N/litre free ammonia, the process was uninhibited; over this concentration, inhibition occurred, forming first a phase with an initial inhibition, then a plateau and then an inhibition stage where the apparent specific growth rate decreased with increasing concentrations of free ammonia. (C) 1998 Elsevier Science Ltd. All rights reserved.

General information
State: Published
Organisations: Department of Environmental Science and Engineering
Contributors: Hansen, K. H., Angelidaki, I., Ahring, B. K.
Pages: 5-12
Publication date: 1998
Peer-reviewed: Yes

Publication information
Journal: Water Research
Volume: 32
Issue number: 1
ISSN (Print): 0043-1354
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 7.55 SJR 2.601 SNIP 2.358
Web of Science (2017): Impact factor 7.051
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 7.49 SJR 2.663 SNIP 2.563
Web of Science (2016): Impact factor 6.942
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 6.63 SJR 2.665 SNIP 2.482
Web of Science (2015): Impact factor 5.991
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 6.13 SJR 2.946 SNIP 2.702
Web of Science (2014): Impact factor 5.528
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 6.02 SJR 2.956 SNIP 2.676
Web of Science (2013): Impact factor 5.323
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
An automatic system for simultaneous monitoring of gas evolution in multiple closed vessels

General information
State: Published
Organisations: Department of Biotechnology
Contributors: Angelidaki, I., Schmidt, J. E., Ellegaard, L., Ahring, B. K.
Pages: 93-100
Publication date: 1998
Peer-reviewed: Yes

Publication information
Journal: Journal of Microbiological Methods
Volume: 33
ISSN (Print): 0167-7012
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.95 SJR 0.696 SNIP 0.781
Web of Science (2017): Impact factor 1.701
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.05 SJR 0.742 SNIP 0.817
Web of Science (2016): Impact factor 1.79
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 2.04 SJR 0.819 SNIP 0.86
Web of Science (2015): Impact factor 1.857
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 2.28 SJR 0.91 SNIP 1.032
Web of Science (2014): Impact factor 2.026
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 2.5 SJR 0.924 SNIP 1.015
Web of Science (2013): Impact factor 2.096
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 2.32 SJR 0.867 SNIP 0.997
Web of Science (2012): Impact factor 2.161
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 2.29 SJR 0.903 SNIP 0.963
Web of Science (2011): Impact factor 2.086
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.954 SNIP 1.05
Web of Science (2010): Impact factor 2.018
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.001 SNIP 1.157
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.936 SNIP 1.023
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.003 SNIP 1.111
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.144 SNIP 1.258
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.976 SNIP 1.13
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.933 SNIP 1.051
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 0.939 SNIP 1.213
Web of Science (2003): Indexed yes
An automatic system for simultaneous monitoring of gas evolution in multiple closed vessels

General information
State: Published
Organisations: Department of Environmental Science and Engineering
Contributors: Angelidaki, I., Schmidt, J. E., Ellegaard, L., Ahring, B. K.
Pages: 93-100
Publication date: 1998
Peer-reviewed: Yes

Publication information
Journal: Journal of Microbiological Methods
Volume: 33
ISSN (Print): 0167-7012
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.95 SJR 0.696 SNIP 0.781
Web of Science (2017): Impact factor 1.701
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.05 SJR 0.742 SNIP 0.817
Web of Science (2016): Impact factor 1.79
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 2.04 SJR 0.819 SNIP 0.86
Web of Science (2015): Impact factor 1.857
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 2.28 SJR 0.91 SNIP 1.032
Web of Science (2014): Impact factor 2.026
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 2.5 SJR 0.924 SNIP 1.015
Web of Science (2013): Impact factor 2.096
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 2.32 SJR 0.867 SNIP 0.997
Web of Science (2012): Impact factor 2.161
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 2.29 SJR 0.903 SNIP 0.963
Web of Science (2011): Impact factor 2.086
Bioforgasning: proces. Kapitel 4.11

General information
State: Published
Organisations: Department of Biotechnology
Contributors: Schmidt, J. E., Angelidaki, I., Ahring, B. K.
Pages: 377-398
Publication date: 1998

Host publication information
Title of host publication: Affaldsteknologi
Place of publication: København
Publisher: Nyt Teknisk Forlag
Editor: Christensen, T. H.
ISBN (Print): 87-571-2148-6
Source: orbit
Source-ID: 171439
Research output: Education › Book chapter – Annual report year: 1998


General information
State: Published
Organisations: Department of Biotechnology
Contributors: Schmidt, J. E., Ahring, B. K., Angelidaki, I., Kræmer, S.
Biogasprocessen - styr på mikrobiologien

General information
State: Published
Organisations: Department of Biotechnology, University of Copenhagen
Contributors: Sørensen, A. H., Angelidaki, I., Ahring, B. K.
Pages: 80 - 83
Publication date: 1998
Peer-reviewed: No

Bioprocessing of organic waste for organic contaminants

General information
State: Published
Organisations: Department of Biotechnology, Technical University of Denmark
Contributors: Angelidaki, I., A.S., M., Alatriste-Mondragon, F., Ahring, B. K.
Publication date: 1998

Host publication information
Title of host publication: Anvendelse af affalds produkter i bæredygtigt jordbrug
Place of publication: Cph
Publisher: DAKOFA
Source: orbit
Source-ID: 170450
Research output: Research - peer-review › Book chapter – Annual report year: 1998

Computerized automatic system for continuous monitoring of gas production in closed systems

General information
State: Published
Organisations: Department of Biotechnology, Department of Applied Chemistry
Contributors: Angelidaki, I., Schmidt, J. E., Ellegaard, L., Ahring, B. K.
Pages: 93-100
Publication date: 1998
Peer-reviewed: Yes
Matematisk model for dynamisk simulering af den anaerobe biogas proces

General information
State: Published
Organisations: Department of Environmental Science and Engineering
Contributors: Angelidaki, I., Ellegaard, L., Ahring, B. K.
Publication date: 1998

Methods for increasing the biogas potential from the recalcitrant organic matter contained in manure

The biogas potential of manure could be significantly increased by treatment of the recalcitrant organic matter (biofibers) contained in the manure. Several treatment methods were tested. Mechanical maceration resulted in an average increase of the biogas potential of approx. 17% as shown by continuous stirred reactor experiment. In general the smaller the fibres the higher the biogas potential was. The best results showed an approx. 20% increase of the biogas potential with fibers smaller than 0.35 mm as measured by batch experiments. The increase was approx. 16% with fibres of size 2 mm. Chemical treatment of the fibres with bases such as NaOH, NH4OH or combination of bases also resulted in an increased methane potential. However, combination of maceration and chemical treatment did not result in a further increase of the methane potential. There was not any significant difference of the biogas potential from fibres in the range 5-20 mm. Treatment of the fibres with hemicellulolytic or cellulolytic enzymes did not result in any significant increase of the methane potential. However, biological treatment of the fibres of the manure with the hemicellulose degrading bacterium B4 resulted in a significant increase of the biogas potential of manure. An increase of approx. 30 % in methane potential was achieved compared to controls.

Metoder til forøgelse af biogasudbyttet fra de tungt omsættelige dele af det organiske stof i gylle og undersøgelser over svinegylles udrådningssegenskaber

General information
A mathematical model for simulation of anaerobic codigestion: Supported by grants from the energy research programme from the Danish Energy Ministry

Codigestion of manure with organic industrial waste. Abstract

Degradation of lipid containing organic industrial waste
Utilization of different wastes in biogas plants

Establishment and Characterization of an Anaerobic Thermophilic (55 degrees C) Enrichment Culture Degrading Long-Chain Fatty Acids

A thermophilic, long-chain fatty acid-oxidizing culture was enriched. Stearate was used as the substrate, and methane and carbon dioxide were the sole end products. Cultivation was possible only when a fed-batch system was used or with addition of activated carbon or bentonite. The enrichment culture consisted of a short rod and two bacteria antigenically related to Methanobacterium thermoautotrophicum DELTA-H and Methanosarcina thermophila TM-1.
Isomerization of n- and i-butyrate in Anaerobic Methanogenic Systems

General information
State: Published
Organisations: Department of Environmental Science and Engineering
Contributors: Angelidaki, I., Ahring, B. K.
Pages: 285-291
Publication date: 1995
Peer-reviewed: Yes

Publication information
Journal: Antonie van Leeuwenhoek: Journal of Microbiology
Volume: 68
ISSN (Print): 0003-6072
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
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Scopus rating (2017): CiteScore 1.87 SJR 0.834 SNIP 0.829
Web of Science (2017): Impact factor 1.588
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.86 SJR 0.83 SNIP 0.851
Web of Science (2016): Impact factor 1.795
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.99 SJR 0.97 SNIP 0.869
Web of Science (2015): Impact factor 1.944
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.99 SJR 0.771 SNIP 0.82
Web of Science (2014): Impact factor 1.806
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 2.25 SJR 0.829 SNIP 1.075
Web of Science (2013): Impact factor 2.137
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 2.02 SJR 1.078 SNIP 0.922
Web of Science (2012): Impact factor 2.072
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 2.17 SJR 0.932 SNIP 1.02
Web of Science (2011): Impact factor 2.091
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.842 SNIP 0.859
Web of Science (2010): Impact factor 1.673
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.976 SNIP 0.887
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.946 SNIP 0.95
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.758 SNIP 1.055
Volatile Fatty Acids as Indicators of Process Imbalance in Anaerobic Digestors

General information
State: Published
Organisations: Department of Environmental Science and Engineering, Department of Biotechnology, Technical University of Denmark
Contributors: Ahring, B. K., Sandberg, M., Angelidaki, I.
Pages: 559-565
Publication date: 1995
Peer-reviewed: Yes

Publication information
Journal: Applied Microbiology and Biotechnology
Volume: 43
ISSN (Print): 0175-7598
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 3.64 SJR 1.182 SNIP 1.161
Web of Science (2017): Impact factor 3.34
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.57 SJR 1.2 SNIP 1.182
Web of Science (2016): Impact factor 3.42
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 3.43 SJR 1.256 SNIP 1.221
Web of Science (2015): Impact factor 3.376
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 3.71 SJR 1.332 SNIP 1.448
Web of Science (2014): Impact factor 3.337
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 4.3 SJR 1.54 SNIP 1.43
Web of Science (2013): Impact factor 3.811
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 4 SJR 1.488 SNIP 1.29
A Mathematical Model for Dynamic Simulation of Anaerobic Digestion of Complex Substrates: Focusing on Ammonia Inhibition

A mathematical model for anaerobic degradation of complex organic material, such as manure, has been developed. The model includes an enzymatic hydrolytic step and four bacterial steps and involves 12 chemical compounds. The model focuses on ammonia inhibition and includes a detailed description of pH and temperature characteristics in order to accurately simulate free ammonia concentration. Free ammonia and acetate constitute the primary modulating factors in the model. The model has been applied for the simulation of digestion of cattle manure in continuously stirred tank reactors (CSTRs), and results compare favorably with experimental data. © 1993 John Wiley & Sons, Inc. Key words: anaerobic digestion ammonia inhibition manure mathematical model.

General information
State: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering, Department of Biotechnology, Technical University of Denmark
Contributors: Angelidaki, I., Ellegaard, L., Ahring, B. K.
Pages: 159-166
Publication date: 1993
Publication information
Journal: Biotechnology and Bioengineering (Print)
Volume: 42
ISSN (Print): 0006-3592
Ratings:
  BFI (2018): BFI-level 1
  Web of Science (2018): Indexed yes
  BFI (2017): BFI-level 1
  Scopus rating (2017): CiteScore 4.07 SJR 1.372 SNIP 1.186
  Web of Science (2017): Impact factor 3.952
  Web of Science (2017): Indexed yes
  BFI (2016): BFI-level 1
  Scopus rating (2016): CiteScore 4.14 SJR 1.447 SNIP 1.178
  Web of Science (2016): Impact factor 4.481
  Web of Science (2016): Indexed yes
  BFI (2015): BFI-level 1
  Scopus rating (2015): CiteScore 4.44 SJR 1.632 SNIP 1.355
  Web of Science (2015): Indexed yes
  BFI (2014): BFI-level 1
  Scopus rating (2014): CiteScore 4.16 SJR 1.612 SNIP 1.395
  Web of Science (2014): Impact factor 4.126
  Web of Science (2014): Indexed yes
  BFI (2013): BFI-level 2
  Scopus rating (2013): CiteScore 4.44 SJR 1.637 SNIP 1.427
  Web of Science (2013): Impact factor 4.164
  ISI indexed (2013): ISI indexed yes
  Web of Science (2013): Indexed yes
  BFI (2012): BFI-level 2
  Scopus rating (2012): CiteScore 4.04 SJR 1.62 SNIP 1.364
  Web of Science (2012): Impact factor 3.648
  ISI indexed (2012): ISI indexed yes
  Web of Science (2012): Indexed yes
  BFI (2011): BFI-level 2
  Scopus rating (2011): CiteScore 4.08 SJR 1.668 SNIP 1.481
  Web of Science (2011): Impact factor 3.946
  ISI indexed (2011): ISI indexed yes
  Web of Science (2011): Indexed yes
  BFI (2010): BFI-level 2
  Scopus rating (2010): SJR 1.551 SNIP 1.354
  Web of Science (2010): Impact factor 3.7
  Web of Science (2010): Indexed yes
  BFI (2009): BFI-level 2
  Scopus rating (2009): SJR 1.498 SNIP 1.358
  Web of Science (2009): Indexed yes
  BFI (2008): BFI-level 1
  Scopus rating (2008): SJR 1.248 SNIP 1.283
  Web of Science (2008): Indexed yes
  Scopus rating (2007): SJR 1.363 SNIP 1.356
  Web of Science (2007): Indexed yes
  Scopus rating (2006): SJR 1.467 SNIP 1.437
  Web of Science (2006): Indexed yes
The ever-increasing global energy demands, together with the negative environmental impact of fossil fuels, have reinforced the efforts to develop alternative fuel sources. The conversion of biomass-derived syngas (CO, H2 and CO2) into biofuels (mostly as ethanol) and commodity chemicals by microbial catalysts has gained considerable attention in past years as an alternative avenue to address the challenge. Though promising, low ethanol yield and accumulation of byproducts (mainly acetic acid) which is toxic to the process at high level are key challenges hindering the commercialization of syngas fermentation technology. In this context, EcoFuel is a timely and ambitious investigation, which proposes to address the aforementioned challenges by means of an innovative platform technology namely microbial electrochemical fermentation.

Zhang, Y., Project Participant, Department of Environmental Engineering, Residual Resource Engineering
Angelidaki, I., Project Coordinator, Department of Environmental Engineering
Project ID: NNF16OC0021568
01/07/2017 → 01/07/2020
Keywords: microbial electrochemical fermentation, Syngas, Biofuels, Biomass
Project: Research

Bioinorganic artificial photosynthesis of single cell protein from carbon dioxide.
Xu, M., PhD Student, Department of Environmental Engineering
Angelidaki, I., Main Supervisor, Department of Environmental Engineering
Zhang, Y., Supervisor, Department of Environmental Engineering
Privatist
01/11/2017 → 31/10/2020
Award relations: Bioinorganic artificial photosynthesis of single cell protein from carbon dioxide.
Project: PhD

Biological production of n-Hexanol
Yang, X., PhD Student, Department of Environmental Engineering
Angelidaki, I., Main Supervisor, Department of Environmental Engineering
Kougias, P., Supervisor, Department of Environmental Engineering
Stipendie fra udlanget
01/12/2017 → 30/11/2020
Award relations: Biological production of n-Hexanol
Project: PhD

Microbial electrochemistry meet UV: For effektive degradation of organic matter
Zou, R., PhD Student, Department of Environmental Engineering
Angelidaki, I., Main Supervisor, Department of Environmental Engineering
Zhang, Y., Supervisor, Department of Environmental Engineering
Stipendie fra udlanget
01/12/2017 → 30/11/2020
Award relations: Microbial electrochemistry meet UV: For effective degradation of organic matter
Project: PhD

**Powdered bioaugmentation inocula to alleviate ammonia toxicity in anaerobic digesters**
Yan, M., PhD Student, Department of Environmental Engineering
Angelidaki, I., Main Supervisor, Department of Environmental Engineering
Fotidis, I., Supervisor, Department of Environmental Engineering
Privatist
01/11/2017 → 31/10/2020
Award relations: Powdered bioaugmentation inocula to alleviate ammonia toxicity in anaerobic digesters
Project: PhD

**Ex-situ biogas upgrading through biologically mediated CO2 hydrogenation**
Peprah, M., PhD Student, Department of Environmental Engineering
Angelidaki, I., Main Supervisor, Department of Environmental Engineering
Kougias, P., Supervisor, Department of Environmental Engineering
Offentlig finansiering
01/11/2017 → 31/10/2020
Award relations: Ex-situ biogas upgrading through biologically mediated CO2 hydrogenation
Project: PhD

**Miljøvurdering af organisk husholdningsaffald**
Hansen, T. L., PhD Student, Department of Environmental Engineering
Christensen, T. H., Main Supervisor, Department of Environmental Engineering
Angelidaki, I., Supervisor, Department of Environmental Engineering
Kjeldsen, P., Examiner, Department of Environmental Engineering
Magid, J., Examiner
Stentiford, E. I., Examiner
DTU-lønnet stipendie
01/01/2002 → 14/11/2005
Award relations: Miljøvurdering af organisk husholdningsaffald
Project: PhD

**On-line styring og regulering af biogasanlæg**
Pind, P. F., PhD Student, Department of Systems Biology
Ahring, B. K., Main Supervisor, Department of Systems Biology
Angelidaki, I., Supervisor
Jørgensen, S. B., Examiner
Lyberatos, G., Examiner
Mattiasson, B., Examiner
DTU-Su Stipendium, Eksperiment
01/08/1997 → 18/06/2001
Award relations: On-line styring og regulering af biogasanlæg
Project: PhD

**Computational modelling and simulation of anaerobic biomass conversion to biogas, focusing on the effects of substrate characterisation, solid-liquid- gas phase interactions and microbial growth dynamics**
Kovalovszki, A., PhD Student, Department of Environmental Engineering
Angelidaki, I., Main Supervisor, Department of Environmental Engineering
Alvarado-Morales, M., Supervisor, Department of Environmental Engineering
Institut stipendie (DTU)
15/09/2016 → 14/01/2020
Award relations: Computational modelling and simulation of anaerobic biomass conversion to biogas, focusing on the effects of substrate characterisation, solid-liquid- gas phase interactions and microbial growth dynamics
Project: PhD

**Innovative bioaugmentation strategies to tackle ammonia inhibition in anaerobic digestion process**
Tian, H., PhD Student, Department of Environmental Engineering
Angelidaki, I., Main Supervisor, Department of Environmental Engineering
Fotidis, I., Supervisor, Department of Environmental Engineering
Kougias, P., Examiner, Department of Environmental Engineering
Schmidt, J. E., Examiner, Department of Environmental Engineering
Wang, A., Examiner
Stipendie fra udlændet
01/10/2015 → 30/09/2018
Award relations: Innovative bioaugmentation strategies to tackle ammonia inhibition in anaerobic digestion process
Project: PhD

Innovative bio-electrochemical-anaerobic-digestion coupled system for ammonia recovery and energy production from food-waste residues
Zhao, N., PhD Student, Department of Environmental Engineering
Angelidaki, I., Main Supervisor, Department of Environmental Engineering
Zhang, Y., Supervisor, Department of Environmental Engineering
Stipendie fra udlændet
01/10/2015 → 28/02/2019
Award relations: Innovative bio-electrochemical-anaerobic-digestion coupled system for ammonia recovery and energy production from food-waste residues
Project: PhD

Innovative microbial electrolysis cell-anaerobic digestion coupled system for ammonia recovery and energy production from ammonia-rich residues
Li, X., PhD Student, Department of Environmental Engineering
Angelidaki, I., Main Supervisor, Department of Environmental Engineering
Zhang, Y., Supervisor, Department of Environmental Engineering
Thomsen, A. B., Examiner
Verstraete, W., Examiner
Stipendie fra udlændet
15/12/2014 → 18/04/2018
Award relations: Innovative microbial electrolysis cell-anaerobic digestion coupled system for ammonia recovery and energy production from ammonia-rich residues
Project: PhD

Deciphering the microbial ecology in biogas reactors for optimizing the anaerobic digestion process
Zhu, X., PhD Student, Department of Environmental Engineering
Angelidaki, I., Main Supervisor, Department of Environmental Engineering
Kougias, P., Supervisor, Department of Environmental Engineering
Treu, L., Examiner, Department of Environmental Engineering
Zhang, Y., Examiner, Department of Environmental Engineering
Lund Nielsen, J., Examiner
de Sousa, D. Z. M., Examiner
Institut stipendie (DTU)
01/12/2014 → 28/02/2018
Award relations: Deciphering the microbial ecology in biogas reactors for optimizing the anaerobic digestion process
Project: PhD

Bioelectrochemical-anaerobic digestion-coupled system for simultaneous recovery and bioenergy production
Jin, X., PhD Student, Department of Environmental Engineering
Angelidaki, I., Main Supervisor, Department of Environmental Engineering
Zhang, Y., Supervisor, Department of Environmental Engineering
Kougias, P., Examiner, Department of Environmental Engineering
He, Z. J., Examiner
Norddahl, B., Examiner
Stipendie fra udlændet
15/10/2014 → 20/12/2017
Award relations: Bioelectrochemical-anaerobic digestion-coupled system for simultaneous recovery and bioenergy production
Project: PhD

Sustainable Production of Third Generation (3G) Bioenergy Carriers and High Value Aquatic Fish Feed from Macroalgae
D'Este, M., PhD Student, Department of Environmental Engineering
Angelidaki, I., Main Supervisor, Department of Environmental Engineering
Alvarado-Morales, M., Supervisor, Department of Environmental Engineering
Fotidis, I., Examiner, Department of Environmental Engineering
Thomsen, A. B., Examiner
Nakashimada, Y., Examiner
Samfinansieret - Andet
01/01/2014 → 30/08/2017
Award relations: Sustainable Production of Third Generation (3G) Bioenergy Carriers and High Value Aquatic Fish Feed from Macroalgae
Project: PhD

Improved Anaerobic Digestion of Energy Crops
Bruni, E., PhD Student, Department of Environmental Engineering
Angelidaki, I., Main Supervisor, Department of Environmental Engineering
Jensen, A. P., Supervisor
Baun, A., Examiner, Department of Environmental Engineering
Mattiasson, B., Examiner
Norddahl, B., Examiner
ErhvervsPhD-ordningen VTU
01/12/2006 → 23/06/2010
Award relations: Improved Anaerobic Digestion of Energy Crops
Project: PhD

Microbial Fuel Cell - used in direct Conversion of Lignocellulosic Waste to Energy
Fang, C., PhD Student, Department of Environmental Engineering
Angelidaki, I., Main Supervisor, Department of Environmental Engineering
Boe, K., Supervisor, Department of Environmental Engineering
Karakashev, D. B., Examiner, Department of Environmental Engineering
Mattiasson, B., Examiner
Norddahl, B., Examiner
Privatist
01/07/2007 → 19/01/2011
Award relations: Microbial Fuel Cell - used in direct Conversion of Lignocellulosic Waste to Energy
Project: PhD

Combined Biohydrogen Biomethane Production from Waste
Liu, D., PhD Student, Department of Environmental Engineering
Angelidaki, I., Main Supervisor, Department of Environmental Engineering
Min, B., Supervisor, Department of Environmental Engineering
Zeng, R. J., Supervisor, Department of Environmental Engineering
Schmidt, J. E., Examiner, Department of Environmental Engineering
Niel, E. W. J. V., Examiner
Svensson, B. H., Examiner
Privatist
01/10/2004 → 04/07/2008
Award relations: Combined Biohydrogen Biomethane Production from Waste
Project: PhD

Kinetic Model Development of Anaerobic Fermentation for Hydrogen Production
Kongjan, P., PhD Student
Angelidaki, I., Main Supervisor
Min, B., Supervisor
Karakashev, D. B., Examiner
Norddahl, B., Examiner
Prasertsan, P., Examiner
Stipendie fra udlandet
25/08/2010 → 25/08/2010
Award relations: Kinetic Model Development of Anaerobic Fermentation for Hydrogen Production
Project: PhD

On-line Monitoring and Control of the Biogas Process
Boe, K., PhD Student, Department of Environmental Engineering
Angelidaki, I., Main Supervisor, Department of Environmental Engineering
Production of Biogas and Bioethanol from Organic Raw Materials
Oleskowicz-Popiel, P., PhD Student, Risø National Laboratory for Sustainable Energy
Schmidt, J. E., Main Supervisor, Risø National Laboratory for Sustainable Energy
Thomsen, A. B., Supervisor, Risø National Laboratory for Sustainable Energy
Angelidaki, I., Examiner
Norddahl, B., Examiner

Optimization of bio-hydrogen production from carbohydrate rich wastes by extreme thermophilic microorganisms
Tomás, A. F., PhD Student, Department of Environmental Engineering
Angelidaki, I., Main Supervisor, Department of Environmental Engineering
Karakashev, D. B., Supervisor, Department of Environmental Engineering
Dechesne, A., Examiner, Department of Environmental Engineering
Norddahl, B., Examiner
Verstraete, W., Examiner

Algal biofilter optimization near fish farm
Silva Marinho, G., PhD Student, Department of Environmental Engineering
Angelidaki, I., Main Supervisor, Department of Environmental Engineering
Holdt, S. L., Supervisor, Department of Environmental Engineering
Karakashev, D. B., Examiner, Department of Environmental Engineering
Bruhn, A., Examiner
Stanley, M. S., Examiner

Innovative biogas process for ammonia-rich wastes
Wang, H., PhD Student, Department of Environmental Engineering
Angelidaki, I., Main Supervisor, Department of Environmental Engineering
Fotidis, I., Supervisor, Department of Environmental Engineering
Dechesne, A., Examiner, Department of Environmental Engineering
Norddahl, B., Examiner
Schnürer, A. L., Examiner

Biogas enhancement and upgrading
Bassani, I., PhD Student, Department of Environmental Engineering
Angelidaki, I., Main Supervisor, Department of Environmental Engineering
Kougias, P., Supervisor, Department of Environmental Engineering
Jensen, M. M., Examiner, Department of Environmental Engineering
Development of new microbial fuel cell configuration for optimization of electricity production with simultaneous wastewater treatment
Zhang, Y., PhD Student, Department of Environmental Engineering
Angelidaki, I., Main Supervisor, Department of Environmental Engineering
Karakashev, D. B., Examiner, Department of Environmental Engineering
Norddahl, B., Examiner
Verstraete, W., Examiner
Institut/centerfinansieret
01/10/2009 → 30/09/2012
Award relations: Development of new microbial fuel cell configuration for optimization of electricity production with simultaneous wastewater treatment
Project: PhD

Sustainable Production and Utilization of Microalgae for industrial wastewater treatment
Podevin, M. P. A., PhD Student, Department of Environmental Engineering
Angelidaki, I., Main Supervisor, Department of Environmental Engineering
Fotidis, I., Supervisor, Department of Environmental Engineering
Zhang, Y., Examiner, Department of Environmental Engineering
Schmidt, J. E., Examiner, Department of Environmental Engineering
Schmidt, J. E., Examiner, Department of Environmental Engineering
Institut stipendie (DTU) Samf.
01/06/2012 → 30/08/2017
Award relations: Sustainable Production and Utilization of Microalgae for industrial wastewater treatment
Project: PhD

Biorefinery
Gunnarsson, I. B., PhD Student, Department of Environmental Engineering
Angelidaki, I., Main Supervisor, Department of Environmental Engineering
Karakashev, D. B., Supervisor, Department of Environmental Engineering
Dechesne, A., Examiner, Department of Environmental Engineering
Norddahl, B., Examiner
Verstraete, W., Examiner
Institut stipendie (DTU) Samf.
15/12/2011 → 26/01/2015
Award relations: Biorefinery
Project: PhD

New technology for an efficient utilization of meadow grass in biogas reactor
Tsapekos, P., PhD Student, Department of Environmental Engineering
Angelidaki, I., Main Supervisor, Department of Environmental Engineering
Kougias, P., Supervisor, Department of Environmental Engineering
Dechesne, A., Examiner, Department of Environmental Engineering
Malpei, F., Examiner
Norddahl, B., Examiner
Samfinansieret - Andet
01/12/2013 → 15/03/2017
Award relations: New technology for an efficient utilization of meadow grass in biogas reactor
Project: PhD

Sustainable Production and Utilization of Microalgae
van Wagenen, J. M., PhD Student, Department of Environmental Engineering
Angelidaki, I., Main Supervisor, Department of Environmental Engineering
De Francisci, D., Supervisor, Department of Environmental Engineering
Karakashev, D. B., Examiner, Department of Environmental Engineering
Environmental Assessment of the Management of Garden and Yard Waste

Boldrin, A., PhD Student, Department of Environmental Engineering
Christensen, T. H., Main Supervisor, Department of Environmental Engineering
Angelidaki, I., Examiner, Department of Environmental Engineering
Jensen, L. S., Examiner
Kranert, M., Examiner
1/3 DTU-stip, 2/3 FUR/andet
01/03/2006 → 23/09/2009
Award relations: Environmental Assessment of the Management of Garden and Yard Waste
Project: PhD

MicrobStopNH3: Innovative bioaugmentation strategies to tackle ammonia inhibition in an-aerobic digestion process

Fotidis, I., Project Participant, Department of Environmental Engineering, Residual Resource Engineering
Angelidaki, I., Project Manager, Department of Environmental Engineering, Residual Resource Engineering
De Francisci, D., Project Participant, Department of Environmental Engineering, Residual Resource Engineering
01/08/2015 → 31/07/2018
Collaborators: Lemvig Biogasanlæg A.m.b.A.
Project: Research

ElectroAD: Innovative bioelectrochemical-an aerobic-digestion coupled system for ammonia recovery and energy production from ammonia-rich residues

Inhibition of anaerobic digestion process by high levels of ammonia (NH4+/NH3) is the most serious problem existing in Danish biogas plants. No viable/applicable method to overcome this problem has been found up to now. This project proposes an innovative process which integrates bioelectrochemical system (BES) with anaerobic digestion to recover ammonia, and thereby enhance biomethanation of ammonia-rich residues. In this process, ammonia recovery and electricity production will be realized in a novel BES submersed in an anaerobic reactor. Moreover, removal of ammonia from anaerobic reactor will alleviate or counteract ammonia inhibition and enhance the conversion of ammonia-rich wastes to biogas, giving synergistic advantages for both ammonia recycling and increase of biogas production. The system performance and potential limitations will be addressed and technical solutions will be developed.
Zhang, Y., Project Participant, Department of Environmental Engineering, Residual Resource Engineering
Angelidaki, I., Project Coordinator, Department of Environmental Engineering, Residual Resource Engineering
Fotidis, I., Project Participant, Department of Environmental Engineering, Residual Resource Engineering
01/10/2013 → 30/09/2017
Keywords: Bioelectrochemistry, Anaerobic digestion, Ammonia recovery, Bioenergy, Biocatalysis, Wastewater handling, Open land, Sustainability
Project: Research

ECO-India: Energy-efficient, community- based water and wastewater-treatment systems for deployment in India

The overall aim of ECO-India is to design and develop innovative cost-effective solutions for community- based water- and wastewater- treatment systems. These systems will be deployed at pilot sites in arsenic-affected water-stressed regions in
India. The two consortia, Indian (DST) and European (FP7), will establish pilot schemes for: • Catchment area and reservoir management • Surface water supply schemes • Arsenic removal (including monitoring using UFZ’s field-tested Arsolux arsenic sensor) • Disinfection treatment for potable water based on Trustwater’s CE-certified mixed-oxidant generation systems. • Online monitoring of water quality • Water distribution network, together with online/offline water quality monitoring programmes • Sewerage and wastewater treatment. In addition, prototype energy-efficient modules for water deionisation and heavy metal removal will be developed. A feasibility study will be performed to assess the potential for energy harvesting from sludge.

Fotidis, I., Project Participant, Department of Environmental Engineering, Residual Resource Engineering
Angelidaki, I., Project Participant, Department of Environmental Engineering, Residual Resource Engineering

FP7 Contract ID: 308467
18/04/2012 – 18/04/2015
Project: Research

SYMBIO: Integration of biomass and wind power for biogas enhancement and upgrading via hydrogen assisted anaerobic digestion
Kougias, P., Project Participant, Department of Environmental Engineering, Residual Resource Engineering
Luo, G., Project Participant, Department of Environmental Engineering, Residual Resource Engineering
Angelidaki, I., Project Coordinator, Department of Environmental Engineering, Residual Resource Engineering
01/07/2013 → …
Keywords: upgrade, biogas, enhancement
Project: Research

Foaming problems in biogas plants
Kougias, P., Project Participant, Department of Environmental Engineering, Residual Resource Engineering
Boe, K., Project Participant, Department of Environmental Engineering, Residual Resource Engineering
Angelidaki, I., Project Participant, Department of Environmental Engineering, Residual Resource Engineering
01/10/2009 → 30/09/2014
Keywords: foaming, biogas
Project: Research

ElectroAD1: A novel method to recover ammonia from biogas plants
In this project, we will develop an innovative technology to recover inhibitors from anaerobic digestion
Zhang, Y., Project Participant, Department of Environmental Engineering, Residual Resource Engineering
Angelidaki, I., Project Participant, Department of Environmental Engineering, Residual Resource Engineering

Project ID: 30992
01/04/2013 → 31/10/2013
Keywords: Biocatalysis, Biogas, Biohydrogen, Bioelectrochemistry, Monitoring, Control, Bioenergy
Project: Research

An innovative process for simultaneous utilization of hydrogen and in-situ biogas upgrading
This project proposes an innovative process in which hydrogen produced by water electrolysis using excess electricity from wind mills, will be biologically converted by binding CO2 to CH4 in biogas reactors. Simultaneous H2 utilization and in-situ biogas upgrading will be achieved in such process, giving synergistic advantages for both wind mills and biogas plants. The effects of hydrogen on the biochemistry and microbiology of the process, and the technical solutions for improving hydrogen utilization in the biogas reactors will be studied in order to optimize the conversion of hydrogen to methane in biogas reactors. This idea of the current project has never been applied and it offers several advantages: (1) Contributes to cheaper upgrading cost of biogas due to low CO2 content in biogas; (2) Increased energy efficiency by full utilization of the wind mill capacity; (3) Possibility to control electricity production according to the energy demand variations.

Luo, G., Project Manager, Department of Environmental Engineering
Angelidaki, I., Project Participant, Department of Environmental Engineering

Project ID: 30954
01/07/2012 → 30/06/2015
Project: Research

FISH4: FISCH4 – Fish Feed from Food Waste
Food waste represents a large fraction of total produced bio-waste and is composed of raw or cooked food materials generated before, during or after food preparation. It includes vegetable peelings, dairy leftovers products, meat trimmings, and spoiled or excess ingredients or prepared food. Although EU measures intend to prevent the wastage of food, waste treatment processes, such as Anaerobic Digestion (AD), are necessary to handle non-edible food waste. Implementation of AD for treating food waste in Europe has increased at a large pace. The overall objective of FISCH4 is the demonstration of a novel biotechnological process that converts food waste (especially of plant and dairy origin) into fish feed ingredients, using unpurified biogas (CH4, CO2, H2S) as intermediate. The two step process involves: (i)
anaerobic digestion of food waste for biogas production, with a focus on process application and not on fundamental research and, (ii) biogas conversion by mixed methanotrophic/ heterotrophic/sulfidotrophic biomass (here referred as mixed biomass – MB), using unpurified biogas containing CO2, CH4 and H2S and the liquid fraction of the anaerobic digester effluent, as source of carbon, energy and nutrients (Figure 1). Although the methanotrophic reactor will be designed and operated to maximize the utilization of methane from the biogas, applying e.g. high pressure and biogas recirculation, there will be a fraction of remaining biogas that can be used for energy production. The concept is envisaged for large-scale biogas plants where the biogas and the liquid effluent can be pumped to a separate industrial unit for MB production. Biogas remaining unused in the biological process will be used for electricity/biogas production after upgrading. The co-production of energy will be evaluated through energy balances that will assess the possibility of turning the process energetically self-sufficient. Economic viability; environmental performance, including, but not limited to, low greenhouse gas (GHG) emissions over the complete life cycle (LC), and social acceptability, the three sets of criteria usually recognized as the tests for sustainability, will be assessed in the project. FISCH4 consortium gathers expertise on biotechnological processes, biogas processes, microbiology, food quality and safety, aquaculture and fisheries and environmental social and economic life cycle assessment. The consortium of 7 academic and 4 SME from 6 European countries and one participant from India has the scientific, technical and management expertise to promote an efficient transfer of lab-scale results into a novel industrial product that will contribute for the development of the EU sustainable economy. Figure 1

Angelidaki, I., Project Manager, Department of Environmental Engineering
Ukendt: DKK0.00
01/01/2013 → 31/12/2017
Award relations: FISCH4 – Fish Feed from Food Waste
Project: Research

KOMBI-cultivation: Integrated aquaculture of fish, seaweed, and mussels for feed and food
Projektets grundidé er at muliggøre en femdobling af havbrugsproduktionen i Danmark og sikre erhvervets internationale konkurrencedygtighed uden at belaste vandmiljøet med kvælstof (N), samtidig med at der udvikles et forretningsområde baseret på produktion af tang til konsum og muslinger til foder.

Angelidaki, I., Project Participant, Department of Environmental Engineering
Ukendt: DKK0.00
01/01/2012 → 31/03/2015
Award relations: KOMBI-cultivation: Integrated aquaculture of fish, seaweed, and mussels for feed and food
Project: Research

SAO-Dom: Innovative biogas process for treating ammonia-rich wastes
One of the main causes for imbalance and low substrate utilization in Danish biogas plants is the high ammonia load. Ammonia is mainly inhibiting acetate-utilizing (acetoclastic) methanogens. There is however, another metabolic pathway, the acetate oxidation pathway, where acetate is oxidized by syntrophic acetate oxidizing bacteria (SAO) to hydrogen and carbon dioxide, followed by hydrogenotrophic methanogenesis, which is much less liable to ammonia inhibition. Up to now, six SAO bacteria have been identified and five of them were classified as acetogenic bacteria. Acetogenic bacteria are following the reductive Wood-Ljungdahl pathway to produce acetate as basic end-product. Acetogenic SAO bacteria, under high ammonia conditions, use reversed Wood-Ljungdahl pathway to syntrophically convert acetate to methane in association with hydrogenotrophic methanogens. These findings are a strong indication that reversed Wood-Ljungdahl pathway of SAO bacteria has significant role in methanogenesis of high ammonia containing waste. In the current project we’ll develop a new approach to avoid or counteract ammonia inhibition and optimize the anaerobic digestion of ammonia-rich wastes. The main objective of the project is to establish a process promoting acetate oxidation, for optimal digestion of ammonia rich waste. A pilot scale bioreactor digesting ammonia-rich wastes will implement, for further process development.

Angelidaki, I., Project Participant, Department of Environmental Engineering
Ukendt: DKK0.00
01/01/2012 → 31/12/2015
Award relations: Innovative biogas process for treating ammonia-rich wastes
Project: Research

MAB: The MacroAlgae Biorefinery
The MacroAlgae Biorefinery
Angelidaki, I., Project Participant, Department of Environmental Engineering
Karakashev, D. B., Project Participant, Department of Environmental Engineering
Ukendt: DKK0.00
01/01/2012 → 31/12/2015
Award relations: The MacroAlgae Biorefinery
Project: Research
JuniorOchre: Concept proof of usability of ocher as a source of iron in wastewater treatment
Confidential
Mikkelsen, P. S., Project Participant, Department of Environmental Engineering
Angelidaki, I., Project Participant, Department of Environmental Engineering
Andersen, H. R., Project Manager, Department of Environmental Engineering
Project ID: 30771
Ukendt: DKK250,000.00
15/03/2010 → 01/02/2011
Award relations: Concept proof of usability of ocher as a source of iron in wastewater treatment
Project: Research

Thalis: Thalis
The objective of the research project will be to investigate the fate of emerging organic micropollutants during wastewater and sludge treatment and to study their fate in the aquatic environment. The title of the proposed research project will be "Investigation of emerging organic micropollutants fate during wastewater treatment and study of their behaviour during treated wastewater disposal into the aquatic environment". The budget of this proposal is 480.000 Euros and its duration is 4 years. The specific objectives of this project are as follows: a) to study the fate of several emerging micropollutants such as PFCs, EDCs, pharmaceuticals, benzotriazoles in different treatment processes (activated sludge, anaerobic digestion, chlorination), b) to study the fate of these compounds in aquatic environment after treated wastewater disposal (role of photodegradation, biodegradation, sorption) and c) to investigate the formation of metabolites of selected micropollutants using LC-MS MS techniques
Angelidaki, I., Project Participant, Department of Environmental Engineering
Andersen, H. R., Project Manager, Department of Environmental Engineering
Ukendt: DKK0.00
01/07/2010 → 30/06/2014
Award relations: Thalis
Project: Research

Titration-VFA: Optimization of a titration method for monitoring of VFA
ForskEL contract no. 2009-1-10231
Angelidaki, I., Project Manager, Department of Environmental Engineering
Boe, K., Project Participant, Department of Environmental Engineering
Project ID: 30736
Ukendt: DKK814,000.00
01/11/2009 → 31/10/2010
Award relations: Optimization of a titration method for monitoring of VFA
Project: Research

Ammonia: Optimal digestion of high ammonia containing wastes
The main objective of the project is to develop a process promoting acetate oxidation, for optimal digestion of high ammonia containing wastes. More specifically with this project we are aiming to: -Investigate the extent of acetate oxidation in full scale biogas plants; and identify the environmental conditions promoting acetate oxidation on the cost of acetoclastic methanogenesis. -Identify best process configuration (temperature, hydraulic retention time, organic loading rate, concentration of ammonia and volatile fatty acids) promoting high syntrophic acetate oxidation activity -Enrich, isolate, characterize and identify acetate oxidising microorganisms; -Find cultures with highest potential for syntrophic acetate oxidation in order to reach maximum exploitation level of the results in the energy sector
Angelidaki, I., Project Participant, Department of Environmental Engineering
Karakashev, D. B., Project Manager, Department of Environmental Engineering
Project ID: 30795
Ukendt: DKK1,859,300.00
01/01/2010 → 31/12/2011
Award relations: Optimal digestion of high ammonia containing wastes
Project: Research

SMFC: Submersible Microbial Fuel Cell (SMFC) for electricity production from wastewater
MFC is a novel technology that can generate electricity directly from organic compounds. It has been known for several years that bacteria can be used to generate electricity that can be harvested in microbial fuel cells (MFCs). An innovative MFC for direct conversion of organic material to electricity has been invented at DTU-Environment, and the patent application was submitted in 2007. The main purpose of the present project is therefore to optimize the SMFC and to upscale it to a small pilot scale in order to demonstrate and validate the optimized SMFC technology for treatment of real wastewaters.
Angelidaki, I., Project Manager, Department of Environmental Engineering
Ukendt: DKK0.00
946: Flow cytometer and UV-laser for Confocal Laser Scanning Microscope

The Flow cytometer will increase our options in cell quantification and the UV-laser for the Confocal Laser Scanning Microscope will enhance our possibilities in terms of direct observations of methanogens and of using tags and labels excited by UV-light.

Albrechtsen, H., Project Participant, Department of Environmental Engineering
Henze, M., Project Participant, Department of Environmental Engineering
Jakobsen, R., Project Participant, Department of Environmental Engineering
Angelidaki, I., Project Participant, Department of Environmental Engineering
Smets, B. F., Project Manager, Department of Environmental Engineering
Dechesne, A., Project Participant, Department of Environmental Engineering

Ukendt: DKK0.00

02/03/2009 → 31/12/2009
Award relations: Flow cytometer and UV-laser for Confocal Laser Scanning Microscope
Project: Research

958: High rate algal biomass production for food, feed, biochemicals and biofuels

Increased population, shortage of fossil fuels and climatic changes constitute global challenges demanding actions and strategic planning for securing access of food, feed and energy supply in the future. Therefore, alternative biomass sources are needed. Algal biomass for production of food, feed, biochemicals and biofuels offers a great potential for meeting the future challenges. Algae possess numerous possibilities that have so far not been exploited. With the proposed project we are going to: • Develop promising technologies for production of alginates, polyunsaturated fatty acids, β-carotene, and sterols that can be used as functional food. • Develop technologies for production of pigments like fucoxanthin and other high value chemicals like chlorophyll a and c, beta-carotene and other xanthophylls from brown algae. Additionally, technologies for production of other high value chemicals such as vitamins, toxins, enzymes etc. will be developed. • Develop technologies for utilisation of algae (both micro and macro algae) with high growth rates for biomass production for production of bioenergy (hydrogen, methane, ethanol, and biodiesel). • Optimise algae cultivation conditions for increased biomass production, including development of a algae cultivation rotation system. • A new concept integrating biofuel production with algae cultivation, based on recycling of CO2 from the exhaust gas from gas motors for autotrophic algae growth and recycling of process effluents as nutrients for promoting algal biomass growth will be developed. • Develop an innovative bioflocculation method for sustainable harvesting of microalgae. • Investigate algae as biofertilisers for promotion of rice, wheat growth. • Evaluate the sustainability of utilisation of algae for food, feed and biofuels production.

Angelidaki, I., Project Manager, Department of Environmental Engineering
Karakashev, D. B., Project Participant, Department of Environmental Engineering

Project ID: 30747
Ukendt: DKK 4,957,776.00

01/01/2010 → 31/12/2012
Award relations: High rate algal biomass production for food, feed, biochemicals and biofuels
Project: Research

AQUATERRE: Integrated European Network for biomass and waste reutilisation for Bio-products

AquaTERRE will promote the cooperation between research centres, business and other stakeholders in Europe devotedunification of efforts and the exchange of knowledge and expertise between partners, to promote the creation of networks for improving biomass and waste reutilisation. Mainly, AquaTERRE aims to make an inventory of existing biomass feedstock in Europe and quantify the potential and to the research, development and application of biomass and biofuel production and valorisation. It will aim integration and identify the best ones. In addition, to study the best possibilities for implementing different biomass sources in different environments to improve their utilisation. Pursuing this target, literature and data survey and current research review will be carried out. Furthermore, the scope of AquaTERRE consists also in mapping European biomass feedstock using different tools as Geographical Information System (GIS). Additionally, AquaTERRE expert members will identify economic and environmental impacts schemes to define the optimum Life Cycle Assessment (LCA). LCA is a standardized and structured method for calculation the environmental load of a product, process or activity throughout all its phases. The implementation of a new bioproduct / biofuel in the market requires the analysys of economical, social and environmental aspects, with the objective of attaining enough information for the decision making progress. The contribution of LCA study to this project can be framed in the identification of best sources of biomass feedstock as well as other agricultural waste for the sustainable obtaining of biofuels and other added value products.

Angelidaki, I., Project Participant, Department of Environmental Engineering
Karakashev, D. B., Project Participant, Department of Environmental Engineering

Project ID: 30618
Ukendt: DKK 334,000.00
EnGreenCIE: INTERREG IVC
The basic idea of the project is to determine the good practices and to design the best policy, which successfully tackle the problem of waste prevention and management for the benefit of regional/local communities not only of the participating but all the EU countries. Many regional/local authorities, with weak knowledge endowments, are confronted with the challenge of supporting the Green concept in environment. However, the ability of local authorities to facilitate or underpin the necessary knowledge transfer from universities with the help of national/regional agencies definitely assists the implementation of ETAP at the participating regions. So, providing the aforementioned background, the main project objective is to enhance the interaction between universities and local authorities, with the aim of facilitating knowledge exchange that can lead not only to increased environmental consciousness but also to the adoption of actions and mechanisms through a solid action plan.
Angelidaki, I., Project Participant, Department of Environmental Engineering
Karakashev, D. B., Project Participant, Department of Environmental Engineering

ForskEL: Fuldskala demonstration og dokumentation mv. af seriedrift på gyllebaseret biogasfællesanlæg (Lemvig Biogas)
Se attachment
Angelidaki, I., Project Manager, Department of Environmental Engineering
Project ID: 30612
Ukendt: DKK242,000.00
01/04/2008 → 01/06/2009
Award relations: Fuldskala demonstration og dokumentation mv. af seriedrift på gyllebaseret biogasfællesanlæg (Lemvig Biogas)
Project: Research

903: Biorefinery for sustainable Reliable Economical Fuel production from energy crops. Second call.
Biorefinery systems use one species or one category of plants to produce bio-based products and energy. An advanced biorefinery system should be able to use different biomass feedstock as well as to produce a wide range of high-value products, in order to be environmental, economic and social sustainable and to have flexibility for changes. These can not be achieved by the "traditional" biorefinery systems, because one plant species is used and for this reason, the biomass supply is not secured and a limited range of bio-products are produced. Moreover, "traditional" biorefineries systems with one culture can not be eco-sustainable in contrast to an advanced polyculture biorefinery. Sustainability and polyculture are interrelated for the following reasons: a) the diversity of crops avoids the susceptibility of monocultures to disease and pest problems, b) cropping systems that include a variety of crops replenish nitrogen (if legumes are included) and use resources such as sunlight, water, or nutrients more efficiently and c) biodiversity is protected in polyculture. Therefore, there is a need for more eco-efficient polyculture biorefinery system. Our proposed biorefinery system uses oilseed crops, as the main biomass feedstock, in combination with other species of plants, especially, from the family Leguminosae (legumes), due to the advantages that this combination offers to the sustainability of the whole system. Also, this combination will eliminate the disadvantages that separately each crop could give in a biorefinery system. Two different biorefinery systems "oilseed biorefinery" and "green biorefinery" injected with new ideas and innovative processes will be integrated into a new advance and sustainable biorefinery system, namely Eco-BioREF, to achieve a breakthrough beyond the "business as usual" scenario. The present project is aiming at the development of a sustainable, novel, technically and economically viable biorefinery for conversion of the biomass -oilseed plants and legumes- into a diverse range of biofuels, food and high-value added chemicals. This will be achieved by overcoming the identified, critical process bottlenecks in the biomass supply chain and by improving the refining section.
Angelidaki, I., Project Participant, Department of Environmental Engineering
Karakashev, D. B., Project Participant, Department of Environmental Engineering
Ukendt: DKK0.00
01/01/2010 → 31/12/2013
Award relations: Biorefinery for sustainable Reliable Economical Fuel production from energy crops. Second call.
Project: Research

896: START-funding II. Preparation of EU project proposal "Biorefinery for sustainable Reliable Economical Fuel production from energy crops" (Acronym: BioREF)
With this project we apply money for formulation, preparation and organization of an EU application under the 7th EU framework programme within "FP7, Cooperation, Theme 2, Food, Agriculture, Fisheries and Biotechnologies, area 2.3.7. BIOREFINERY joint call, call identifier FP7-2009-BIOREFINERY."
conditions for optimal hexose and pentose fermentation to ethanol. More specifically we aim to: enrich, isolate and ethanol yields and low ethanol tolerance. The overall goal of this project is to screen and select microorganisms for industrial process. On the contrary all known pentose utilizing wild-type microorganisms were characterized with low human health and environment protection. High efficient microbial conversion of hexoses to ethanol is a well developed application of the recombinant microbial strains for bioethanol production is still restricted by legislations with respect to (native) microorganisms that are able to efficiently ferment pentoses and hexoses with high tolerance to ethanol. Industrial challenge for sustainable 2nd generation bioethanol production from lignocellulose.

CLEANWASTE: Clean and environmentally friendly animal waste technologies for fertilizer and energy production
This project aims to research and develop novel, environmentally friendly technologies which from livestock manure can recover the nitrogen (N) and phosphorous (P), in the form of marketable fertilizers. Energy production technology is optimally an integrated part of manure management systems and is included as an important, but minor R&amp;D activity. Animal manure contains large amounts of plant nutrients and organic carbon, which if left untreated, may potentially pollute surface waters and is a source of greenhouse gases (GHG), ammonia (NH3) and odour. Phosphorous (P) is a very limited global resource which has a supply horizon of 60-130 years. Continuously wasting this limited plant nutrient resource constitutes a risk to the global feed and food supply. The energy rich organic material may supply 3-4% of the Danish energy consumption. Novel technologies for sustainable management and utilisation of animal manure and biowaste are necessary because the continued increase in specialisation and scale of operation of animal farms makes it difficult to comply with new environmental regulations of waste management on limited land, and attractive due to the rapidly increasing prices on the resources of fuels and fertilisers. The vision of this project is to i) develop unit operations to treat slurry and recover plant nutrients into marketable products and ii) to integrate environmental, nutrient recovery and bioenergy technologies for animal manure and biowaste processing in a whole system approach to ensure cost-effectiveness. The project will provide verified analyses (systems modelling, life cycle assessment (LCA), environmental economics) on the impact of these new environmentally friendly bio-energy technologies. This is needed for policy making as well as when marketing on a rapidly growing world market for cleantech.

Bio-hydrogen is a CO2-neutral energy source with very promising perspectives, as an alternative to fossil fuels for future energy production. Hydrogen can be produced from organic waste, i.e. utilizing an otherwise undesirable burden to society, as a useful raw material for production of fuel for road vehicles or for production of electricity. Biohydrogen production through conventional fermentation has a serious disadvantage, limited by a maximum hydrogen production of only 33% of the energy content in the organic material. A new method, where electricity is assisting the biological process to overcome its limitations and fully recover the energy in the organic matter in the form of hydrogen, has recently been discovered. The method is however in it infancy and requires expensive membranes which makes the application of such technology not practically feasible. Preliminary results at the DTU-Environment indicate however, that membranes-free anaerobic environment can be used for hydrogen production from organic matter. The aim with this project is to investigate possibilities for develop an efficient and economic process for electricity assisted biological hydrogen production. With the proposed project we intent to: - disclose the fundamental biological process for the fully oxidation of organic matter to hydrogen and carbon dioxide by electrically assisted hydrogen fermentation - evaluate the parameters important for bihydrogen production in an anaerobic reactor - Develop an innovative process configuration, with membrane-free reactors, for efficient biohydrogen production - Evaluate the process by system analysis.

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identify a number of wild-type ethanologens with high ethanol tolerance and ability for high rate fermentation of both
hexoses and pentoses; -identify optimal process conditions for bioethanol production from real lignocellulosic hydrolysate;
-demonstrate bioethanol production with selected microorganisms in pilot scale conditions
Angelidaki, I., Project Participant, Department of Environmental Engineering
Karakashev, D. B., Project Participant, Department of Environmental Engineering

**Foaming: Foaming problems in biogas plants**

Biogas has never anist as yet the mainstream for which bioconversion and conversion and is not the economically viable process for conversion of whole plant biomass into a diverse range of biofuels, foods and high-value added chemicals from a single feedstock, rapeseed. This will be achieved by overcoming the identified, critical process bottlenecks of present rapeseed – to- biodiesel, -bioethanol, -biohydrogen, -biogas, and high value-added products conversion technologies. The project aims at an innovative biorefinery process approach focusing on 1) Field studies to investigate and optimize rapeseed crop production, harvesting, storage and transport, 2) Laboratory scale studies devoted to the rapeseed oil extraction, production of high value-added chemicals from oilseed bioprocesing, development of new enzymatic transesterification process for biodiesel production, pre-treatment and enzymatic hydrolysis of cellulose and hemicellulose for downstream bioconversion to bioethanol and biohydrogen, 3) Pilot scale study at DTU to optimize a two steps process for biohydrogen and biomethane production from the process wastewaters, 4) Supply chain analysis based on Life-Cycle – assessment methodologies for comparison of different process chains from well to product. Sensitivity analysis will be devoted to determine bottlenecks for different processes. Additionally, key emissions and/or resource consumption data related to the individual processes will be identified for further optimization of the overall biorefinery concept, 5) Demonstration of the final biorefinery concept at DONG existing infrastructure.

Angelidaki, I., Project Manager, Department of Environmental Engineering
Karakashev, D. B., Project Participant, Department of Environmental Engineering
Boe, K., Project Participant, Department of Environmental Engineering

**BIOREF: Biorefinery for sustainable Reliable Economical Fuel production from energy crops. First call.**

The project focuses on development of a novel, technically and economically viable process for conversion of whole plant biomass into a diverse range of biofuels, foods and high-value added chemicals from a single feedstock, rapeseed. This will be achieved by overcoming the identified, critical process bottlenecks of present rapeseed – to- biodiesel, -bioethanol, -biohydrogen, -biogas, and high value-added products conversion technologies. The project aims at an innovative biorefinery process approach focusing on 1) Field studies to investigate and optimize rapeseed crop production, harvesting, storage and transport, 2) Laboratory scale studies devoted to the rapeseed oil extraction, production of high value-added chemicals from oilseed bioprocesing, development of new enzymatic transesterification process for biodiesel production, pre-treatment and enzymatic hydrolysis of cellulose and hemicellulose for downstream bioconversion to bioethanol and biohydrogen, 3) Pilot scale study at DTU to optimize a two steps process for biohydrogen and biomethane production from the process wastewaters, 4) Supply chain analysis based on Life-Cycle – assessment methodologies for comparison of different process chains from well to product. Sensitivity analysis will be devoted to determine bottlenecks for different processes. Additionally, key emissions and/or resource consumption data related to the individual processes will be identified for further optimization of the overall biorefinery concept, 5) Demonstration of the final biorefinery concept at DONG existing infrastructure.

Angelidaki, I., Project Participant, Department of Environmental Engineering
Karakashev, D. B., Project Manager, Department of Environmental Engineering

**796: START-funding I. Preparation of international proposal**

Application for grant to organize and formulate an application for the call FP7-KBBE-2007-2A within the Program "FP7, Cooperation, Theme 2, Food, Agriculture, Fisheries and Biotechnologies" together with partners from Denmark, Greece, Ireland, Poland, Sweden, and Germany (Table 1). The project application will be based on an iirst stage application that was submitted in EU with the applicant as coordinator. The final project is intended to last for a period of 4 years with a joint budget of approximately 5.5 million EUR. DTU as the coordinator is expected to receive 1 million EUR as part of the
761: Optimization of Microbial Fuel Cells via Directed Bio-Electricigenesis
One of the global trends in applied energy systems R&D encompasses electricity generation using renewable sources, such as microbial biofilm-powered fuel cells, where electrical energy is directly obtained from biochemical reactions. Although this microbial ability to generate electrons has been revealed for a long time, the achieved process understanding has been insufficient to optimize microbial fuel cells (MFCs) into efficient and practical power generators. The present proposal’s primary goal is to achieve more efficient energy conversions in MFCs, by establishing and then manipulating the relationship between properties of the microbial biofilms—which develop in the MFCs’ anodic compartment—and power generation. We contend that the biofilm structure and its architecture have a direct influence on the electric properties of the MFCs (by means of diffusional limitations and current transfer restrictions). These causal relationships will be determined. Directed bio-electricigenesis is proposed, which consists of manipulating and controlling biofilm properties (i.e. mass transport limitation, biofilm heterogeneity and distribution control) to maximize electroactive sites and hence improve power generation. Electrochemical studies are therefore proposed to allow real time monitoring of the systems’ bio-electrochemical response and to establish the relationship between biofilm properties and electron transfer performance (e.g. the current transfer distribution), which establish current generation in the MFCs. The electrochemical response will be measured using electrochemical impedance spectroscopy (EIS) and will be analyzed using a transmission-line approach, from which the biogenically-induced current transfer distributions will be determined. In addition, the biofilm structure and architecture heterogeneities which establish in the novel-design MFCs will be experimentally manipulated, measured using advanced microscopic techniques (i.e. confocal laser scanning microscopy) and microelectrodes, and predicted using a new Individual Based Modelling platform for Microbial Interactions (iDynoMiCs). In summary, this proposal will combine knowledge on microbial fuel cells, biofilm structural modelling, advanced microscopic and techniques and electrochemical monitoring to operate and investigate novel microbial fuel cells based on anodic biofilms, where biofilm structure can be predicted and manipulated in order to rigorously establish the relationships between biofilm properties and electrochemical behaviour of MFCs, leading to MFCs that can obtain significantly higher energy transfer efficiencies via directed bio-electricigenesis.

 Angelidaki, I., Project Participant, Department of Environmental Engineering
Smets, B. F., Project Participant, Department of Environmental Engineering
Karakashev, D. B., Project Participant, Department of Environmental Engineering

Project ID: 30576
Ukendt: DKK264,600.00
01/11/2007 → 18/02/2008
Award relations: START-funding I. Preparation of international proposal “Biorefinery for sustainable Reliable Economical Fuel production from energy crops” (Acronym: BioREF)
Project: Research

777: Biorefinery for Fuel production from energy crops
Sustainable use and production of renewable bio-resources is one of the key instruments for achieving the goal of 20% CO2 reduction that the European Community is aiming by year 2025 At the same time decrease of fossile fuels dependency and boosting of the rural development in Europe will be achieved. To gain full benefits from biomass conversion it is important to utilise all parts of biomass in an integrated process scheme by a multi-product scheme, so called “biorefinery”. By producing multiple products (bioenergy and green chemicals), through an integrated process the differences in biomass components and intermediates can be exploited and maximize the value derived from the biomass and thus achieve a competitive economy. This project will investigate and develop an integrated and innovative whole crop approach to produce a multi-product biofuel (ethanol, biohydrogen, methane, biodiesel) and high-value products (glucosinolates, high-quality proteins rich in lysine and methionine etc.) from oily plants based on a number of novel and mutually synergistic production methods. The evaluation criteria assisting the development of the biorefinery concept will be based on an feed forwards and backwards assessment of the economical and environmental benefits and drawbacks related to the concept. With the proposed project we intent to: Optimise harvest, transportation logistics of oily plants to the biorefinery facilities and return the process effluents to be used as fertilisers on the agricultural soil. From the oil part of the plant biodiesels will be produced, by a new enzymatic transesterification method. High value products such as glucosinolates, high value proteins etc. extracted from the press cake will be compared with alternative utilizations From the straw part of the oily plant a chain of processes will result in bioethanol production (from hexoses), biohydrogen (from pentoses) and finally, effluents from different processes will be treated by anaerobic digestion for methane production. To document the level of sustainability, identify key environmental impacts, and evaluate market implementation aspects, the individual process as well as the combined biorefinery concept will be evaluated through life cycle assessment methods as well as with respect to process economy. The results from the above research will be used to demonstrate an integrated biorefinery operation for producing biofuels and high-value products from rapeseed or oilseed with a processing/marketing link between agriculture and industry.

Angelidaki, I., Project Manager, Department of Environmental Engineering
**Microorganisms:** Microbial community structure related to process conditions: a challenge for improving performance of anaerobic digesters

Anaerobic digestion is a technology for producing renewable energy as methane, used widely in the EU. Anaerobic degradation of organic matter is a complex process mediated by microbial communities. The process can be affected by many factors, including operational conditions and feed composition. The microbes mediating the process have generally been well described in terms of phylogeny and function. However, the link between microbial populations, operational parameters, and anaerobic reactors performance is not well established. This link can be used for development of strategies aiming to improve the anaerobic digestion process. Optimization of anaerobic digestion process is expecting to result in considerable reduction of environmental pollution combined with increase in renewable energy production. It will make contributions to the objectives of the overall EU research program, human society, industry, and natural sciences in general. The overall goal of the project proposed is to relate the microbial community composition to biogas reactor process parameters in order to improve anaerobic digesters performance. More specifically we will: - identify the key microorganisms mediating the anaerobic digestion in variety of biogas producing systems; - elucidate the influence of process parameters on the microbial diversity; - use structured mathematical modeling for quantitatively assessment of the link between microbial community structure and operational conditions; - identify microbial markers for best digesters performance with respect to maximal biogas production and organic matter removal; - develop and demonstrate the practical applicability of a strategy for improvement of anaerobic digestion process performance via manipulation of microbial community composition in biogas reactors. The project aims will be achieved by laboratory work and data collection through the industrial contacts of the applicant which will promote future collaboration between the applicant and cooperative partners throughout the Europe.

Angelidaki, I., Project Participant, Department of Environmental Engineering
Karakashev, D. B., Project Participant, Department of Environmental Engineering

Ukendt: DKK0.00
01/01/2008 → 31/12/2010
Award relations: Microbial community structure related to process conditions: a challenge for improving performance of anaerobic digesters
Project: Research

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**356: SAFEWATER. Hazardous chemicals and micro-organisms in urban water management.**

Proposal to Marie Curie Host Fellowships for Early Stage Research Training (EST) No funding!

Eilersen, A. M., Project Participant, Department of Environmental Engineering
Ledin, A., Project Manager, Department of Environmental Engineering
Arvin, E., Project Participant, Department of Environmental Engineering
Albrechtsen, H., Project Participant, Department of Environmental Engineering
Schmidt, J. E., Project Participant, Department of Environmental Engineering
Christensen, N., Project Participant, Department of Environmental Engineering
Mikkelsen, P. S., Project Participant, Department of Environmental Engineering
Angelidaki, I., Project Participant, Department of Environmental Engineering

Ukendt: DKK0.00
01/01/2003 → 02/01/2003
Collaborators: WaterTech A/S
Award relations: SAFEWATER. Hazardous chemicals and micro-organisms in urban water management.
Project: Research

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**338: Start-programmet. Improved monitoring and control of the biogas process for reliable efficient and cost-effective energy production.**

Start-programmet

Angelidaki, I., Project Manager, Department of Environmental Engineering
Project ID: 30270
Ukendt: DKK5,200.00
20/01/2003 → 20/03/2003
Award relations: Start-programmet. Improved monitoring and control of the biogas process for reliable efficient and cost-effective energy production.
Project: Research

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**287: Development bioprocesses for handling and recycling seasonal industrial wastewaters.**

Food processing and other industries typically generate wastewaters that contain a high organic content. An optimal basic treatment for such wastewater could be anaerobic digestion, a process, on top of significantly reduction of the organic...
matter, can generate biogas. The proposed work will: -examine the characteristics of seasonally produced wastewater - investigate the co-digestibility of these wastewaters from a kinetic and microbial point of view -determine the optimal planning and scheduling for digestion process -investigate alternative digesters types, configurations and designs for flexibility -evaluate overall processes that exploit fully the by-products of anaerobic digestion

Schmidt, J. E., Project Manager, Department of Environmental Engineering
Angelidaki, I., Project Participant, Department of Environmental Engineering

Award relations: Development bioprocesses for handling and recycling seasonal industrial wastewaters.
Project: Research

Pig farming is a major EU agricultural industry, with about 300 million tons of manure produced annually by the SME farmers. This is a major environmental problem, resulting in severe pollution of ground water and eutrophication of surface waters due to high nitrate, ammonia and phosphate emissions. This project provides an integrated solution using a combination of innovative technologies, thereby enabling the farmers to attain environmental compliance with the IPPC, and Waste directives. The project develops UASB technology for a digester, combined with dilution by Brammox effluent to prevent ammonia and sulphur inhibition. C-digestion with several other organic wastes will improve biogas output. The Anphos process will remove phosphate as struvite, as well as ammonia removal with precipitation of the non-digested solids. The Brammox process will be used for the first time for the removal of ammonia from the digested pig manure.
PIGMAN will develop nitrification/denitrification in an activated sludge process combined with ultra filtration membranes (Biomembrane process).

Schmidt, J. E., Project Participant, Department of Environmental Engineering
Angelidaki, I., Project Manager, Department of Environmental Engineering
Karakashev, D. B., Project Participant, Department of Environmental Engineering

Project ID: 30452
Forsk. EU - Rammeprogram: DKK900,975.00
01/01/2006 → 31/12/2007
Collaborators: SELOR eeig, Hegndal svineproduktion, Colsen BV, WasteMan, Lahav C.R.O, KAILAS&SONS LTD, University of Ioannina, Knops pork B.V., ROL-KON Spolka z o.o, Ghent University
Award relations: A sustainable solution for pig manure treatment: Environmental compliance with the Integrated Pollution Prevention and Control directive. Contract COOP-CT-2005-017641
Project: Research

Dansk-Indisk samarbejde: Maximization of gaseous energy recovery by simultaneous biohydrogen production and biomethanation.
Maximization of gaseous energy recovery by simultaneous biohydrogen production and biomethanation.

Angelidaki, I., Project Manager, Department of Environmental Engineering

Project ID: 30491
Ukendt: DKK25,000.00
03/06/2006 → 31/12/2007
Award relations: Maximization of gaseous energy recovery by simultaneous biohydrogen production and biomethanation.
Project: Research

Mikrobiel fysiologi og økologi.

Angelidaki, I., Project Participant, Department of Biotechnology

Project ID: 30423
Ukendt: DKK1,700,000.00
01/01/2006 → 31/12/2008
Collaborators: Riso National Laboratory
Award relations: Mikrobiel fysiologi og økologi.
Project: Research

MFC-Risø: MFC-Risø. Microbial fuel cell - used in direct conversion of lignocellulosic waste to energy.

Angelidaki, I., Project Manager, Department of Environmental Engineering

Project ID: 30423
Ukendt: DKK1,700,000.00
01/01/2006 → 31/12/2008
Collaborators: Riso National Laboratory
Award relations: MFC-Risø. Microbial fuel cell - used in direct conversion of lignocellulosic waste to energy.
Project: Research
PSO - VFA: PSO-VFA. Anvendelse af online fedtsyresensor for at kontrollere og optimere anaerob processen for lav omkostnings biogas fra gyllen.
Angelidaki, I., Project Manager, Department of Environmental Engineering
Boe, K., Project Participant, Department of Environmental Engineering
Project ID: 30441
Ukendt: DKK1,660,700.00
01/03/2006 → 29/02/2008
Award relations: PSO-VFA. Anvendelse af online fedtsyresensor for at kontrollere og optimere anaerob processen for lav omkostnings biogas fra gyllen.
Project: Research

563: Indsamling og systematisering af den eksisterende viden om gaspotential i forskellige typer biomasse og afgrøder.
Angelidaki, I., Project Manager, Department of Environmental Engineering
Hejnfelt, A., Project Participant, Department of Environmental Engineering
Project ID: 30361
Ukendt: DKK48,750.00
01/11/2004 → 30/04/2005
Award relations: Indsamling og systematisering af den eksisterende viden om gaspotential i forskellige typer biomasse og afgrøder.
Project: Research

561: Udvikling af innovativ proces for udnyttelse af biomasse til produktion af brint og biogas
Angelidaki, I., Project Manager, Department of Environmental Engineering
Sam.arb.aftaler, Private danske - Fonde: DKK750,000.00
21/03/2005 → 31/01/2006
Award relations: Udvikling af innovativ proces for udnyttelse af biomasse til produktion af brint og biogas
Project: Research

CONTROL-AD4H2: CONTROL-AD4H2. Control of Anaerobic Digestion Processes for Optimisation of Hydrogen Production
Hydrogen can be biological produced from organic wastes by several methods among which anaerobic fermentation is a very attractive one. However, the main obstacles in bio-hydrogen application as industrial process are the low yields and non-optimized process. This project focuses on these points studying the following main objectives: 1. Identify important parameters influencing metabolic pathways for optimal hydrogen production 2. Compare the different modelling approaches available in the literature for anaerobic digestion processes and include the hydrogen pathways. 3. Investigate process configurations for maximising energy output of combined biogas (as first priority) and biogas (as second priority) in a combined treatment process. 4. Develop appropriate control laws to optimise hydrogen and biogas production.
Angelidaki, I., Project Manager, Department of Environmental Engineering
Steyer, J., Project Participant, Department of Environmental Engineering
Project ID: 30380
Forskningsprojekter - Miljø- og Energiministeriet: DKK973,720.00
01/02/2005 → 31/01/2006
Award relations: CONTROL-AD4H2. Control of Anaerobic Digestion Processes for Optimisation of Hydrogen Production
Project: Research

EFP05-Biogas-ustabilitet: Process imbalance in biogas plants and strategies for prevention and reestablishment of process stability. EFP05
Angelidaki, I., Project Manager, Department of Environmental Engineering
Project ID: 30384
Forskningsprojekter - Miljø- og Energiministeriet: DKK1,878,000.00
01/03/2005 → 01/05/2008
Award relations: Process imbalance in biogas plants and strategies for prevention and reestablishment of process stability. EFP05
Project: Research

BioHydro: Hydrogen from biomass. START-programme.
A grant to organize and formulate an application for a "Specific Targeted Research Project (STRP)" of the 6. Framework Programme.
Angelidaki, I., Project Manager, Department of Environmental Engineering
415: Biogas Forum Øresund. (INTERREG IIIA Øresundregionen)
Formålet er at etablere et netværk bestående af universiteter, virksomheder, rådgivere og offentlige myndigheder for at fremme funktionaliteten og forøge anvendelsen af biogas i regionen (Øresund) til gavn for samfundet og miljøet.
Angelidaki, I., Project Manager, Department of Environmental Engineering
Boe, K., Project Participant, Department of Environmental Engineering
Hejnfelt, A., Project Participant, Department of Environmental Engineering

397: Monitoring of the anaerobic biogas process by on-line VFA measurement
Development of on-line VFA meter based on gas phase gas chromatographic analysis of VFA, VFA and other parameters are evaluated as indicators for the biogas process. Advanced control based on several process parameters will be developed.
Angelidaki, I., Project Manager, Department of Environmental Engineering
Boe, K., Project Participant, Department of Environmental Engineering
Batstone, D. J., Project Participant, Department of Environmental Engineering

The main objective is to investigate and suggest methods for increasing the biogas yield in manure based biogas plants with focus on the following 3 areas: 1)to investigate different reactor configurations for biogas plants for achieving more effective biogas production and more stable operation. 2)to investigate operational procedures, aiming to selectively retain/return degradable material in the reactor. 3)to investigate methods for degradation of undegraded material, by returning without/with aftertreatment to the main reactor.
Angelidaki, I., Project Manager
Kaparaju, P. L., Project Participant

BioH2: Bio-hydrogen production by anaerobic fermentation of waste
Angelidaki, I., Project Manager
Zeng, R. J., Project Participant
Liu, D., Project Participant

399: Innovative reactor configurations for biogas production
Innovative reactor configurations for biogas production
Angelidaki, I., Project Manager
**398: Use of membranes for extraction of H2 produced by fermentation**

In order to optimize hydrogen production by fermentation process it is impant to develop technologies for effective reduction of hydrogen in the fermentation liquid. Selective membranes for extraction and removal of hydrogen during fermentation is a promising way for improving process effectivity and increasing hydrogen productivity from wastes.

Angelidaki, I., Project Manager

Ukendt: DKK0.00

15/10/2004 → 31/12/2007

Collaborators: Technical University of Denmark, Environment & Resources,

Award relations: Use of membranes for extraction of H2 produced by fermentation

Project: Research

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**BIOWASTE: BIOWASTE. Bioprocessing of sewage sludge for safe recycling on agricultural land**

Disposal and handling of sewage sludge are an increasing problem in Europe due to increasing quantities of sewage sludge produced. A large amount of the sewage sludge contains small fractions of toxic chemicals, which results in problems with safe use of the sewage sludge on agricultural land. From an ecological and economical point of view, it would be essential to establish methodologies, which could allow sewage sludge to be reused as fertilizers on agricultural land. Energy efficient biotreatment processes of organic waste are, therefore, of crucial importance. BIOWASTE will offer an integrated study of this area. The typical composition of sewage sludge will be characterized with regard to key contaminating compounds. Analytical techniques suitable for qualitative and quantitative evaluation of the chemical species involved in the processes under investigation will be determined. Bacteria that are able to degrade selected contaminating compounds under anaerobic and aerobic conditions will be isolated, characterized and bioaugmented for decontamination of sewage sludge by bioprocessing. Aerobic, anaerobic and combination of aerobic/anaerobic bioprocessing of sewage sludge will be applied. A mathematical model will be developed to describe the biodegradation processes of the contaminating compounds after establishing the kinetic parameters for degradation of contaminating compounds. The bioprocessed sewage sludge will be used in eco- and planttoxicology tests to evaluated the impact of the xenobiotics on the environment. Methodologies will be developed and applied to assess the cleanliness of the bioprocessing as a safe method for waste recycling.

Schmidt, J. E., Project Manager
Christensen, N., Project Participant
Angelidaki, I., Project Participant
Batstone, D. J., Project Participant
Caro Garcia, H. H., Project Participant
Trably, E., Project Participant
Eriksson, E., Project Participant, Department of Environmental Engineering, Environmental Chemistry

Project ID: 30250

Forsk. EU - Rammeprogram: DKK5,463,000.00

01/10/2002 → 30/09/2005

Collaborators: Rittmo Agroenvironnement, European Association of Chemistry and Environment, University of Patras, Randa Group SA, Technical University of Denmark, Environment & Resources,

Award relations: BIOWASTE. Bioprocessing of sewage sludge for safe recycling on agricultural land

Project: Research

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**Kortlægning og dokumentation af procesforhold på danske biogasanlæg.**


Data fra Lintrup biogasanlæg kan benyttes. Resultater fra Thorsø biogasanlæg følges.

Angelidaki, I., Project Manager

Project ID: 30206

Forskningsprojekter - Miljø- og Energiministeriet: DKK768,000.00

01/04/2002 → 31/12/2005

Collaborators: Technical University of Denmark, Environment & Resources,

Award relations: Kortlægning og dokumentation af procesforhold på danske biogasanlæg.

Project: Research

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**Reduction of xenobiotic compounds found in the sewage sludge by bioprocessing. START-programmet.**

Reduction of xenobiotic compounds found in the sewage sludge by bioprocessing.

Schmidt, J. E., Project Manager, Department of Environmental Engineering

Angelidaki, I., Project Participant, Department of Environmental Engineering
**Study on anerobic treatment of sewage sludge for removal of linear alkylbenzene sulfonates (LAS).**

We are aiming with this project to investigate anaerobic treatment of sludge with respect of eliminating/reducing LAS concentration. The influence of several parameters, such as temperature, hydraulic retention time, etc. on the removal efficiency will be investigated.

Angelidaki, I., Project Manager, Department of Environmental Engineering
Batstone, D. J., Project Participant, Department of Environmental Engineering
Schmidt, J. E., Project Participant, Department of Environmental Engineering
Toräng, L., Project Participant, Department of Environmental Engineering

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**Biogasprogram**

Sammenfattning af Biogasprogrammet aktiver og resultater til programmet slutrapportering.

Angelidaki, I., Project Manager, Department of Environmental Engineering
Pind, P. F., Project Participant, Department of Environmental Engineering

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**Improved monitoring and control of the anaerobic process. START-programmet**

Angelidaki, I., Project Manager, Department of Environmental Engineering

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**Anaerobic degradation of the organic fraction of municipal solid waste with recirculation of process water**

In this project it will be developed a system for efficiently and economically feasible to treat the organic fraction of municipal solid waste. A Ph.D. student is working in this project: Hinrich Hartmann

Ahring, B. K., Project Manager, Department of Biotechnology
Uellendahl, H., Project Participant, Department of Biotechnology
Angelidaki, I., Project Participant, Department of Biotechnology

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**Mathematical Model for dynamic simulation of the anaerobic digestion in UASB reactors treating wastewater with seasonal variations**

Schmidt, J. E., Project Manager, Department of Applied Chemistry
Skiadas, I. V., Project Participant, Department of Biotechnology
Angelidaki, I., Project Participant, Department of Biotechnology
Ahring, B. K., Project Participant, Department of Biotechnology

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**Modelling of the anaerobic decomposition of xenobiotic micropollutants common found in wastewater**

Schmidt, J. E., Project Manager, Department of Applied Chemistry
Modeling of the anaerobic process
Development of a kinetic model for simulation of the anaerobic biogas process. Furthermore, development of a model for description of anaerobic degradation and granulation in an UASB reactor

On-Line VFA measurement in biogas reactors.
An on line VFA meter is developed. It is based on Gas chromatographic analysis of samples. The samples are automatically taken and prepared by the system. The system will be used for monitoring and control of the biogas process. There is a Ph.D. student working in this project: Peter Frode Pind

Mathematical model for dynamic simulation of co-digestion of manure and industrial waste

Method for enhancement of gas yield from organic matter in biogas plants

Activities:

Bioelectrochemical systems serve anaerobic digestion process for process monitoring and biogas upgrading

Period: 12 Sep 2018

Xiangdan Jin (Speaker)
Irini Angelidaki (Speaker)
Yifeng Zhang (Speaker)

Department of Environmental Engineering
Residual Resource Engineering

Description
EU-ISMET 2018, 12th-14th September 2018, Newcastle upon Tyne, United Kingdom

Degree of recognition: International
Related event

4th EU-ISMET 2018
12/09/2018 → 14/09/2018
Tyne, United Kingdom
Activity: Talks and presentations › Conference presentations