Application of the NDHA model to describe N$_2$O dynamics in activated sludge mixed culture biomass

A pseudo-mechanistic model describing three biological nitric oxide (NO) and nitrous oxide (N$_2$O) production pathways was calibrated for an activated sludge mixed culture biomass treating municipal wastewater with laboratory-scale experiments. The model (NDHA) comprehensively describes N$_2$O producing pathways by both autotrophic ammonium oxidizing and heterotrophic bacteria. Extant respirometric assays and anaerobic batch experiments were designed to calibrate the endogenous, heterotrophic denitrification and autotrophic ammonium/nitrite oxidation processes together with the associated net N$_2$O production. Ten parameters describing heterotrophic processes and seven for autotrophic processes were estimated accurately (variance/mean < 25%). The model predicted the N$_2$O and NO dynamics at varying dissolved oxygen, ammonium and nitrite levels and was validated with a different set of batch experiments with the same biomass. Aerobic ammonium oxidation experiments at two oxygen levels used for model evaluation (2 and 0.5 mg/L) indicated that the nitrifier denitrification (42, 64%) and heterotrophic denitrification (7, 17%) pathways increased and dominated the total N$_2$O production at high nitrite and low oxygen concentrations; while the nitrifier nitrification pathway showed the largest contribution at high dissolved oxygen levels (51, 19%). The uncertainty of the biological parameter estimates was propagated to N$_2$O model outputs via Monte Carlo simulations as 95% confidence intervals. The accuracy of the estimated parameters corresponded to a low uncertainty of the N$_2$O emission factors (4.6 ± 0.6% and 1.2 ± 0.1%).

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Contributors: Domingo-Felez, C., Smets, B. F.
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Comammox Nitrospira are abundant ammonia oxidizers in diverse groundwater-fed rapid sand filter communities

The recent discovery of completely nitrifying Nitrospira demands a re-examination of nitrifying environments to evaluate their contribution to nitrogen cycling. To approach this challenge, tools are needed to detect and quantify comammox Nitrospira. We present primers for the simultaneous quantification and diversity assessment of both comammox Nitrospira clades. The primers cover a wide range of comammox diversity, spanning all available high quality sequences. We applied these primers to 12 groundwater-fed rapid sand filters, and found comammox Nitrospira to be abundant in all filters. Clade B comammox comprise the majority (∼75%) of comammox abundance in all filters. Nitrosomonadaceae were present in all filters, although at low abundance (mean=1.8%). Ordination suggests that temperature impacts the structure of nitrifying communities, and in particular that increasing temperature favours Nitrospira. The nitrogen content of the filter material, sulfate concentration and surface ammonium loading rates shape the structure of the comammox guild in the filters. This work provides an assay for simultaneous detection and diversity assessment of clades A and B comammox Nitrospira, expands our current knowledge of comammox Nitrospira diversity and demonstrates a key role for comammox Nitrospira in nitrification in groundwater-fed biofilters.

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BFI (2017): BFI-level 2
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Web of Science (2017): Impact factor 4.974
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.02 SJR 2.377 SNIP 1.383
Web of Science (2016): Impact factor 5.395
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.61 SJR 3.02 SNIP 1.571
Web of Science (2015): Impact factor 5.932
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.6 SJR 2.862 SNIP 1.599
Web of Science (2014): Impact factor 6.201
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 6.37 SJR 3.273 SNIP 1.823
Web of Science (2013): Impact factor 6.24
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.94 SJR 3.165 SNIP 1.639
Web of Science (2012): Impact factor 5.756
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 6.1 SJR 3.368 SNIP 1.7
Web of Science (2011): Impact factor 5.843
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.775 SNIP 1.551
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Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.502 SNIP 1.378
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.495 SNIP 1.322
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 2.303 SNIP 1.498
Scopus rating (2006): SJR 2.451 SNIP 1.517
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 2.431 SNIP 1.519
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 2.08 SNIP 1.239
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.794 SNIP 1.241
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 2.378 SNIP 1.028
Scopus rating (2001): SJR 1.317 SNIP 1.228
Web of Science (2001): Indexed yes
Comparative genomics sheds light on niche differentiation and the evolutionary history of comammox Nitrospira

The description of comammox Nitrospira spp., performing complete ammonia-to-nitrate oxidation, and their co-occurrence with canonical β-proteobacterial ammonia oxidizing bacteria (β-AOB) in the environment, calls into question the metabolic potential of comammox Nitrospira and the evolutionary history of their ammonia oxidation pathway. We report four new comammox Nitrospira genomes, constituting two novel species, and the first comparative genomic analysis on comammox Nitrospira. Unlike canonical Nitrospira, comammox Nitrospira genomes lack genes for assimilatory nitrite reduction, suggesting that they have lost the potential to use external nitrite nitrogen sources. By contrast, compared to canonical Nitrospira, comammox Nitrospira harbor a higher diversity of urea transporters and copper homeostasis genes and lack cyanate hydratase genes. Additionally, the two comammox clades differ in their ammonium uptake systems. Contrary to β-AOB, comammox Nitrospira genomes have single copies of the two central ammonia oxidation pathway operons. Similar to ammonia oxidizing archaea and some oligotrophic AOB strains, they lack genes involved in nitric oxide reduction. Furthermore, comammox Nitrospira genomes encode genes that might allow efficient growth at low oxygen concentrations. Regarding the evolutionary history of comammox Nitrospira, our analyses indicate that several genes belonging to the ammonia oxidation pathway could have been laterally transferred from β-AOB to comammox Nitrospira. We postulate that the absence of comammox genes in other sublineage II Nitrospira genomes is the result of subsequent loss.
Corrigendum to "Decay Experiments of Effective N-Removing Microbial Communities in Sequencing Batch Reactors"

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State: Published
Organisations: Department of Environmental Engineering, Water Technologies, Tsinghua University, Jilin Jianzhu University
Contributors: Lv, C., Ming, L., Zhong, S., Wang, J., Lei, W., Mutlu, A. G., Smets, B. F.
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Scopus rating (2016): CiteScore 0.71 SJR 0.245 SNIP 0.446
Web of Science (2016): Impact factor 1.3
Scopus rating (2015): CiteScore 0.68 SJR 0.238 SNIP 0.457
Web of Science (2015): Impact factor 0.996
Scopus rating (2014): CiteScore 0.55 SJR 0.23 SNIP 0.46
Does universal 16S rRNA gene amplicon sequencing of environmental communities provide an accurate description of nitrifying guilds?

Universal (i.e., targeting most bacteria/prokaryotes) 16S rRNA gene based amplicon sequencing is widely used for assessing microbial communities due to its low cost, time efficiency, and ability to provide a full overview of the community. However, it is currently unclear if it can yield reliable information on specific microbial guilds, which can be obtained by using primer sets targeting functional genes or specific 16S rRNA gene sequences. Here, we compared the relative abundance, diversity, richness, and composition of selected guilds (nitrifiers), obtained from universal 16S rRNA gene based amplicon sequencing and from guild targeted approaches. The universal amplicon sequencing provided 1) accurate estimates of nitrifier composition, 2) clustering of the samples based on these compositions consistent with sample origin, 3) estimates of the relative abundance of the guilds correlated with those obtained from the targeted approaches and within ~1.2 orders of magnitude of them, but with measurable bias that should be considered when comparing estimates from both approaches. In contrast, the diversity and richness estimations using the universal 16S rRNA based amplicon sequencing were likely limited by the sequencing depth; therefore, we suggest preferring targeted approaches for assessing nitrifiers diversity and richness or using sequencing depth larger than those currently typically practiced.
Estimating the Transfer Range of Plasmids Encoding Antimicrobial Resistance in a Wastewater Treatment Plant Microbial Community

Wastewater treatment plants (WWTPs) have been suggested as reservoirs and sources of antibiotic resistance genes (ARGs) in the environment. In a WWTP ecosystem, human enteric and environmental bacteria are mixed and exposed to pharmaceutical residues, potentially favoring genetic exchange and thus ARG transmission. However, the contribution of microbial communities in WWTPs to ARG dissemination remains poorly understood. Here, we examined for the first time plasmid permissiveness of an activated sludge microbial community by utilizing an established fluorescent bioreporter system. The activated sludge microbial community was challenged in standardized filter matings with one of three multidrug resistance plasmids (pKJK5, pB10, and RP4) harbored by Escherichia coli or Pseudomonas putida. Different donor–plasmid combinations had distinct transfer frequencies, ranging from 3 to 50 conjugation events per 100000 cells of the WWTP microbial community. In addition, transfer was observed to a broad phylogenetic range of 13 bacterial phyla with several taxa containing potentially pathogenic species. Preferential transfer to taxa belonging to the predicted evolutionary host range of the plasmids was not observed. Overall, the ARG dissemination potential uncovered in WWTP communities calls for a thorough risk assessment of ARG transmission across the wastewater system, before identification of possible mitigation strategies.

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Organisations: Department of Environmental Engineering, Water Technologies, University of Copenhagen, Technical University of Denmark
Contributors: Li, L., Dechesne, A., He, Z., Madsen, J. S., Nesme, J., Sørensen, S. J., Smets, B. F.
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Web of Science (2017): Impact factor 5.869
Web of Science (2016): Indexed yes
Web of Science (2015): Impact factor 5.308
Web of Science (2015): Indexed yes
Original language: English
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Source: FindIt
Source-ID: 2398495485
Research output: Research - peer-review – Journal article – Annual report year: 2018

Evidence of co-metabolic bentazone transformation by methanotrophic enrichment from a groundwater-fed rapid sand filter
The herbicide bentazone is recalcitrant in aquifers and is therefore frequently detected in wells used for drinking water production. However, bentazone degradation has been observed in filter sand from a rapid sand filter at a waterworks with methane-rich groundwater. Here, the association between methane oxidation and removal of bentazone was investigated with a methanotrophic enrichment culture derived from methane-fed column reactors inoculated with that filter sand. Several independent lines of evidence obtained from microcosm experiments with the methanotrophic enrichment culture, tap water and bentazone at concentrations below 2 mg/L showed methanotrophic co-metabolic bentazone transformation: The culture removed 53% of the bentazone in 21 days in presence of 5 mg/L of methane, while only 31% was removed in absence of methane. Addition of acetylene inhibited methane oxidation and stopped bentazone removal. The presence of bentazone partly inhibited methane oxidation since the methane consumption rate was significantly lower at high (1 mg/L) than at low (1 μg/L) bentazone concentrations. The transformation yield of methane relative to bentazone normalized by their concentration ratio ranged from 58 to 158, well within the range for methanotrophic co-metabolic degradation of trace contaminants calculated from the literature, with normalized substrate preferences varying from 3 to 400. High-resolution mass spectrometry revealed formation of the transformation products (TPs) 6-OH, 8-OH, isopropyl-OH and di-OH-bentazone, with higher abundances of all TPs in the presence of methane. Overall, we found a suite of evidence all showing that bentazone was co-metabolically transformed to hydroxy-bentazone by a methanotrophic culture enriched from a rapid sand filter at a waterworks.

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- 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
Genomic and ecological variation in comammox Nitrospira populations

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Organisations: Department of Environmental Engineering, Water Technologies
Contributors: Palomo, A., Smets, B. F.
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Source: PublicationPreSubmission
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Research output: Research - peer-review » Poster – Annual report year: 2018
Metagenomic analysis to elucidate the metabolic potential of microbial communities in Danish waterworks

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Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2018

Model-based optimization biofilm based systems performing autotrophic nitrogen removal using the comprehensive NDHA model
Completely autotrophic nitrogen removal (CANR) can be obtained in single stage biofilm-based bioreactors. However, their environmental footprint is compromised due to elevated N2O emissions. We developed novel spatially explicit biochemical process model of biofilm based CANR systems that predicts N2O dynamics and stripping, using the biological NDHA model coupled with a simple and robust pH calculator. In this work we present two case studies: i) membrane aerated biofilm reactor (MABR) with focus on model calibration; and ii) granular system with focus on process optimization.

General information
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Organisations: Department of Environmental Engineering, Residual Resource Engineering, Water Technologies, Technical University of Denmark, University of Santiago de Compostela
Contributors: Valverde Pérez, B., Ma, Y., Morset, M., Domingo-Felez, C., Mauricio-Iglesias, M., Smets, B. F.
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Monitoring and modeling of nitrogen conversions in membrane-aerated biofilm reactors: Effects of intermittent aeration
Nitrogen can be removed from sewage by a variety of physicochemical and biological processes. Due to the high removal efficiency and relatively low costs, biological processes have been widely adopted for treating nitrogen-rich wastewaters. Among the biological technologies, biofilm processes show great advantages as compared to suspended growth processes, allowing for biomass accumulation and retention without the need of external solid separation devices. The decoupling of solids retention from hydraulic retention is especially useful for slow-growing microorganisms, such as nitrifying bacteria, e.g. ammonium-oxidizing bacteria (AOB) and nitrite-oxidizing bacteria (NOB), and anaerobic ammonium-oxidizing bacteria (AnAOB), which are involved in ammonium (NH4+) removal process.

Stability of engineered biological processes requires an appropriate balance between activities of the main microbial groups involved in the system. However, finding proper operational conditions is especially challenging in biofilms. On the one hand, the existence of strong spatial chemical gradients within biofilms increases the difficulty to prescribe environmental conditions that favor any desired biological process. On the other hand, the presence of multiple simultaneous chemical gradients complicates the performance optimization. Mathematical modeling offers a way to describe and analyze multi-ple processes that occur simultaneously in time and space in biofilm systems.

This PhD project investigated NH4+ removal process in membrane-aerated biofilm reactors (MABRs), focusing on aeration control, especially the application of intermittent aeration. Compared to conventional biofilms which are characterized by co-diffusion, MABRs display counter-diffusion fluxes of substrates: oxygen is supplied through the membrane, whilst NH4+ is provided from the bulk liquid phase. The counter substrate supply not only offers flexible aeration control, but also supports the development of a unique micro-biological community and spatial structure inside the biofilm. In this study, lab-scale MABRs were operated under two types of aeration control: continuous versus intermittent aeration. Long-term reactor performance was monitored. Based on bulk measurements of NH4+, nitrite (NO2-) and nitrate
(NO3-), microbiological activities of individual functional guilds were evaluated. I found that NOB suppression occurred under intermittent aeration, but not under continuous aeration. Relative aeration duration and aeration intermittency were two effective operational factors in regulating MABR performance under inter-mittent aeration. Besides daily bulk monitoring, in situ microprofiles of dissolved oxygen (DO), pH and nitrous oxide (N2O) were performed. The significant temporal fluctuations in local biofilm pH (not DO) during aeration control suggested that pH-related effects drive the changing microbial activities under intermittent aeration, as compared to continuous aeration. Total N2O emissions were dramatically reduced at the onset of intermittent aeration, due to the development of an anoxic N2O reduction zone by heterotrophic bacteria (HB).

To further investigate the causal link between NOB suppression and aeration regime change, a 1-dimensional (1-D) multispecies nitrifying biofilm model was developed in Aquasim software, incorporating a pH calculation. Kinetic parameters to be estimated were chosen based on a local sensitivity analysis, and were estimated from in situ microprofiles. With the calibrated model, I identified that the periodically varying free ammonia inhibition, which was associated with transient pH variations, was the likely key factor causing NOB suppression in intermittently-aerated nitrifying MABRs.

To further investigate the mechanisms of N2O mitigation under aeration control, the 1-D biofilm model was extended to a partial nitritation-anammox (PNA) biofilm model, including description of all relevant biological N2O production pathways. Sensitive kinetic parameters were estimated with long-term bulk performance data. With the calibrated model, roles of HB and AnAOB were discussed and evaluated in mitigating N2O emissions in auto-trophic nitrogen removal MABRs. Moreover, I developed a 1-D biofilm model in Matlab software describing the counter-diffusion PNA process, aiming at an improved model calibration/evaluation for the highly variable N2O emissions.

Overall, a combination of experimental and modeling efforts were implemented to study nitrogen conversions in MABRs. The results showed that intermittent aeration was an efficient strategy to regulate microbial activities in counter-diffusion biofilms, achieving an energy-efficient NH4+ removal process with low N2O emissions.

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- **Organisations:** Department of Environmental Engineering, Water Technologies
- **Contributors:** Ma, Y., Smets, B. F.
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- **Research output:** Research › Ph.D. thesis – Annual report year: 2018

### Nitrous oxide emissions from biofilm processes for wastewater treatment

This paper discusses the microbial basis and the latest research on nitrous oxide (N2O) emissions from biofilms processes for wastewater treatment. Conditions that generally promote N2O formation in biofilms include (1) low DO values, or spatial DO transitions from high to low within the biofilm; (2) DO fluctuations within biofilm due to varying bulk DO concentrations or varying substrate concentrations; (3) conditions with high reaction rates, which lead to greater formation of intermediates, e.g., hydroxylamine (NH2OH) and nitrite (NO2-), that promote N2O formation; and (4) electron donor limitation for denitrification. Formation of N2O directly results from the activities of ammonia-oxidizing bacteria (AOB), ammonia-oxidizing archaea (AOA), and heterotrophic denitrifying bacteria. More research is needed on the roles of AOA, comammox, and specialized denitrifying microorganisms. In nitrifying biofilms, higher bulk ammonia (NH3) concentrations, higher nitrite (NO2-) concentrations, lower dissolved oxygen (DO), and greater biofilm thicknesses result in higher N2O emissions. In denitrifying biofilms, N2O accumulates at low levels as an intermediate and at higher levels at the oxic/anoxic transition regions of the biofilms and where COD becomes limiting. N2O formed in the outer regions can be consumed in the inner regions if COD penetrates sufficiently. In membrane-aerated biofilms, where nitritation takes place in the inner, aerobic biofilm region, the exterior anoxic biofilm can serve as a N2O sink. Reactors that include variable aeration or air scouring, such as denitrifying filters, trickling filters, or rotating biological contactors (RBCs), can form peaks of N2O emissions during or following a scouring or aeration event. N2O emissions from biofilm processes depend on the microbial composition, biofilm thickness, substrate concentrations and variability, and reactor type and operation. Given the complexity and difficulty in quantifying many of these factors, it may be difficult to accurately predict emissions for full-scale treatment plants. However, a better understanding of the mechanisms and the impacts of process configurations can help minimize N2O emission from biofilm processes for wastewater treatment.

### General information
- **State:** Accepted/In press
- **Organisations:** Department of Environmental Engineering, Water Technologies, Northwestern University, Tokyo University of Agriculture and Technology, University of Notre Dame
- **Contributors:** Sabba, F., Terada, A., Wells, G., Smets, B. F., Nerenberg, R.
- **Number of pages:** 15
Nitrous oxide production in intermittently aerated Partial Nitritation-Anammox reactor: oxic N₂O production dominates and relates with ammonia removal rate

Emissions of the greenhouse gas nitrous oxide from the Partial Nitritation-Anammox process are of concern and can determine the carbon footprint of the process. In order to reduce nitrous oxide emissions intermittent aeration regimes have been shown to be a promising mode of operation, possibly due to an effective control of accumulation of nitrogen intermediates. However, due to frequent changes of redox conditions under intermittent aeration regimes, nitrous oxide production and emissions are dynamic. In this study the production and emission dynamics of nitrous oxide in an intermittently aerated sequencing batch reactor were monitored in high temporal resolution, the contribution of different redox conditions to overall nitrous oxide production was quantified and the most relevant factors for nitrous oxide production were identified. The average fraction of nitrous oxide produced (per unit ammonium removed) was 1.1 ± 0.5%.

Cycle-averaged approx. 80% of nitrous oxide was produced during aerated phases, the remaining 20% were produced during non-aerated phases. Yet, the intra-cycle dynamics of nitrous oxide were substantial. The net-production rate of nitrous oxide during aerated phases correlated with the ammonia removal rate, whereas the concentration of nitrite determined the production during non-aerated phases. While aerated phases contributed predominantly at the beginning of reactor cycles, non-aerated phases became the dominant source of nitrous oxide at the end. Particularly low net-production rates were observed at ammonia removal rates below 5 mg NH₃-N*gVSS−1*L−1, when the fraction of nitrous oxide produced was 0.011 ± 0.004% (per ammonia removed). Based on the nitrous oxide dynamics and correlations, reactor operation at relatively low nitrogen loadings (below 100 mg NH₄+-N*L−1), ammonia removal rates of approx. 5 mg NH₃-N*gVSS−1*L−1 and nitrite concentrations below 1 mg NO₂−1-N*L−1 appears as beneficial for low emission of nitrous oxide.

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Contributors: Blum, J., Jensen, M. M., Smets, B. F.
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Scopus rating (2017): CiteScore 3.18
Web of Science (2017): Impact factor 6.735
Novel method reveals a narrow phylogenetic distribution of bacterial dispersers in environmental communities exposed to low hydration conditions

In this study, we developed a method that provides community-level surface dispersal profiles under controlled hydration conditions from environmental samples and enables us to isolate and uncover the diversity of the fastest bacterial dispersers. The method expands on the Porous Surface Model (PSM), previously used to monitor dispersal of individual bacterial strains in liquid films at the surface of a porous ceramic disc. The novel procedure targets complex communities
and captures the dispersed bacteria on a solid medium for growth and detection. The method was first validated by distinguishing motile Pseudomonas putida and Flavobacterium johnsoniae strains from their non-motile mutants. Applying the method to soil and lake water bacterial communities showed that community-scale dispersal declined as conditions became drier. However, for both communities, dispersal was detected even under low hydration conditions (matric potential: -3.1 kPa), previously proven too dry for P. putida KT2440 motility. We were then able to specifically recover and characterize the fastest dispersers from the inoculated communities. For both soil and lake samples, 16S rRNA gene amplicon sequencing revealed that the fastest dispersers were substantially less diverse than the total communities. The dispersing fraction of the soil microbial community was dominated by Pseudomonas which increased in abundance at low hydration conditions, while the dispersing fraction of the lake community was dominated by Aeromonas and, under wet conditions (-0.5 kPa), also by Exiguobacterium. The results gained in this study bring us a step closer to assessing the dispersal ability within complex communities under environmentally relevant conditions.

**IMPACT IMPORTANCE** Dispersal is a key process of bacterial community assembly. Yet, very few attempts have been made at assessing bacterial dispersal at the community level as focus has previously been on pure culture studies. A crucial factor for dispersal in habitats where hydration conditions vary, such as soils, is the thickness of the liquid films surrounding solid surfaces, but little is known on how the ability to disperse in such films varies within bacterial communities. Therefore, we developed a method to profile community dispersal and identify fast dispersers on a rough surface resembling soil surfaces. Our results suggest that within the motile fraction of a bacterial community only a minority of the bacterial types are able to disperse in the thinnest liquid films. During dry periods, these efficient dispersers can gain a significant fitness advantage through their ability to colonize new habitats ahead of the rest of the community.

**General information**
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Contributors: Krüger, U. S., Bak, F., Aamand, J., Nybroe, O., Badawi, N., Smets, B. F., Dechesne, A.
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Web of Science (2016): Impact factor 3.807
Scopus rating (2015): CiteScore 4.14
Scopus rating (2014): CiteScore 4.02
Web of Science (2014): Impact factor 3.668
Scopus rating (2013): CiteScore 4.25
Web of Science (2013): Impact factor 3.952
Scopus rating (2012): CiteScore 4.29
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Scopus rating (2011): CiteScore 4.12
Web of Science (2011): Impact factor 3.829
Web of Science (2010): Impact factor 3.778
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Research output: Research - peer-review > Journal article – Annual report year: 2018
Patterns of permissiveness towards broad host range plasmids in microbial communities across the urban water cycle in Europe

Antimicrobial resistance genes are often carried by plasmids, which greatly facilitates their spread into microbial communities. Therefore, microbial community permissiveness (the propensity of a community to take up plasmids) and the diversity of the permissive members of the community constitute key parameters to understand and predict the fate of resistance genes. This is especially true for communities across the urban water cycle. Indeed, patients under antibiotics treatment excrete resistant microbes, which are collected and transported via the sewage collection network to wastewater treatment plants (WWTP). When these resistant, host-associated bacteria mix with other bacteria better adapted to life in the environment, there is a risk of transfer of resistance plasmids. Here, we measured permissiveness towards three gfp-tagged model broad host range plasmids for communities at multiples points of the urban water cycle (hospital and residential sewers, influent of the WWTP, main WWTP reactor) in three European cities. Permissiveness to pKJK5 was highest and varied between $8.5 \times 10^{-4}$ and $1.3 \times 10^{-2}$ transfer per recipient, and that to RP4 was about one order of magnitude lower. Permissiveness to these two plasmids were correlated and was highest for the residential sewer samples. The cells that received the plasmids were sorted using flow cytometry and characterized by 16S rRNA gene amplicon sequencing. Preliminary analysis identified genera that are consistently capable of engaging in plasmid uptake at most points of the urban water cycle, highlighting their potential role as facilitators of antimicrobial resistance dissemination.

General information
State: Published
Organisations: Department of Environmental Engineering, Water Technologies, University of Santiago de Compostela, Technical University of Denmark, University of Copenhagen, Newcastle University
Contributors: Dechesne, A., Li, L., He, Z., Nesme, J., Quintela-Baluja, M., Balboa, S., Romalde, J. L., Graham, D., Sørensen, S. J., Smets, B. F.
Number of pages: 1
Publication date: 2018
Peer-reviewed: Yes
Event: Abstract from 17th International Symposium on Microbial Ecology (ISME), Leipzig, Germany.
Electronic versions:
Abstract book
Source: PublicationPreSubmission
Source-ID: 154554930
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2018

Reactor staging influences microbial community composition and diversity of denitrifying MBBRs- Implications on pharmaceutical removal

The subdivision of biofilm reactor in two or more stages (i.e., reactor staging) represents an option for process optimisation of biological treatment. In our previous work, we showed that the gradient of influent organic substrate availability (induced by the staging) can influence the microbial activity (i.e., denitrification and pharmaceutical biotransformation kinetics) of a denitrifying three-stage Moving Bed Biofilm Reactor (MBBR) system. However, it is unclear whether staging and thus the long-term exposure to varying organic carbon type and loading influences the microbial community structure and diversity. In this study, we investigated biofilm structure and diversity in the three-stage MBBR system (S) compared to a single-stage configuration (U) and their relationship with microbial functions. Results from 16S rRNA amplicon libraries revealed a significantly higher microbial richness in the staged MBBR (at 99% sequence similarity) compared to single-stage MBBR. A more even and diverse microbial community was selected in the last stage of S (S3), likely due to exposure to carbon limitation during continuous-flow operation. A core of OTUs was shared in both systems, consisting of Burkholderiales, Xanthomonadales, Flavobacteriales and Sphingobacteriales, while MBBR staging selected for specific taxa (i.e., Candidate division WS6 and Deinococcales). Results from quantitative PCR (qPCR) showed that S3 exhibited the lowest abundance of 16S rRNA but the highest abundance of atypical nosZ, suggesting a selection of microbes with more diverse N-metabolism (i.e., not-complete denitrifiers) in the stage exposed to the lowest carbon availability. A positive correlation ($p<0.05$) between removal rate constants of several pharmaceuticals with abundance of relevant denitrifying genes was observed, but not with biodiversity. Despite the previously suggested positive relationship between microbial diversity and functionality in macrobial and microbial ecosystems, this was not observed in the current study, suggesting a need to further investigate structure-function relationships for denitrifying systems.

General information
State: Published
Organisations: Department of Environmental Engineering, Water Technologies, Environmental Fate & Effect of Chemicals, Veolia Water Technologies AB
Contributors: Torresi, E., Gülay, A., Polesel, F., Jensen, M. M., Christensson, M., Smets, B. F., Plósz, B. G.
Pages: 333-345
Publication date: 2018
Peer-reviewed: Yes
Research in organic waste as resources: How to implement circular bio-economy in the urban context?

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

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Location: Herning, Denmark
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Source: PublicationPreSubmission
Source-ID: 149423814
Research output: Research › Sound/Visual production (digital) – Annual report year: 2018

Stochastic processes govern invasion success in microbial communities when the invader is phylogenetically close to resident bacteria

Despite recent efforts in identifying the determinants of invasion in microbial communities, experimental observations across different ecosystems are inconclusive. While relationships between resident community diversity and invasion success are often noted, community diversity says little about community assembly processes. Community assembly processes may provide a more inclusive framework to explain-and potentially prevent or facilitate-invasion. Here we let replicate nitrite-oxidizing bacterial guilds assemble under different conditions from a natural source community and study their compositional patterns to infer the relative importance of the assembly processes. Then, an invader strain from that same guild was introduced at one of three propagule pressures. We found no significant correlation between community diversity and invasion success. Instead, we observed that the effect of selection on invasion success was surpassed by the effect of drift, as inferred from the substantial influence of propagule pressure on invasion success. This dominance of drift can probably be generalized to other invasion cases with high phylogenetic similarity between invader and resident community members. In these situations, our results suggest that attempting to modulate the invasibility of a community by altering its diversity is futile because stochastic processes determine the invasion outcome. Increasing or reducing propagule pressure is then deemed the most efficient avenue to enhance or limit invasion success.

General information
State: Accepted/In press
Organisations: Department of Environmental Engineering, Water Technologies, Urban Water Systems
Contributors: Kinnunen, M., Dechesne, A., Albrechtsen, H., Smets, B. F.
Number of pages: 9
Publication date: 2018
Peer-reviewed: Yes

Publication information
Journal: ISM E Journal
The industrial dynamics of water innovation: A comparison between China and Europe

The expansion of the green economy agenda has increased the attention on eco-innovations globally, with issues related to water stress identified as one of the major bottlenecks for sustainable economic growth. Using evolutionary economic theory, this study investigates the industrial dynamics of the water sector, comparing China and Europe using patent data.
This comparison feeds into the “catching up” literature, addressing the challenges of the “green economy” agenda in different regions in various stages of development. We highlight the neglected micro-dynamics of water innovation, investigating the roles of different innovators in the development of water technological trajectories, with a special focus on water innovations closely related to climate change adaptation and mitigation technologies. Public water innovators (universities) were found to be more important in China than in Europe. Similarities were also identified between Europe and China; big companies were found to be the main innovative leaders with no substantial changes documented over the timeframe investigated. Overall, the finding implies a rapid Chinese technological catching up of water technologies in the last three decades, where our research has pointed towards the role of redirection of Chinese policies with a stronger focus on sustainable development. The analysis, overall, sheds light on the state and nature of the globalizing green growth agenda.

General information
State: Published
Organisations: Department of Environmental Engineering, Water Technologies, Environmental Fate & Effect of Chemicals, Water Resources Engineering, Department of Management Engineering, Technology and Innovation Management, Chinese Academy of Sciences
Contributors: Moro, M. A., McKnight, U. S., Smets, B. F., Min, Y., Andersen, M. M.
Pages: 14-32
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The_industrial_dynamics_of_water_innovation_A_comparisson_between_Europe_and_China.pdf
1_s2.0_S2096248718300109_main.pdf
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10.1016/j.ijis.2018.03.001
Source: FindIt
Source-ID: 2434421912
Research output: Research - peer-review » Journal article – Annual report year: 2018

The pH dependency of N-converting enzymatic processes, pathways and microbes: effect on net N\textsubscript{2}O production
Nitrous oxide (N\textsubscript{2}O) is emitted during microbiological nitrogen (N) conversion processes, when N\textsubscript{2}O production exceeds N\textsubscript{2}O consumption. The magnitude of N\textsubscript{2}O production vs. consumption varies with pH and controlling net N\textsubscript{2}O production might be feasible by choice of system pH. This article reviews how pH affects enzymes, pathways and microorganisms that are involved in N-conversions in water engineering applications. At a molecular level, pH affects activity of cofactors and structural elements of relevant enzymes by protonation or deprotonation of amino acid residues or solvent ligands, thus causing steric changes in catalytic sites or proton/electron transfer routes that alter the enzymes’ overall activity. Augmenting molecular information with, e.g., nitritation or denitrification rates yields explanations of changes in net N\textsubscript{2}O production with pH. Ammonia oxidizing bacteria are of highest relevance for N\textsubscript{2}O production, while heterotrophic denitrifiers are relevant for N\textsubscript{2}O consumption at pH > 7.5. Net N\textsubscript{2}O production in N-cycling water engineering systems is predicted to display a 'bell-shaped' curve in the range of pH 6.0-9.0 with a maximum at pH 7.0-7.5. Net N\textsubscript{2}O production at acidic pH is dominated by N\textsubscript{2}O production, whereas N\textsubscript{2}O consumption can outweigh production at alkaline pH. Thus, pH 8.0 may be a favourable pH set-point for water treatment applications regarding net N\textsubscript{2}O production.

General information
State: Published
Organisations: Department of Environmental Engineering, Water Technologies, Residual Resource Engineering
Contributors: Blum, J., Su, Q., Ma, Y., Valverde Pérez, B., Domingo-Felez, C., Jensen, M. M., Smets, B. F.
Pages: 1623-1640
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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 4.83 SJR 2.209 SNIP 1.31
- **Web of Science (2017):** Impact factor 4.974
- **Web of Science (2017):** Indexed yes
- **BFI (2016):** BFI-level 2
- **Scopus rating (2016):** CiteScore 5.02 SJR 2.377 SNIP 1.383
- **Web of Science (2016):** Impact factor 5.395
- **Web of Science (2016):** Indexed yes
- **BFI (2015):** BFI-level 2
- **Scopus rating (2015):** CiteScore 5.61 SJR 3.02 SNIP 1.571
- **Web of Science (2015):** Impact factor 5.932
- **Web of Science (2015):** Indexed yes
- **BFI (2014):** BFI-level 2
- **Scopus rating (2014):** CiteScore 5.6 SJR 2.862 SNIP 1.599
- **Web of Science (2014):** Impact factor 6.201
- **Web of Science (2014):** Indexed yes
- **BFI (2013):** BFI-level 2
- **Scopus rating (2013):** CiteScore 6.37 SJR 3.273 SNIP 1.823
- **Web of Science (2013):** Impact factor 6.24
- **ISI indexed (2013):** ISI indexed yes
- **Web of Science (2013):** Indexed yes
- **BFI (2012):** BFI-level 2
- **Scopus rating (2012):** CiteScore 5.94 SJR 3.165 SNIP 1.639
- **Web of Science (2012):** Impact factor 5.756
- **ISI indexed (2012):** ISI indexed yes
- **Web of Science (2012):** Indexed yes
- **BFI (2011):** BFI-level 2
- **Scopus rating (2011):** CiteScore 6.1 SJR 3.368 SNIP 1.7
- **Web of Science (2011):** Impact factor 5.843
- **ISI indexed (2011):** ISI indexed yes
- **Web of Science (2011):** Indexed yes
- **BFI (2010):** BFI-level 2
- **Scopus rating (2010):** SJR 2.775 SNIP 1.551
- **Web of Science (2010):** Impact factor 5.537
- **Web of Science (2010):** Indexed yes
- **BFI (2009):** BFI-level 2
- **Scopus rating (2009):** SJR 2.502 SNIP 1.378
- **Web of Science (2009):** Indexed yes
- **BFI (2008):** BFI-level 2
- **Scopus rating (2008):** SJR 2.495 SNIP 1.322
- **Web of Science (2008):** Indexed yes
- **Scopus rating (2007):** SJR 2.303 SNIP 1.498
- **Scopus rating (2006):** SJR 2.451 SNIP 1.517
- **Web of Science (2006):** Indexed yes
- **Scopus rating (2005):** SJR 2.431 SNIP 1.519
- **Web of Science (2005):** Indexed yes
- **Scopus rating (2004):** SJR 2.08 SNIP 1.239
- **Web of Science (2004):** Indexed yes
Transfer and long-term persistence of plasmids encoding antimicrobial resistance in wastewater treatment plant microbial communities

There is increasing concern that wastewater treatment plants (WWTPs) may contribute to the dissemination of antimicrobial resistance genes (ARGs). Indeed, there transfer of plasmid-encoded ARGs might occur as human intestinal and environmental bacteria mix. Assuming that most enteric bacteria die off, ARG survival depends on transfer to and maintenance in WWTP adapted bacteria. Here, we explore, at the community level, the notion that plasmids cannot maximize both their within-population maintenance and their transfer proficiency, but that a tradeoff exists between these two properties.

We provide the first assessment of the transfer and maintenance of typical ARG-carrying plasmids in a WWTP activated sludge microbial community. This community was challenged with Escherichia coli carrying one of three GFP-tagged plasmids spanning multiple important incompatibility groups: pKJK5 (IncP), R27 (IncH) and R64 (IncI). Transconjugants were separated by fluorescence-activated cell sorting and identified by 16S rRNA gene amplicon sequencing. pKJK5 transferred to a broad phylogenetic range of bacteria, spanning 13 phyla, while transfer of R27 and R64 was limited to Enterobacteriaceae. Following initial transfer, the communities were serially propagated over at least 60 generations, and plasmid persistence monitored. For pKJK5, high plasmid-carrying fractions (up to 10%) were transiently observed, which decreased and remained above 1% by the end of the experiment. In contrast, R27 and R64 never reached high incidence. The description of the diversity of the plasmid carriers along the serial propagation experiment is pending, but will provide a unique insight into the dynamics of contrasting plasmids in complex microbial communities.

General information
State: Published
Organisations: Department of Environmental Engineering, Water Technologies, University of Copenhagen
Contributors: Li, L., Dechene, A., Madsen, J. S., Nesme, J., Kalckar, A., Sørensen, S. J., Smets, B. F.
Number of pages: 1
Publication date: 2018
Peer-reviewed: Yes
Event: Abstract from 17th International Symposium on Microbial Ecology (ISME), Leipzig, Germany.
Electronic versions: ISME2018_final.pdf
Source: PublicationPreSubmission
Source-ID: 154730466
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2018

Use of Forward Osmosis to Harvest Methane Oxidizing Bacteria Producing Single Cell Protein

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering, Water Technologies, Technical University of Denmark
Pages: 25-25
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Host publication information
Title of host publication: Danish Water Forum Annual Water Conference 2018 - abstract book
Place of publication: Lyngby, Denmark
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Electronic versions:
Valorisation of Effluents from Anaerobic Digestion as Single Cell Protein – Focus on Safe Gas Supply

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Organisations: Department of Environmental Engineering, Residual Resource Engineering, Water Technologies, Technical University of Denmark
Number of pages: 2
Publication date: 2018
Peer-reviewed: Yes
Event: Abstract from 6th International Conference on Sustainable Solid Waste Management (NAXOS 2018), Naxos Island, Greece.
Electronic versions:
SCP_NAXOS2018Conference.pdf
Source: PublicationPreSubmission
Source-ID: 149423783
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2018

Water & Sanitation: An Essential Battlefront in the War on Antimicrobial Resistance

Water and sanitation represents a key battlefront in combating the spread of antimicrobial resistance (AMR). Basic water sanitation infrastructure is an essential first step to protecting public health, thereby limiting the spread of pathogens and the need for antibiotics. AMR presents unique human health risks, meriting new risk assessment frameworks specifically adapted to water and sanitation-borne AMR. There are numerous exposure routes to AMR originating from human waste, each of which must be quantified for its relative risk to human health. Wastewater treatment plants (WWTPs) play a vital role in centralized collection and treatment of human sewage, but there are numerous unresolved questions in terms of the microbial ecological processes occurring within and the extent to which they attenuate or amplify AMR. Research is needed to advance understanding of the fate of resistant bacteria and antibiotic resistance genes (ARGs) in various waste management systems, depending on the local constraints and intended re-use applications. WHO and national AMR action plans would benefit from a more holistic ‘One Water’ understanding. Here we provide a framework for research, policy, practice, and public engagement aimed at limiting the spread of AMR from water and sanitation in both low-, medium- and high-income countries, alike.

General information
State: Published
Organisations: Department of Environmental Engineering, Water Technologies, Technical University of Denmark, Swiss Federal Institute of Aquatic Science and Technology, McGill University, University of Exeter, Catholic University of Portugal, Virginia Tech, Natural Environmental Research Council, The University of Hong Kong
Contributors: Bürgmann, H., Frigon, D., Gaze, W., Manaia, C., Pruden, A., Singer, A. C., Smets, B. F., Zhang, T.
Number of pages: 14
Publication date: 2018
Peer-reviewed: Yes

Publication information
Journal: Fems Microbiology Ecology
Volume: 94
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Article number: fiy101
ISSN (Print): 0168-6496
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.87
Web of Science (2017): Impact factor 11.392
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.85
Web of Science (2016): Impact factor 12.198
Where does N2O from Partial Nitritation-Anammox processes come from? – A high temporal resolution study of a lab-scale system gives answers

General information
State: Published
Organisations: Department of Environmental Engineering, Water Technologies
Contributors: Blum, J., Jensen, M. M., Smets, B. F.
Pages: 27-27
Publication date: 2018
Bacteria from Wheat and Cucurbit Plant Roots Metabolize PAHs and Aromatic Root Exudates: Implications for Rhizodegradation

The chemical interaction between plants and bacteria in the root zone can lead to soil decontamination. Bacteria which degrade PAHs have been isolated from the rhizospheres of plant species with varied biological traits, however, it is not known what phytochemicals promote contaminant degradation. One monocot and two dicotyledon plants were grown in PAH-contaminated soil from a manufactured gas plant (MGP) site. A phytotoxicity assay confirmed greater soil decontamination in rhizospheres when compared to bulk soil controls. Bacteria were isolated from plant roots (rhizobacteria) and selected for growth on anthracene and chrysene on PAH-amended plates. Rhizosphere isolates metabolized 3- and 4-ring PAHs and PAH catabolic intermediates in liquid incubations. Aromatic root exudate compounds, namely flavonoids and simple phenols, were also substrates for isolated rhizobacteria. In particular, the phenolic compounds - morin, caffeic acid, and protocatechuic acid - appear to be linked to bacterial degradation of 3- and 4-ring PAHs in the rhizosphere.
Calibration of the comprehensive NDHA-N₂O dynamics model for nitrifier-enriched biomass using targeted respirometric assays

The NDHA model comprehensively describes nitrous oxide (N₂O) producing pathways by both autotrophic ammonium oxidizing and heterotrophic bacteria. The model was calibrated via a set of targeted extant respirometric assays using enriched nitrifying biomass from a lab-scale reactor. Biomass response to ammonium, hydroxylamine, nitrite and N₂O additions under aerobic and anaerobic conditions were tracked with continuous measurement of dissolved oxygen (DO) and N₂O. The sequential addition of substrate pulses allowed the isolation of oxygen-consuming processes. The parameters to be estimated were determined by the information content of the datasets using identifiability analysis. Dynamic DO profiles were used to calibrate five parameters corresponding to endogenous, nitrite oxidation and ammonium oxidation processes. The subsequent N₂O calibration was not significantly affected by the uncertainty propagated from the DO calibration because of the high accuracy of the estimates. Five parameters describing the individual contribution of three biological N₂O pathways were estimated accurately (variance/mean < 10% for all estimated parameters). The NDHA model response was evaluated with statistical metrics (F-test, autocorrelation function). The 95% confidence intervals of DO and N₂O predictions based on the uncertainty obtained during calibration are studied for the first time. The measured data fall within the 95% confidence interval of the predictions, indicating a good model description. Overall, accurate parameter estimation and identifiability analysis of ammonium removal significantly decreases the uncertainty propagated to N₂O production, which is expected to benefit N₂O model discrimination studies and reliable full scale applications.

General information
State: Published
Organisations: Department of Environmental Engineering, Water Technologies, Department of Chemical and Biochemical Engineering, PROSYS - Process and Systems Engineering Centre, Technical University of Denmark
Contributors: Domingo-Felez, C.; Calderó-Pascual, M.; Sin, G.; Plósz, B. G.; Smets, B. F.
Pages: 29-39
Publication date: 2017
Peer-reviewed: Yes

Publication information
Calibration of the NDHA N2O model via respirometric assays

General information
State: Published
Organisations: Department of Environmental Engineering, Water Technologies, Department of Chemical and Biochemical Engineering, PROSYS - Process and Systems Engineering Centre, Centre for oil and gas – DTU, Technical University of Denmark
Contributors: Domingo-Felez, C., Calderó-Pascual, M., Sin, G., Plósz, B. G., Smets, B. F.
Number of pages: 4
Publication date: 2017
Peer-reviewed: Yes
Event: Abstract from Frontiers International Conference on Wastewater Treatment (FICWTM2017), Palermo, Italy.
Electronic versions: FICWTM2017_Domingo_Felez_abstract.pdf
Research output: Research - peer-review → Conference abstract for conference → Annual report year: 2017

Challenges in using allylthiourea and chlorate as specific nitrification inhibitors
Allylthiourea (ATU) and chlorate (ClO3-) are often used to selectively inhibit nitritation and nitratation. In this work we identified challenges with use of these compounds in inhibitory assays with filter material from a biological rapid sand filter for groundwater treatment. Inhibition was investigated in continuous-flow lab-scale columns, packed with filter material from a full-scale filter and supplied with NH4+ or NO2-. ATU concentrations of 0.1-0.5 mM interfered with the indophenol blue method for NH4+ quantification leading to underestimation of the measured NH4+ concentration. Interference was stronger at higher ATU levels and resulted in no NH4+ detection at 0.5 mM ATU. ClO3- at typical concentrations for inhibition assays (1-10 mM) inhibited nitratation by less than 6%, while nitritation was instead inhibited by 91% when NH4+ was supplied. On the other hand, nitratation was inhibited by 67-71% at 10-20 mM ClO3- when NO2- was supplied, suggesting significant nitratation inhibition at higher NO2- concentrations. No chlorite (ClO2-) was detected in the effluent, and thus we could not confirm that nitration inhibition was caused by ClO3- reduction to ClO2-. In conclusion, ATU and ClO3- should be used with caution in inhibition assays, because analytical interference and poor selectivity for the targeted process may affect the experimental outcome and compromise result interpretation.

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Systems, Water Technologies, University of Southern Denmark
Contributors: Tatari, K., Gülay, A., Thamdrup, B., Albrechtsen, H., Smets, B. F.
Number of pages: 5
Pages: 301-305
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Journal: Chemosphere
Volume: 182
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BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 4.62 SJR 1.435 SNIP 1.448
Web of Science (2017): Impact factor 4.427
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 4.39 SJR 1.447 SNIP 1.625
Web of Science (2016): Impact factor 4.208
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 4.04 SJR 1.497 SNIP 1.567
Web of Science (2015): Impact factor 3.698
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 3.76 SJR 1.59 SNIP 1.639
Web of Science (2014): Impact factor 3.34
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 3.92 SJR 1.721 SNIP 1.751
Web of Science (2013): Impact factor 3.499
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 3.5 SJR 1.794 SNIP 1.618
Web of Science (2012): Impact factor 3.137
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 3.61 SJR 1.962 SNIP 1.508
Web of Science (2011): Impact factor 3.206
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.879 SNIP 1.424
Web of Science (2010): Impact factor 3.155
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.842 SNIP 1.572
Web of Science (2009): Indexed yes
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
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 1.479 SNIP 1.558
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.627 SNIP 1.479
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.321 SNIP 1.323
Changes in intermittent aeration regimes are effective tools to manage bio-granule size and microbial communities in partial nitritation-anammox SBRs

General information
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Organisations: Department of Environmental Engineering, Water Technologies
Contributors: Blum, J., Smets, B. F.
Pages: 20-20
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Host publication information
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Electronic versions:
Abstract proceedings book
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2017

Comammox Nitrospira are key nitrifiers in diverse groundwater-fed drinking water filters
Nitrification is a dominant process in groundwater-fed rapid sand filters (RSFs) used for drinking water purification. Near complete removal of ammonium and nitrite is required in the EU and Denmark due to strict regulatory limits that enable high water stability in the distribution system. RSFs are a unique environment harboring diverse microbial communities including a range of ammonia oxidizers (AOs); Betaproteobacterial ammonia oxidizers (Nitrosomonas, Nitrosospira), ammonia oxidizing archaea, diverse heterotrophs and a large fraction of Nitrospira spp., which in one studied filter have been shown to comprise both nitrite oxidizers as well as complete nitrifying (comammox) Nitrospira spp. (Palomo et al. 2016). We developed a new qPCR assay for the quantification of the comammox Nitrospira amoA gene which amplifies both clades A and B and applied this assay to the study of 12 drinking water treatment plants across Denmark. We further sequenced amplicons of the 16S rRNA gene of total Bacteria and amoA gene of Nitrospira to examine the microbial biodiversity present in the filters. Our results show that comammox Nitrospira are present in high abundance making up an average of 19% of the microbial communities in the examined filters. While members of both clades A (41 sequence variants) and B (47 sequence variants) were both present in high abundance, the majority of comammox diversity (70-90% in each filter) was made up by clade B. Ordination analysis with variance partitioning was performed on the total microbial communities and the comammox Nitrospira communities to identify physicochemical parameters of the influent water, filter material, or operational parameters which influenced the community structures in an effort to understand the success of comammox Nitrospira in these filters. Temperature as well as the sulfate and calcium content of the influent water made significant contributions towards explaining both the total and comammox community structures, while the iron content of the filter material made a significant contribution to explaining only the structure of the comammox Nitrospira communities. Further examination of groundwater-fed RSFs with higher variability in microbial communities and physicochemical parameters may provide further information on the ecology of comammox Nitrospira and explain their success in the groundwater-fed filters examined in this study. Together this work provides a new assay for the simultaneous detection of clade A and B comammox Nitrospira and expands our current knowledge of the diversity of comammox Nitrospira, while attempting to explain the success of comammox Nitrospira in these groundwater-fed filters.

General information
State: Published
Copper dosing enhances nitrification in biofilters treating groundwater

General information
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Organisations: Department of Environmental Engineering, Urban Water Systems, Water Technologies, Krüger A/S
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Counter-diffusion biofilms have lower N₂O emissions than co-diffusion biofilms during simultaneous nitrification and denitrification: Insights from depth-profile analysis

The goal of this study was to investigate the effectiveness of a membrane-aerated biofilm reactor (MABR), a representative of counter-current substrate diffusion geometry, in mitigating nitrous oxide (N₂O) emission. Two laboratory-scale reactors with the same dimensions but distinct biofilm geometries, i.e., a MABR and a conventional biofilm reactor (CBR) employing co-current substrate diffusion geometry, were operated to determine depth profiles of dissolved oxygen (DO), nitrous oxide (N₂O), functional gene abundance and microbial community structure. Surficial nitrogen removal efficiencies were comparable (96.9 ± 1.0% for MABR and 98.0 ± 0.8% for CBR). In stark contrast, the dissolved N₂O concentration in the MABR was two orders of magnitude lower (0.011 ± 0.001 mg N₂O-N/L) than that in the CBR (1.38 ± 0.25 mg N₂O-N/L), resulting in distinct N₂O emission factors (0.0058 ± 0.0005% in the MABR vs. 0.72 ± 0.13% in the CBR). Analysis on local net N₂O production and consumption rates unveiled that zones for N₂O production and consumption were adjacent in the MABR biofilm. Real-time quantitative PCR indicated higher abundance of denitrifying genes, especially nitrous oxide reductase (nosZ) genes, in the MABR versus the CBR. Analyses of the microbial community composition via 16S rRNA gene amplicon sequencing revealed the abundant presence of the genera Thauera (31.2 ± 11%), Rhizobium (10.9 ± 6.6%), Stenotrophomonas (6.8 ± 2.7%), Sphingobacteria (3.2 ± 1.1%) and Brevundimonas (2.5 ± 1.0%) as potential N₂O-reducing bacteria in the MABR.

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Density and distribution of nitrifying guilds in rapid sand filters for drinking water production: Dominance of Nitrospira spp.
We investigated the density and distribution of total bacteria, canonical Ammonia Oxidizing Bacteria (AOB) (Nitrosomonas plus Nitrosospira), Ammonia Oxidizing Archaea (AOA), as well as Nitrobacter and Nitrospira in rapid sand filters used for groundwater treatment. To investigate the spatial distribution of these guilds, filter material was sampled at four drinking water treatment plants (DWTPs) in parallel filters of the pre- and after-filtration stages at different locations and depths. The target guilds were quantified by qPCR targeting 16S rRNA and amoA genes. Total bacterial densities (ignoring 16S rRNA gene copy number variation) were high and ranged from 109 to 1010 per gram (1015 to 1016 per m3) of filter material. All examined guilds, except AOA, were stratified at only one of the four DWTPs. Densities varied spatially within filter (intra-filter variation) at two of the DWTPs and in parallel filters (inter-filter variation) at one of the DWTPs. Variation analysis revealed random sampling as the most efficient strategy to yield accurate mean density estimates, with collection of at least 7 samples suggested to obtain an acceptable (below half order of magnitude) density precision. Nitrospira was consistently the most dominant guild (5–10% of total community), and was generally up to 4 orders of magnitude more abundant than Nitrobacter and up to 2 orders of magnitude more abundant than canonical AOBs. These results, supplemented with further analysis of the previously reported diversity of Nitrospira in the studied DWTPs based on 16S rRNA and nxrB gene phylogeny (Gülay et al., 2016; Palomo et al., 2016), indicate that the high Nitrospira abundance is due to their comammox (complete ammonia oxidation) physiology. AOA densities were lower than AOB densities, except in the highly stratified filters, where they were of similar abundance. In conclusion, rapid sand filters are microbially dense, with varying degrees of spatial heterogeneity, which requires replicate sampling for a sufficiently precise determination of total microbial community and specific population densities. A consistently high Nitrospira to bacterial and archaeal AOB density ratio suggests that non-canonical pathways for nitrification may dominate the examined RSFs.
Diffusion and sorption of organic micropollutants in biofilms with varying thicknesses

Solid-liquid partitioning is one of the main fate processes determining the removal of micropollutants in wastewater. Little is known on the sorption of micropollutants in biofilms, where molecular diffusion may significantly influence partitioning kinetics. In this study, the diffusion and the sorption of 23 micropollutants were investigated in novel moving bed biofilm reactor (MBBR) carriers with controlled biofilm thickness (50, 200 and 500 μm) using targeted batch experiments (initial
concentration = 1 μg L$^{-1}$, for X-ray contrast media 15 μg L$^{-1}$) and mathematical modelling. We assessed the influence of biofilm thickness and density on the dimensionless effective diffusivity coefficient $f$ (equal to the biofilm-to-aqueous diffusivity ratio) and the distribution coefficient $K_{d,eq}$ (L g$^{-1}$). Sorption was significant only for eight positively charged micropollutants (atenolol, metoprolol, propranolol, citalopram, venlafaxine, erythromycin, clarithromycin and roxithromycin), revealing the importance of electrostatic interactions with solids. Sorption equilibria were likely not reached within the duration of batch experiments (4 h), particularly for the thickest biofilm, requiring the calculation of the distribution coefficient $K_{d,eq}$ based on the approximation of the asymptotic equilibrium concentration ($t > 4$ h). $K_{d,eq}$ values increased with increasing biofilm thickness for all sorptive micropollutants (except atenolol), possibly due to higher porosity and accessible surface area in the thickest biofilm. Positive correlations between $K_{d,eq}$ and micropollutant properties (polarity and molecular size descriptors) were identified but not for all biofilm thicknesses, thus confirming the challenge of improving predictive sorption models for positively charged compounds. A diffusion-sorption model was developed and calibrated against experimental data, and estimated $f$ values also increased with increasing biofilm thickness. This indicates that diffusion in thin biofilms may be strongly limited ($f \ll 0.1$) by the high biomass density (reduced porosity).

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Discovery and description of complete ammonium oxidizers in groundwater-fed rapid sand filters

Microbial communities are directly linked with process performance in several engineered systems. In the last century, intense study of microorganisms has contributed to optimize important environmental biotechnologies such as the activated sludge process or anaerobic digestion. However, less attention has been paid to the role of microorganisms in drinking water treatment technologies. In contrast, much effort has been devoted to eliminate potential pathogens in the drinking water treatment and supply systems. Nevertheless, the role of microbes in some drinking water treatments systems as biological filtration has long been acknowledged and recently been investigated. Biological filtration technology is widely used around the world and is especially important in Denmark as groundwater is the main source water for drinking water production. Because the groundwater has a relative high-quality, aeration followed by biological filtration is the only required treatment before distribution. In the last years, the microbial communities in rapid gravity sand filters, the typical biological filter used in Denmark, have been characterized, but little knowledge had been required about their physiological activity and roles in compound removal from the source water.

This PhD project focused on a comprehensive investigation of the microbial communities in rapid sand filters beyond their purely taxonomical identification. For this purpose, samples collected from a rapid sand filter were subjected to metagenomics analysis and genome recovery to identify the genetic capacities of the dominant types in the microbial community. Fourteen near-complete population genomes representing the dominant community were recovered comprising the capacity to grow on the typical compounds found in groundwater. The identified population genomes contained capabilities to oxidize ammonium, nitrite, methane, hydrogen sulfide, iron and manganese as well as to assimilate organic compounds. A composite population genome was assigned to Nitrospira. This genus had previously been found in multiple rapid sand filters at an unexplained high abundance. Nitrospira spp. are known to perform the second step of nitrification: oxidation of nitrite to nitrate. The two-step nitrification process disclosed at the end of the 19th
century was assumed to be carried out by two different functional groups, ammonia oxidizing prokaryotes and nitrite oxidizing bacteria. Strikingly, the Nitrospira composite population genome not only contained the genes to oxidize nitrite to nitrate, but also the genetic potential to execute the first step of nitrification. Exhaustive bioinformatics investigation ruled out the possibility of genomic contamination and confirmed that the Nitrospira composite population genome harboured the complete ammonium oxidation (comammox) pathway. At the same time, evidence of a single microbe's capacity to carry out complete nitrification was obtained by three other groups; in all cases the comammox type belonged to the Nitrospira genus.

To further investigate the genomic capacities of comammox Nitrospira, the Nitrospira composite genome was separated into individual population genomes using a differential coverage binning approach. As a result, five individual genomes were recovered, four of them containing the complete ammonium oxidation pathway. These genomes together with 11 high-quality publically available Nitrospira genomes (seven comammox and four strict nitrite oxidizers) were subject to a comparative genomics analysis. This examination showed specific genomic features for comammox, strict nitrite oxidizers and the two comammox clades. Thus, comammox Nitrospira harbour a higher variety of genes related to adaptation to nutrient-limited environments. The two comammox clades differ in their ammonium uptake affinity systems. Additionally, comammox Nitrospira genomes lack the genetic capacity to use nitrite as the only nitrogen source.

The evolutionary history of comammox Nitrospira was also examined based on protein dissimilarity, gene arrangement and reconciliation analysis. We detected a high probability of horizontal gene transfer events from betaproteobacterial ammonia oxidizers to comammox Nitrospira for genes belonging to the ammonium oxidation pathway as well as from comammox clade B to clade A for a subset of genes.

I investigated the abundance of comammox Nitrospira in rapid sand filters at 12 different waterworks in Denmark. As these new microorganisms are taxonomically similar to strict Nitrospira nitrite oxidizers, we developed specific primers to exclusively target comammox based on their gene encoding the ammonia monooxygenase subunit A. With these primers, we detected comammox Nitrospira as the dominant nitrifier in the biofilters with an abundance typically one order of magnitude higher than canonical ammonium oxidizing prokaryotes.

Lastly, I carried out lab-scale experiments with filter material from the top and bottom layers of a rapid sand filter containing different proportions of comammox Nitrospira, and strict nitrite and ammonia oxidizing prokaryotes under different loading conditions. Specifically, I exposed the filter material to distinct ammonium loading, under presence or absence of external carbon source as well as under oxygen limitation. In relation to the nitrifying community three main findings were made: (i) simultaneous growth of comammox Nitrospira and ammonium oxidizing prokaryotes; (ii) lower fitness of ammonium oxidizing archaea at higher temperatures; (iii) selection of comammox clade A over clade B at increasing ammonium loadings at reference temperature.

Overall, this PhD has provided insights into the genomic capabilities of the main types in the microbial community of a groundwater-fed biological filter. Moreover, the previously observed high abundances of Nitrospira spp. in rapid sand filters, has now been explained, by the discovery of complete ammonium oxidizing (comammox) Nitrospira from metagenomics analysis. In addition, this thesis presents the first extensive analysis of the genomic capabilities of comammox Nitrospira compared to canonical ammonium and nitrite oxidizers.
Dramatic loss of comammox Nitrospira associated with long-term nitrite feeding

Until recently, nitrification was thought to be a strict two-step process where ammonia was first oxidized to nitrite by ammonia-oxidizing bacteria and/or archaea, and subsequently to nitrate by nitrite oxidizing bacteria (NOB). Recent studies in NOB metabolism, however, have revealed that certain Nitrospira are capable of performing both steps, resulting in complete ammonia oxidation (comammox) by single microorganisms. These comammox Nitrospira have been detected in drinking water (Pinto et al., 2015; Palomo et al., 2016) and aquaculture systems (van Kessel et al., 2015), as well as deep oil exploration wells (Daims et al., 2015). The discovery of comammox Nitrospira has significantly changed our understanding of biogeochemical nitrogen cycle. The goal of this experiment was to determine the extent of competition between comammox Nitrospira and canonical Nitrospira in ammonium scarce environment, with nitrite as the main energy source. Community assembly was monitored on well-established biofilms formed on the grains of rapid sand filter (RSF) for drinking water production. RSF sand was placed in laboratory scale column bioreactors and subjected to continuous feeding of tap water spiked with NO2- (1 mg-N/L) for 250 days. The biofilms were then characterized by Illumina MiSeq platform, targeting the 16S rRNA gene. The relative abundance of a putative comammox clade B Nitrospira sequence variant (with 100% 16S rRNA gene similarity to comammox CG24_A assembled genome) identified in the initial RSF sand (Palomo et al., unpublished) at a relative abundance of 12.4±1.1%, was not detected in 4 out of 6 replicates after 250 days. Similar trend was observed for other putative comammox clade B Nitrospira sequence variants. In contrast, we observed significant increase (padj<0.001) in canonical Nitrospira sequences (100% similarity to uncultured Nitrospira sp. clone KC836101 (Pester et al., 2014)). These observations indicate different behavior of Nitrospira in the absence of ammonia and point to a possible competitive advantage of canonical Nitrospira in environments where nitrite is the sole nitrogen, as well as energy source. In addition, the results suggest that other comammox Nitrospira could also be unable to grow in the only presence of nitrite as it was observed for comammox Ca. Nitrospira inopinata (Daims et al., 2015).

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Dynamics of N2O production pathways analyzed by 15N18O isotope labeling

Nitrous oxide production associated with biological nitrogen transformations can contribute substantially to the CO2 footprint of both man-made and natural systems, but the pathways and regulation of N2O production are poorly understood. We developed a 15N/18O dual isotope labelling technique to distinguish and quantify these pathways in mixed communities. The use of 18O2 permits differentiation of hydroxylamine oxidation and nitrifier-denitrification driven N2O production by ammonium oxidizing bacteria. We analysed N2O production pathways during biological nitrogen removal at Lynetten wastewater treatment plant. Under anoxia, N2O accumulated due to denitrification, but N2O accumulation was ~3 and 1.7 times higher at 30 and 100 µM O2, respectively. Oxic N2O production was dominated by nitrifier-denitrification, reaching 73% of the total with the remainder due to hydroxylamine oxidation. Our results demonstrate three active pathways of N2O production, each with different environmental controls. The dual 15N/18O isotope labelling approach can contribute to the development of strategies to minimise N2O emissions from man-made and natural systems.

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Establishment and calibration of consensus process model for nitrous oxide dynamics in water quality engineering

Research on biological nitrogen removal (BNR) in wastewater treatment plants (WWTP) has historically focused on achieving good effluent quality, with more recent attention to energy savings and carbon dioxide (CO2) footprints. Novel processes and operating conditions are being implemented that enhance cost and energy efficiency in BNR, while maintaining effluent quality. Now, increasing attention is placed on direct emissions of nitrous oxide (N2O) as by-product of BNR. N2O is a greenhouse gas (GHG) with a high warming potential and also an ozone depleting chemical compound. Several N2O production pathways have been identified from pure culture studies, while mechanisms are still being unravelled. Heterotrophic bacteria (HB) and ammonium oxidizing bacteria (AOB) are well known to produce N2O. However, the effect of environmental factors on N2O production is not yet well understood. Current process modelling efforts aim to reproduce ex-perimental data with mathematical equations, structuring our understanding of the system. Various mechanistic models with different structures describing N2O production have been proposed, but no consensus exists between researchers. Hence, the existing plant-wide GHG models still lack a complete biological process model that can be integrated in a methodology that assesses N2O emissions and their impact on overall plant performance. A mathematical model structure that describes N2O production during biological nitrogen removal is proposed. Two autotrophic and one heterotrophic biological pathways are coupled with abiotic processes. The model stoichiometry and process rates synthesize a comprehensive literature review on the metabolism of microbes involved in nitrogen removal. The proposed model can describe all relevant NO and N2O production pathways with fewer parameters than present in other proposed models. A novel experimental design based on the developed model and on extant respirometric techniques is introduced. Monitoring dissolved oxygen and N2O allowed the isolation of individual processes and the estimation of parameters associated to oxygen consumption (endogenous activity, nitrite and ammonium oxidation) and N2O production (NN, ND and HD pathway contributions). To estimate parameters of the N2O model a rigorous procedure is presented as a case study. The calibrated model predicts the NO and N2O dynamics at varying ammonium, nitrite and dissolved oxygen levels in two independent systems: (a) an AOB-enriched biomass and (b) activated sludge (AS) mixed liquor biomass. A total of ten (a) and seventeen (b) parameters are identified with high accuracy (coefficients of variation < 25%). The critical validation of the model response and the estimated parameter values represent a novel and rigorous tool for N2O modelling studies. For the first time, uncertainty associated with parameter estimation from N2O models is reported, this procedure is recommended to be included with best-fit simulations. Additionally, modelling electron competition in heterotrophic processes is explored via an analogy to current intensity through resistors in electric circuits. While further model validation is required, this approach captured the electron competition during denitrification for four different carbon sources. Overall, a combination of modelling and experimental efforts to study N2O dynamics was successfully implemented. Results represent a step forward in the development of consensus process model for N2O emissions in WQE processes.

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From biofilm ecology to reactors: a focused review
Biofilms are complex biotissues that appear on all surfaces that are regularly in contact with water. They are structurally complex, dynamic systems with attributes of primordial multicellular organisms and multifaceted ecosystems. The presence of biofilms may have a negative impact on the performance of various systems, but they can also be used beneficially for the treatment of water (defined herein as potable water, municipal and industrial wastewater, fresh/brackish/salt water bodies, groundwater) as well as in water stream-based biological resource recovery systems. This review addresses the following three topics: (1) biofilm ecology, (2) biofilm reactor technology and design, and (3) biofilm modeling. In so doing, it addresses the processes occurring in the biofilm, and how these affect and are affected by the broader biofilm system. The symphonic application of a suite of biological methods has led to significant advances in the understanding of biofilm ecology. New metabolic pathways, such as anaerobic ammonium oxidation (anammox) or complete ammonium oxidation (comammox) were first observed in biofilm reactors. The functions, properties, and
constituents of the biofilm extracellular polymeric substance matrix are somewhat known, but their exact composition and role in the microbial conversion kinetics and biochemical transformations are still to be resolved. Biofilm grown microorganisms may contribute to increased metabolism of micro-pollutants. Several types of biofilm reactors have been used for water treatment, with current focus on moving bed biofilm reactors, integrated fixed-film activated sludge, membrane-supported biofilm reactors, and granular sludge processes. The control and/or beneficial use of biofilms in membrane processes is advancing. Biofilm models have become essential tools for fundamental biofilm research and biofilm reactor engineering and design. At the same time, the divergence between biofilm modeling and biofilm reactor modeling approaches is recognized.

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Heterotrophs are key contributors to nitrous oxide production in mixed liquor under low C-to-N ratios during nitrification - batch experiments and modelling

Nitrous oxide (N2O), a by-product of biological nitrogen removal during wastewater treatment, is produced by ammonia-oxidizing bacteria (AOB) and heterotrophic denitrifying bacteria (HB). Mathematical models are used to predict N2O emissions, often including AOB as the main N2O producer. Several model structures have been proposed without consensus calibration procedures. Here, we present a new experimental design that was used to calibrate AOB-driven N2O dynamics of a mixed culture. Even though AOB activity was favoured with respect to HB, oxygen uptake rates indicated HB activity. Hence, rigorous experimental design for calibration of autotrophic N2O production from mixed cultures is essential. The proposed N2O production pathways were examined using five alternative process models confronted with experimental data inferred. Individually, the autotrophic and heterotrophic denitrification pathway could describe the observed data. In the best-fit model, which combined two denitrification pathways, the heterotrophic was stronger than the autotrophic contribution to N2O production. Importantly, the individual contribution of autotrophic and heterotrophic to the total N2O pool could not be unambiguously elucidated solely based on bulk N2O measurements. Data on NO would increase the practical identifiability of N2O production pathways.
Intermittent Aeration Suppresses Nitrite-Oxidizing Bacteria in Membrane-Aerated Biofilms: A Model-Based Explanation

Autotrophic ammonium oxidation in membrane-aerated biofilm reactors (MABRs) can make treatment of ammonium-rich wastewaters more energy-efficient, especially within the context of short-cut ammonium removal. The challenge is to exclusively enrich ammonium-oxidizing bacteria (AOB). To achieve nitritation, strategies to suppress nitrite-oxidizing bacteria (NOB) are needed, which are ideally grounded on an understanding of underlying mechanisms. In this study, a nitrifying MABR was operated under intermittent aeration. During eight months of operation, AOB dominated, while NOB were suppressed. On the basis of dissolved oxygen (DO), ammonium, nitrite, and nitrate profiles within the biofilm and in the bulk, a 1-dimensional nitrifying biofilm model was developed and calibrated. The model was utilized to explore the potential mechanisms of NOB suppression associated with intermittent aeration, considering DO limitation, direct pH effects on enzymatic activities, and indirect pH effects on activity via substrate speciation. The model predicted strong periodic shifts in the spatial gradients of DO, pH, free ammonia, and free nitrous acid, associated with aerated and non-aerated phases. NOB suppression during intermittent aeration was mostly explained by periodic inhibition caused by free ammonia due to periodic transient pH upshifts. Dissolved oxygen limitation did not govern NOB suppression. Different intermittent aeration strategies were then evaluated for nitritation success in intermittently aerated MABRs: both aeration intermittency and duration were effective control parameters.
Invasion in microbial communities: Role of community composition and assembly processes

Microbes contribute to all biogeochemical cycles on earth and are responsible for key biological processes that support the survival of plants and animals. There is increased interest in controlling and managing microbial communities in different ecosystems in order to make targeted microbiological processes more effective. In order to manage microbial communities, it is essential to understand the factors that shape and influence microbial community composition. In addition to abiotic factors, such as environmental conditions and resource availability, biotic factors also shape the dynamics of microbial community assembly. Biotic factors include interactions between different microbial groups as well as the community response to alien species – invaders.

Microbial invasions can have significant effects on the composition and functioning of resident communities. There is, however, lack of agreement on the core determinants of invasion in microbial communities. Current models and concepts for invasion in microbial ecology are largely based on the macro-ecology literature. Although attempts have been made to examine the applicability of these concepts to microbial communities, a general conceptual framework for microbial invasion applicable across ecosystems is missing. The overall aim of this PhD project was therefore to propose a conceptual framework to study microbial community invasion and to test this framework against experimental observations.

Based on a synthesis of earlier frameworks on invasion and community ecology, I defined invasion in a microbial community as the establishment of an alien microbial type in a resident community and have proposed simple criteria to define aliens, residents, and alien establishment, applicable across a wide variety of communities. I suggested the adoption of the community ecology framework advanced by Vellend (2010) to identify determinants of invasion. This framework lists the four fundamental processes that govern community assembly as: dispersal, selection, drift and diversification. We have suggested that it is important to determine which processes dominate the assembly of a resident community in order to understand what governs invasion in that community.

To test invasion in microbial communities while controlling the processes driving community assembly, I developed a high-throughput flow-through experimental microcosm system that enabled me to manipulate the relative importance of selection versus drift during initial community assembly. I used this new system to establish resident microbial biofilm communities dominated by nitrite-oxidizing bacteria, where the direction of selection as well as contribution of drift was manipulated through differential nitrite loading rates.

Subsequently, I experimentally characterized the community assembly processes in the biofilm communities, using replicate communities assembled under same conditions. Both total community and guild-level analyses provided evidence for contribution of neutral processes (drift) combined with selection. More precisely, I observed the deterministic enrichment of certain types of nitrite-oxidizing bacteria in the biofilms: elevated nitrite loading selected for a single Nitrotoga representative, while lower nitrite conditions selected for a number of Nitrospira.

I then repeated the assembly experiment and subjected the assembled biofilms to invasion by a Nitrotoga HW29 culture. I found no significant (negative) correlation between community diversity and invasion success, in contrast with the often cited diversity/invasibility relationship. Instead, I observed that at high phylogenetic similarity between invader and resident types, the effect of selection is surpassed by the effect of drift on invasion success. My results suggest that controlling invasion in communities that contain members that are phylogenetically similar to the invader is nearly impossible because stochastic processes determine the invasion outcome when selection towards invader and resident community is similar. In conclusion, during this PhD project I proposed a simple conceptual framework to study and characterize microbial invasions. This conceptual framework allows comparison of experimental observations across ecosystems using a coherent ecological terminology and consideration of community assembly processes rather than indices to describe community composition. Furthermore, I experimentally identified the dominant processes in newly assembled biofilms enriched in nitrite-oxidizing guilds before subjecting the resident guilds to invasion by an alien nitrite-oxidizer. The results of my experiments indicate that neutral processes have significantly higher contribution to community assembly – including invasion – than previously suggested.

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Contributors: Kinnunen, M., Smets, B. F., Dechesne, A., Albrechtsen, H.
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Invasion of nitrite oxidizer dominated communities: interactions between propagule pressure and community composition

Managing invasion of microbial communities by new members can be a powerful tool in microbial resource management. Abundant studies have examined how resource availability and resident community diversity affect invasion success. Yet, a more rigorous approach towards studying invasion would consider a broader community ecology framework. For example, the effect of propagule pressure, often studied in macro-ecology, has rarely been examined for microbial communities. Also, the interactions between processes governing community assembly and propagule pressure on invasion success have never been reported.

The objective of this study was to determine the effect of propagule pressure on invasion success in microbial communities, shaped by varying degrees of stochasticity and determinism. The experimental system consisted of nitrite oxidizing bacterial enrichments, developed in replicate flow-through biofilm reactors using drinking water as inoculum and continuous feeding with nitrite a sole energy source. Different nitrite loading rates were applied, as these were previously shown to influence nitrifying guild composition and stochasticity [1]. After 6 weeks, the reactors were invaded for 24 hours by nitrite oxidizer strain (Candidatus Nitrotoga sp. HW29) at 3 different propagule pressures. The reactors were then operated another 2 weeks before analyzing community composition by targeted qPCRs and 16S rRNA gene amplicon analysis. We successfully assembled resident communities with different ratios of Nitrotoga to Nitrospira as a result of determinism created by different nitrite concentrations: High nitrite loading selected for a diverse and abundant Nitrotoga population while low nitrite loading selected for an abundant Nitrospira population. We noted invasion success only at the highest propagule pressure, and the frequency of establishment was higher under low versus high nitrite loading conditions. Contrary to previous invasion studies, we found no significant correlation between resident community diversity and invasion success. Instead, our results suggest that deterministic processes combined with resident-invader phylogenetic relatedness influence invasion success.

Low nitrous oxide production in intermittent-feed high performance nitritating reactors

Nitrous oxide (N2O) production from autotrophic nitrogen removal processes, especially nitritating systems, is of growing concern. N2O dynamics were characterized and N2O production factors were quantified in two lab-scale intermittent-feed nitritating SBRs. 93 ± 14% of the oxidized ammonium was converted to nitrite, with the average total net N2O production of 2.1 ± 0.7% of the ammonium oxidized. Operation with intermittent feeding appears an effective optimization approach to mitigate N2O emissions from nitritating systems. Net N2O production rates transiently increased with a rise in pH after each feeding, indicating a potential role of pH in N2O production.

Low nitrous oxide production through nitrifier-denitrification in intermittent-feed high-rate nitritation reactors

Nitrous oxide (N2O) production from autotrophic nitrogen conversion processes, especially nitritation systems, can be significant, requires understanding and calls for mitigation. In this study, the rates and pathways of N2O production were quantified in two lab-scale sequencing batch reactors operated with intermittent feeding and demonstrating long-term and high-rate nitritation. The resulting reactor biomass was highly enriched in ammonia-oxidizing bacteria, and converted
~93 ± 14% of the oxidized ammonium to nitrite. The low DO set-point combined with intermittent feeding was sufficient to maintain high nitritation efficiency and high nitritation rates at 20-26 °C over a period of ~300 days. Even at the high nitritation efficiencies, net N2O production was low (~2% of the oxidized ammonium). Net N2O production rates transiently increased with a rise in pH after each feeding, suggesting a potential effect of pH on N2O production. In situ application of 15N labeled substrates revealed nitrifier denitrification as the dominant pathway of N2O production. Our study highlights operational conditions that minimize N2O emission from two-stage autotrophic nitrogen removal systems.

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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 (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
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Scopus rating (2010): SJR 2.592 SNIP 2.192
Membrane-aerated Nitrifying Biofilms: Continuous versus Intermittent Aeration

This study evaluated the process performance of a lab-scale membrane-aerated nitrifying biofilm under continuous versus intermittent aeration regimes. Effects of intermittent aeration on the competition between individual microbial communities and the emission of nitrous oxide (N2O) were specifically studied. The principle observation under continuous aeration was more efficient ammonium removal (4.3 gNH4+_N/m2/day) but also higher N2O emission (2.9% of the N loading) and minor anaerobic ammonium oxidizer (AMX) activity compared to intermittent aeration (3.1 gNH4+_N/m2/day, 0.3% of the N loading). AMX activity increased at the expense of decreasing nitrite oxidizer (NOB) activity with intermittent aeration. Dissolved oxygen and pH microprofiles under each aeration regimes revealed that the dynamic variation of pH relevant effects could be the potential causes to these different performances. A high intermittency in aeration favors the suppression of NOB with positive effects on N2O emission reduction.

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Organisations: Department of Environmental Engineering, Water Technologies, Technical University of Denmark
Contributors: Ma, Y., Piscedda, A., Smets, B. F.
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Electronic versions: Biofilm2017_Yunjie_Ma.pdf

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Metal stressors consistently modulate bacterial conjugal plasmid uptake potential in a phylogenetically conserved manner

The environmental stimulants and inhibitors of conjugal plasmid transfer in microbial communities are poorly understood. Specifically, it is not known whether exposure to stressors may cause a community to alter its plasmid uptake ability. We assessed whether metals (Cu, Cd, Ni, Zn) and one metalloid (As), at concentrations causing partial growth inhibition, modulate community permissiveness (that is, uptake ability) against a broad-host-range IncP-type plasmid (pKJK5). Cells were extracted from an agricultural soil as recipient community and a cultivation-minimal filter mating assay was conducted with an exogenous E. coli donor strain. The donor hosted a gfp-tagged pKJK5 derivative from which conjugation events could be microscopically quantified and transconjugants isolated and phylogenetically described at high resolution via FACS and 16S rRNA amplicon sequencing. Metal stress consistently decreased plasmid transfer frequencies to the community, while the transconjugal pool richness remained unaffected with OTUs belonging to 12 bacterial phyla. The taxonomic composition of the transconjugal pools was distinct from their respective recipient communities and clustered dependent on the stress type and dose. However, for certain OTUs, stress increased or decreased permissiveness by more than 1000-fold and this response was typically correlated across different metals and doses. The response to some stresses was, in addition, phylogenetically conserved. This is the first demonstration that community permissiveness is sensitive to metal(loid) stress in a manner that is both partially consistent across stressors and phylogenetically conserved. The ISME Journal advance online publication, 2 August 2016; doi:10.1038/ismej.2016.98.
Microbial biotechnologies for potable water production

Sustainable Development Goal 6 requires the provision of safe drinking water to the world. We propose that increased exploitation of biological processes is fundamental to achieving this goal due to their low economic and energetic costs. Biological processes exist for the removal of most common contaminants, and biofiltration processes can establish a biologically stable product that retains high quality in distribution networks, minimizing opportunities for pathogen invasion.

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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.56
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Web of Science (2016): Indexed yes
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Moving bed biofilm reactors (MBBRs) for removal of pharmaceuticals in biological wastewater treatment

General information
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Organisations: Department of Environmental Engineering, Water Technologies, Environmental Chemistry, AnoxKaldnes AB
Contributors: Torresi, E., Polesel, F., Smets, B. F., Andersen, H. R., Plósz, B. G., Christensson, M.
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N2O and NO dynamics in AOB-enriched and mixed-culture biomass: experimental observations and model calibration

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Organisations: Department of Environmental Engineering, Water Technologies, Department of Chemical and Biochemical Engineering
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N2O and NO dynamics in AOB-enriched and mixed-culture biomass: Experimental Observations and Model Calibration

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Niche differentiation and evolution of comammox Nitrospira through a comparative genomics analysis

Nitrification, the biological oxidation of ammonium to nitrate, is a fundamental process in the nitrogen cycle and plays an important role in natural and engineered systems. Throughout the last century, nitrification was assumed to be a two-step process executed by two different functional groups, ammonia oxidizing prokaryotes (AOP) and nitrite oxidizing bacteria (NOB). Recently, several articles have shown the capability of a single microorganism, belonging to the genus Nitrospira, to carry out the complete oxidation of ammonia to nitrate (comammox). Nitrospira spp. are widespread in both natural and engineered ecosystems associated with nitrogen cycling and different species are frequently observed to coexist in the same environment. Besides recent discoveries pointing towards versatile metabolism in some Nitrospira species, little is known about the functional potential of the two comammox Nitrospira clades, and the factors involved in niche-partitioning between comammox and canonical Nitrospira.

A comparative genomics analysis was conducted with five genomes recovered from a groundwater-fed rapid sand filter (including both comammox clades and a nitrite-oxidizing Nitrospira population genome) and high quality published Nitrospira genomes, to reveal distinct genomic features within Nitrospira. In addition, we investigated the evolution of the ammonia oxidation pathway in comammox Nitrospira. This analysis revealed distinct genetic capabilities of the different comammox clades and canonical Nitrospira which can help to explain the coexistence and niche partitioning of Nitrospira spp. These divergences range from the nitrogen source utilization capacity to the ability for electron donor versatility, and other characteristics such as stress response. With respect to the evolutionary history of comammox Nitrospira, our analysis indicates transfer events with betaproteobacterial ammonia oxidizers. In addition, transfer events between comammox clade A and clade B were also detected for genes belonging to the ammonium oxidation pathway.

Together, these results expand the actual knowledge of the ecology and evolution of the recently discovered comammox Nitrospira.

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Organisations: Department of Environmental Engineering, Water Technologies, Department of Biotechnology and Biomedicine, Department of Bio and Health Informatics, Disease Intelligence and Molecular Evolution, Metagenomics
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Niche partitioning within genus Nitrospira is affected by environmental copper concentration

Nitrification is a dominant process in groundwater-fed rapid sand filters (RSFs) used for drinking water purification. Near complete removal of ammonium and nitrite is required in the EU and Denmark due to strict regulatory limits that enable high water stability in the distribution system. Previous work has revealed that in poorly functioning filters, the addition of trace copper can increase the rate of nitrification, leading to increased removal of ammonium and nitrite to below regulatory limits. RSFs are a unique environment harboring diverse microbial communities including a range of nitrifying bacteria; Betaproteobacterial ammonia oxidizers (Nitrosomonas, Nitrosospira; AOB), ammonia oxidizing archaea (AOA),
diverse heterotrophs potentially capable of ammonia and/or nitrite oxidation and a large fraction of Nitrospira spp., recently shown to comprise both nitrite oxidizers and comammox Nitrospira spp.. This diversity points towards extensive niche partitioning within the nitrifying guild, and particularly within Nitrospira which generally comprises between 10 and 65% of the total filter community. Copper is a co-factor in the ammonia monoxygenase enzyme and is thus an essential and at times limiting nutrient in nitrifying environments. We sought to examine the effects of copper on niche partitioning within the genus Nitrospira in full-scale filters. Sand samples from the top of an after-filter that displayed incomplete ammonium oxidation at Nærum waterworks were taken prior to Cu dosing treatment and 4 months following the commencement of low-level Cu dosing (~ μg Cu L-1). Copper treatment had an immediate effect on nitrification, resulting in removal of ammonium and nitrite to below regulatory levels. DNA was extracted from sand samples and was subject to qPCR and amplicon based Illumina sequencing of Nitrospira nxrB (nitrite reductase B-subunit) and amoA genes using newly designed primers targeting clades A and B comammox. Quantitative PCR revealed that Cu addition resulted in a 4-fold increase of total Nitrospira, but a 5-fold decrease in the abundance of comammox Nitrospira. However, further examination of the qPCR melt curves and amoA sequence data revealed that the reduction in comammox Nitrospira resulted from the near complete loss of Clade B comammox, while Clade A comammox were present at similar absolute abundances as in the community prior to copper dosing. The reasons for the loss of Clade B comammox are currently unclear. Higher sensitivity to copper toxicity in Clade B relative to Clade A and nitrite-oxidizing Nitrospira seems unlikely due to the extremely low copper concentrations applied. An overall stimulation of the growth of nitrifying bacteria occurred once copper limitation was removed, likely resulting in the out-competition of Clade B Nitrospira ammonium oxidizers. These results suggest that copper availability plays a role in determining the diversity and distribution of Nitrospira spp. in nitrifying environments.

**General information**

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Organisations: Department of Environmental Engineering, Water Technologies, Urban Water Systems
Contributors: Fowler, J., Dechesne, A., Wagner, F. B., Diwan, V., Albrechtsen, H., Smets, B. F.
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**Nitrogen recovery from wastewater to produce microbial protein using methane oxidizing bacteria**

**General information**

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Organisations: Department of Environmental Engineering, Water Technologies, Residual Resource Engineering, Technical University of Denmark
Contributors: Xing, W., Valverde Pérez, B., Pape, M. L., De Francisci, D., Smets, B. F.
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**Nitrotoga is selected over Nitrospira in newly assembled biofilm communities from a tap water source community at increased nitrite loading**

Community assembly is a central topic in microbial ecology: how do assembly processes interact and what is the relative contribution of stochasticity and determinism? Here, we exposed replicate flow-through biofilm systems, fed with nitrite-supplemented tap water, to continuous immigration from a source community, present in the tap water, to determine the extent of selection and neutral processes in newly assembled biofilm communities at both the community and the functional guild (of nitrite-oxidizing bacteria, NOB) levels. The community composition of biofilms assembled under low and high nitrite loading was described after 40 days of complete nitrite removal. The total community assembly, as well as the NOB guild assembly were largely governed by a combination of deterministic and stochastic processes. Furthermore, we observed deterministic enrichment of certain types of NOB in the biofilms. Specifically, elevated nitrite loading selected for a single Nitrotoga representative, while lower nitrite conditions selected for a number of Nitrospira. Therefore, even...
when focusing on ecologically coherent ensembles, assembly is the result of complex stochastic and deterministic processes that can only be interrogated by observing multiple assemblies under controlled conditions. This article is protected by copyright. All rights reserved.
Nitrous oxide Production in Membrane-aerated Nitrifying Biofilms: Experimentation and Modelling

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Organisations: Department of Environmental Engineering, Water Technologies
Contributors: Ma, Y., Domingo-Felez, C., Smets, B. F.
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Electronic versions: FICWTM2017_Ma.pdf
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N₂O emissions from a single-stage partial nitritation/anammox granule-based reactor – a model based assessment

General information
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Organisations: Department of Environmental Engineering, Water Technologies, Technical University of Denmark, University of Santiago de Compostela
Contributors: Morset, M., Valverde Pérez, B., Blum, J., Domingo Felez, C., Mauricio-Iglesias, M., Smets, B. F.
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Research output: Research - peer-review › Poster – Annual report year: 2017
Paths and Controls of N₂O Production in Nitritation-Anammox Biomass

Nitrous oxide (N₂O) is an unwanted byproduct during biological nitrogen removal processes in wastewater. To establish strategies for N₂O mitigation, a better understanding of production mechanisms and their controls is required. A novel stable isotope labeling approach using ¹⁵N and ¹⁸O was applied to investigate pathways and controls of N₂O production by biomass taken from a full-scale nitritation-anammox reactor. The experiments showed that heterotrophic denitrification was a negligible source of N₂O under oxic conditions (≥0.2 mg O₂ L⁻¹). Both hydroxylamine oxidation and nitrifier denitrification contributed substantially to N₂O accumulation across a wide range of conditions with varying concentrations of O₂, NH₄⁺, and NO₂⁻. The O₂ concentration exerted the strongest control on net N₂O production with both production pathways stimulated by low O₂, independent of NO₂⁻ concentrations. The stimulation of N₂O production from hydroxylamine oxidation at low O₂ was unexpected and suggests that more than one enzymatic pathway may be involved in this process. N₂O production by hydroxylamine oxidation was further stimulated by NH₄⁺, whereas nitrifier denitrification at low O₂ levels was stimulated by NO₂⁻ at levels as low as 0.2 mM. Our study shows that ¹⁵N and ¹⁸O isotope labeling is a useful approach for direct quantification of N₂O production pathways applicable to diverse environments.
Plasmid host range (permisseveness) in communities of activated sludge in wastewater treatment plant

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**Plasmid host range (permisseveness) in microbial communities of activated sludge in wastewater treatment plant.**

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**Removal of micropollutants in Moving Bed Biofilm reactors (MBBRs): Microbial-diversity-and-functional-relationships**
Numerous pollutants such as pharmaceuticals and personal care products are continuously released into municipal wastewater treatment plants (WWTP). Present at concentration of nano- to milligram per liter, they are defined as micropollutants. Micropollutants are only partially removed, possibly due to design and operational limitation of conventional WWTP. Eventually, micropollutant parent compounds and transformation products are discharged into receiving water bodies, possibly causing acute and chronic toxic effects on aquatic organisms even at very low concentrations. Therefore, research currently focuses on the enhancement of conventional WWTPs via physical-chemical and biological treatment processes. Biofilm-based treatment processes, such as the Moving Bed Biofilm Reactor (MBBR), were shown to harbour bio-catalytic potential that can enhance the biotransformation of a number of micropollutants compared to conventional activated sludge. In MBBRs, biofilm grow on plastic carriers kept in suspension in the reactor basin via mechanical mixing or aeration, offering a suit of benefits, amongst all comparably small footprint. Despite few existing evidences in aerobic MBBR, an in-depth understanding of the fate of micropollutants in such systems under different operational conditions is still required. In this context, this PhD thesis investigated different optimization strategies using MBBRs towards the removal of 23 commonly detected micropollutants (i.e., pharmaceuticals) in municipal wastewater. Specifically, I studied the impact of (i) biofilm thickness on the diffusion, sorption and biotransformation of the selected pharmaceuticals in nitrifying MBBR; and (ii) of organic carbon quality and availability on micropollutant biotransformation in anoxic pre- and post-denitrifying MBBRs. In both case, the influence of (i) and (ii) on the microbial activity (nitrification and denitrification) and microbial community composition and diversity were investigated. The existence of possible relationships between microbial diversity (analyzed via 16S rRNA amplicon sequencing) and biotransformation of micropollutants was evaluated to investigate which microbial processes and factors underlay the removal of micropollutants. The PhD objectives were evaluated in long- and short-term experiments in three laboratory-scale MBBR systems for pre-denitrification (MBBR1), nitrification (MBBR2) and post-denitrification (MBBR3). Biokinetics of nitrification, denitrification and micropollutant biotransformation rate constants (kBio, L/g-d-1) were estimated through batch experiments using Activated Sludge Models (ASMs) and ASM for Xenobiotics (ASM-X), respectively. In the pre-denitrifying MBBR1 study, denitrification, biotransformation of micropollutants and microbial community were evaluated in three-stage (S) and single-stage (U) MBBR configurations. The three-stage configuration produced a prolonged exposure of the biofilm to a gradient of organic carbon loading and complexity, leading to a significant differentiation of denitrification and biotransformation kinetics in the three MBBR sub-reactors. The highest and lowest biotransformation kinetics were found in the first and the last stage, respectively (up to 4-fold decrease for selected compounds), suggesting a possible correlation of micropollutant biotransformation with denitrification rates. The long term-operation with carbon availability and complexity gradient led to higher (p<0.05) biodiversity in the three-stage system, with a more diverse and even microbial community in the last stage. Specific taxa such as Candidate division WS6 and Deinococcales were selected in S, possibly due to oligotrophic conditions occurring in the last reactor stage. The influence of biofilm thickness was studied
in nitrifying MBBR2 using newly developed Z-carriers that allow the control of defined biofilm thickness. The use of thinner biofilms (~ 50 µm), rather than thicker biofilms (>200 µm), had a positive effect on nitrification rates and on the biotransformation kinetics of a number of compound such as diclofenac (kBio up to 6 L g⁻¹ d⁻¹) and the three sulfonamide antibiotics. However, the biotransformation of more than 60% of targeted compounds was enhanced in thicker biofilms, that exhibited higher (p<0.05) microbial diversity and were more even. Additionally, a biofilm model was developed and calibrated to evaluate sorption and diffusion of micropollutants in nitrifying biofilms. Sorption was significant only for eight out of the targeted compounds. All compounds removed by sorption were predicted to carry a net positive charge at the experimental pH, suggesting the importance of electrostatic interactions on sorption in biofilms. Sorption coefficients Kd (L g⁻¹) and effective diffusivity coefficients f increased with increasing biofilm thickness, suggesting reduced diffusion limitation and higher surface area accessibility in the thickest, least dense biofilm (~500 µm). Two types of commonly dosed degradable carbon sources (methanol and ethanol) were investigated in two parallel post-denitrifying systems (MBBR3). The methanol-dosed MBBR exhibited in the enhancement of kBio (up to 2.5-fold) for a number of micropollutants (nine out 23) compared to the ethanol-dosed MBBR, while for 10 compounds biokinetics were similar between the two reactors. The higher denitrification rates exhibited by the ethanol-dosed MBBR during batch experiments likely influenced the biotransformation of the sulfonamides antibiotics, in analogy with what observed in MBBR2. A strong cometabolic effect (i.e., an enhancement of micropollutant biotransformation in the presence of organic carbon) was observed for venlafaxine, carbamazepine, sulfamethoxazole and sulfamethizole. However, an increase in methanol or ethanol loading to the MBBRs during continuous-flow experiment did not influence the removal of the targeted micropollutants, most likely due to the short hydraulic residence time (2 hours) used in the study as well as in full-scale reactors. Diversity-function relationships (assessed through Pearson correlation analyses) were tested by comparing diversity estimators against biomass-normalized biotransformation rates. A positive influence of biodiversity for most of the targeted compounds (~60%) was shown in MBBR2 study, while biotransformation of few compounds (diclofenac and sulfonamides) was positively associated to microbial activity (i.e., nitrification). Similarly, a positive association (p<0.05) with the specific denitification rate was shown in MBBR1, while biotransformation of most of the detected pharmaceuticals in wastewater did not associate or negatively associated with biodiversity. The relationship between biodiversity and micropollutant biotransformation may depend on whether its biotransformation is catalysed by a narrow (i.e., performed by few species) or broad processes. It is likely that for highly redundant microbial processes (such as denitrification), micropollutant biotransformation may be catalysed by broadly distributed enzymes and pathways, and microbial diversity provides no benefit. Conversely, increasing biodiversity under nitrifying conditions may be necessary to increase the inclusion of microorganisms with specific functionality towards micropollutant biotransformation. Overall, the biotransformation rates were significantly enhanced in MBBR3 compared to MBBR1 and MBBR2 for the majority of micropollutants (~60%) suggesting the positive impact of easily degradable carbon sources (such as methanol or ethanol) on micropollutant removal. Finally, the removal of compounds such propranolol atenolol, citalopram, venlafaxine (under post-denitifying conditions) and diclofenac (under aerobic conditions) was improved compared to conventional activated sludge. It can be thus concluded that MBBRs can offer a suitable technology that can be optimized for the removal of micropollutants in municipal wastewaters under a range of operating conditions (nitrifying, pre- and post-denitrifying).
Simple control rules for mitigating N₂O emissions in phase isolated fullscale WWTPs

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ABSTRACT BOOK
ABSTRACT

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Simple control strategy for mitigating N₂O emissions in phase isolated full-scale WWTPs

Nitrous oxide (N₂O) is a strong greenhouse gas (GHG) and ozone depleter, with a warming potential 300 times higher than carbon dioxide (CO₂). 1.2% of the total anthropogenic N₂O emissions are believed to originate from the wastewater treatment (WWT) sector. Conventional biological nutrient removal processes relying on nitrification and denitrification are known to produce N₂O. A one year long-term study of N₂O production and emissions was performed at Lynetten, Denmark’s largest WWTP. Nitrification and denitrification take place by alternating process conditions as well as influent and effluent flows in 20 pairs of interconnected and surface aerated reactors. The long-term data revealed that the N₂O emissions contribute to as much as 30% of the total CO₂ footprint from the WWTP. High ammonium concentrations and long aeration phases lead to high N₂O production and emissions rates. Nitrification phases were identified to produce and emit most of the N₂O. High production and emissions were also associated with the afternoon loading peaks at the WWTP. During denitrification phases N₂O was produced initially but consumed consequently. An effective control strategy was implemented, whereby N₂O emissions were reduced from 0.8% to 0.3% of the nitrogen load during the mitigation period.

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Sorption and diffusion of micropollutants on/in biofilms: experimental observations and a model-based interpretation

In this study we investigated the diffusion and sorption of 22 pharmaceuticals in/on nitrifying biofilms of different thickness. Experimental observations were subject to model-based interpretation and the assessment of a sorption coefficient Kₐ.
and effective diffusivity coefficient $f$. Three biofilm depths were obtained by using Z-carriers (AnoxKaldnes) as support, which allows tight control of biofilm thickness. Biofilms of increasing thickness had increased porosity (and thus decreasing density). Sorption was significant for the positively charged compounds at experimental pH (with few exceptions) and $K_d$ increased with biofilm thickness. The effective diffusivity $f$ negatively correlated with biofilm density, suggesting that diffusion of micropollutants in thinner biofilms could be limited. Overall, this study elucidated how biofilm thickness can positively influence sorption of micropollutants on biofilm as well as how diffusion limitation is strongly impact by biofilm characteristics (density and porosity) and the specific chemical.

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Organisations: Department of Environmental Engineering, Water Technologies, Environmental Chemistry, AnoxKaldnes AB
Contributors: Torresi, E., Polesel, F., Christensson, M., Trapp, S., Smets, B. F., Andersen, H. R., Plósz, B. G.
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**The competitive edge: competition and biofilm composition, an individual-based modelling approach**

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Organisations: Department of Environmental Engineering, Water Technologies, University of Birmingham, Friedrich Schiller University Jena
Contributors: Cockx, B., Clegg, R. J., Lang, S., Kreft, J., Smets, B. F.
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**The Europe - China Water Innovation Balance – Findings from the PIANO project's mapping**

**General information**

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Contributors: Andersen, M. M., McKnight, U. S., Smets, B. F., Liu, J.
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**Tracking and understanding AMR dynamics across European urban water systems**

**General information**

State: Published
A conceptual framework for invasion in microbial communities

There is a growing interest in controlling—promoting or avoiding—the invasion of microbial communities by new community members. Resource availability and community structure have been reported as determinants of invasion success. However, most invasion studies do not adhere to a coherent and consistent terminology nor always include rigorous interpretations of the processes behind invasion. Therefore, we suggest that a consistent set of definitions and a rigorous conceptual framework are needed. We define invasion in a microbial community as the establishment of an alien microbial type in a resident community and argue how simple criteria to define aliens, residents, and alien establishment can be applied for a wide variety of communities. In addition, we suggest an adoption of the community ecology framework advanced by Vellend (2010) to clarify potential determinants of invasion. This framework identifies four fundamental processes that control community dynamics: dispersal, selection, drift and diversification. While selection has received ample attention in microbial community invasion research, the three other processes are often overlooked. Here, we elaborate on the relevance of all four processes and conclude that invasion experiments should be designed to elucidate the role of dispersal, drift and diversification, in order to obtain a complete picture of invasion as a community process.
A conceptual framework for invasion in microbial communities

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A consilience model to describe N₂O production during biological N removal

Nitrous oxide (N₂O), a potent greenhouse gas, is produced during biological nitrogen conversion in wastewater treatment operations. Complex mechanisms underlie N₂O production by autotrophic and heterotrophic organisms, which continue to be unravelled. Mathematical models that describe nitric oxide (NO) and N₂O dynamics have been proposed. Here, a first comprehensive model that considers all relevant NO and N₂O production and consumption mechanisms is proposed. The model describes autotrophic NO production by ammonia oxidizing bacteria associated with ammonia oxidation and with nitrite reduction, followed by NO reduction to N₂O. It also considers NO and N₂O as intermediates in heterotrophic denitrification in a 4-step model. Three biological NO and N₂O production pathways are accounted for, improving the
capabilities of existing models while not increasing their complexity. Abiotic contributions from NH2OH and HNO2 reactions are also included. The consilient model structure can theoretically predict NO and N2O emissions under a wide range of operating conditions and will help develop mitigation strategies.
Biofilm Thickness Influences Biodiversity in Nitrifying MBBRs-Implications on Micropollutant Removal

In biofilm systems for wastewater treatment (e.g., moving bed biofilms reactors-MBBRs) biofilm thickness is typically not under direct control. Nevertheless, biofilm thickness is likely to have a profound effect on the microbial diversity and activity, as a result of diffusion limitation and thus substrate penetration in the biofilm. In this study, we investigated the impact of biofilm thickness on nitrification and on the removal of more than 20 organic micropollutants in laboratory-scale nitrifying MBBRs. We used novel carriers (Z-carriers, AnoxKaldnes) that allowed controlling biofilm thickness at 50, 200, 300, 400, and 500 μm. The impact of biofilm thickness on microbial community was assessed via 16S rRNA gene amplicon sequencing and ammonia monooxygenase (amoA) abundance quantification through quantitative PCR (qPCR). Results from batch experiments and microbial analysis showed that (i) the thickest biofilm (500 μm) presented the highest specific biotransformation rate constants (kbio, L g(-1) d(-1)) for 14 out of 22 micropollutants; (ii) biofilm thickness positively associated with biodiversity, which was suggested as the main factor for the observed enhancement of kbio; (iii) the thinnest biofilm (50 μm) exhibited the highest nitrification rate (gN d(-1) g(-1)), amoA gene abundance and kbio values for some of the most recalcitrant micropollutants (i.e., diclofenac and targeted sulfonamides). Although thin biofilms favored nitrification activity and the removal of some micropollutants, treatment systems based on thicker biofilms should be considered to enhance the elimination of a broad spectrum of micropollutants.
Can we enhance the biotransformation of pharmaceutical micropollutants by controlling biofilm thickness in MBBR?

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Organisations: Department of Environmental Engineering, Water Technologies, Environmental Chemistry, AnoxKaldnes AB
Challenges in microbial ecology: Building predictive understanding of community function and dynamics

The importance of microbial communities (MCs) cannot be overstated. MCs underpin the biogeochemical cycles of the earth's soil, oceans and the atmosphere, and perform ecosystem functions that impact plants, animals and humans. Yet our ability to predict and manage the function of these highly complex, dynamically changing communities is limited. Building predictive models that link MC composition to function is a key emerging challenge in microbial ecology. Here, we argue that addressing this challenge requires close coordination of experimental data collection and method development with mathematical model building. We discuss specific examples where model-experiment integration has already resulted in important insights into MC function and structure. We also highlight key research questions that still demand better integration of experiments and models. We argue that such integration is needed to achieve significant progress in our understanding of MC dynamics and function, and we make specific practical suggestions as to how this could be achieved.

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De novo biofilm community assembly from tap water source communities favors Nitrotoga over Nitrospira under elevated nitrite surface loading

Four main processes are considered to drive microbial community assembly: selection, drift, dispersal and speciation. These processes occur simultaneously, but the extent to which each process contributes to community assembly is unclear in natural communities. We exposed a high-throughput flow-through biofilm system to continuous immigration from a tap water metacommunity while applying different nitrite surface loading rates. After 63 days of operation, we extracted biofilms and analyzed the community composition via Illumina MiSeq targeting the 16S rRNA gene. Previous studies have shown that Nitrospira is the dominant nitrite oxidizing genus in low nitrite environments. Hence, we postulated that by elevating the nitrite surface loading we would select for NOB with lower nitrite affinity than Nitrospira. We observed different dominant NOB species under different loading rates. While in the metacommunity, Nitrotoga and Nitrospira were found at near equal abundances, in the biofilm community, elevated nitrite loading strongly selected for Nitrotoga over Nitrospira. The biofilms were also significantly different in their alpha-diversity (p<0.001) and beta-diversity, and the evenness and richness of the biofilm community decreased significantly (p=0.004) compared to the metacommunity. These observations indicate that the selection towards Nitrotoga and Nitrospira dominated community assembly under different nitrite loadings. Lastly, we compared our observations of community composition with that predicted by neutral community assembly model. The predictions did not match the community structure observed in the biofilms (p=0.31), providing further evidence of the importance of selection during community assembly.
Depth investigation of rapid sand filters for drinking water production reveals strong stratification in nitrification biokinetic behavior

The biokinetic behavior of NH4+ removal was investigated at different depths of a rapid sand filter treating groundwater for drinking water preparation. Filter materials from the top, middle and bottom layers of a full-scale filter were exposed to various controlled NH4+ loadings in a continuous-flow lab-scale assay. NH4+ removal capacity, estimated from short term loading up-shifts, was at least 10 times higher in the top than in the middle and bottom filter layers, consistent with the stratification of Ammonium Oxidizing Bacteria (AOB). AOB density increased consistently with the NH4+ removal rate, indicating their primarily role in nitrification under the imposed experimental conditions. The maximum AOB cell specific NH4+ removal rate observed at the bottom was at least 3 times lower compared to the top and middle layers. Additionally, a significant up-shift capacity (4.6 and 3.5 times) was displayed from the top and middle layers, but not from the bottom layer at increased loading conditions. Hence, AOB with different physiological responses were active at the different depths. The biokinetic analysis predicted that despite the low NH4+ removal capacity at the bottom layer, the entire filter is able to cope with a 4-fold instantaneous loading increase without compromising the effluent NH4+. Ultimately, this filter up-shift capacity was limited by the density of AOB and their biokinetic behavior, both of which were strongly stratified.
Does reactor staging influence microbial structure and functions in biofilm systems? The case of pre-denitrifying MBBRs

To date, a number of treatment technologies and configurations have been tested to improve the elimination of conventional and trace (e.g., pharmaceutical residues) pollutants via biological wastewater treatment. Bioreactor staging and the moving bed biofilm reactor (MBBR) technology have emerged as promising bioengineered solutions (Plósz et al., 2010) for this purpose. In this study, we combined the two solutions and investigated microbial functions (heterotrophic denitrification, pharmaceutical removal) and structure of the microbial community in staged MBBRs for pre-denitrification.
A three-stage MBBR system (S1+S2+S3), fed with pre-clarified wastewater, was operated at laboratory-scale with (i) controlled biomass exposure to organic substrate (COD); and (ii) enhanced the physical retention of biomass, thus inducing adaptation to different substrate exposure conditions. During long-term operation (~500 days) of the three-stage MBBR under continuous-flow conditions, biofilm samples were collected to assess the temporal evolution of the microbial structure in terms of functional gene abundance and biodiversity. A set of batch experiments (day 471) was performed to assess denitrification and pharmaceutical removal in each MBBR, following prolonged biofilm exposure to specific COD availability.

Results from batch experiments showed declining denitrification potential and pharmaceutical biotransformation rate constants ($k_{\text{bio}}$, L gTSS$^{-1}$ d$^{-1}$) from MBBR S1 (exposed to highest COD availability) to S3 (exposed to lowest availability). These findings indicate that the exposure to tiered substrate availability influenced the capacity of utilizing a different range of carbon sources in each MBBR, thus impacting denitrification and pharmaceutical biotransformation. Preliminary analysis on the microbial community based on qPCR (quantitative polymerase chain reaction) showed differences in the abundance of genes (nirS, nirK, nosZ) encoding for denitrifying enzymes in the three staged MBBRs. Further microbial characterization through 16sRNA sequencing (Illumina) is currently under investigation to determine whether differences in microbial functions should be associated to differences in the microbial diversity in the three MBBRs.

**General information**

State: Published
Organisations: Department of Environmental Engineering, Water Technologies, Aarhus University, AnoxKaldnes AB
Contributors: Polesel, F., Torresi, E., Jensen, M. M., Fowler, J., Escola Casas, M., Smets, B. F., Christensson, M., Bester, K., Plósz, B. G.
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Dynamics of N$_2$O production pathways in a full-scale activated sludge system analysed by $^{15}$N/$^{18}$O dual isotope labelling

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Contributors: Ma, C., Jensen, M. M., Smets, B. F., Lavik, G., Thamdrup, B.
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Ecological patterns, diversity and core taxa of microbial communities in groundwater-fed rapid gravity filters

Here, we document microbial communities in rapid gravity filtration units, specifically serial rapid sand filters (RSFs), termed prefilters (PFs) and after-filters (AFs), fed with anoxic groundwaters low in organic carbon to prepare potable waters. A comprehensive 16s rRNA-based amplicon sequencing survey revealed a core RSF microbiome comprising few bacterial taxa (29–30 genera) dominated by Nitrospirae, Proteobacteria and Acidobacteria, with a strikingly high abundance (75–87±18%) across five examined waterworks in Denmark. Lineages within the Nitrospira genus consistently comprised the second most and most abundant fraction in PFs (27±23%) and AFs (45.2±23%), respectively, and were far more abundant than typical proteobacterial ammonium-oxidizing bacteria, suggesting a physiology beyond nitrite oxidation for Nitrospira. Within the core taxa, sequences closely related to types with ability to oxidize ammonium, nitrite, iron, manganese and methane as primary growth substrate were identified and dominated in both PFs (73.6±6%) and AFs (61.4±21%), suggesting their functional importance. Surprisingly, operational taxonomic unit richness correlated strongly and positively with sampling location in the drinking water treatment plant (from PFs to AFs), and a weaker negative correlation held for evenness. Significant spatial heterogeneity in microbial community composition was detected in both PFs and AFs, and was higher in the AFs. This is the first comprehensive documentation of microbial community diversity...
in RSFs treating oligotrophic groundwaters. We have identified patterns of local spatial heterogeneity and dispersal, documented surprising energy–diversity relationships, observed a large and diverse Nitrospira fraction and established a core RSF microbiome.

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Contributors: Gülay, A., Musovic, S., Albrechtsen, H., Al-Soud, W. A., Sørensen, S. J., Smets, B. F.
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- Scopus rating (2016): CiteScore 8.91 SJR 4.938 SNIP 2.248
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- Scopus rating (2015): CiteScore 9.64 SJR 6.385 SNIP 2.473
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- Web of Science (2012): Impact factor 8.951
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- Scopus rating (2011): CiteScore 6.5 SJR 3.732 SNIP 1.826
- Web of Science (2011): Impact factor 7.375
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- Web of Science (2011): Indexed yes
- BFI (2010): BFI-level 2
- Scopus rating (2010): SJR 3.361 SNIP 1.652
- Web of Science (2010): Indexed yes
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Ecological patterns of nitrifiers in the urban water cycle

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Contributors: Diwan, V., Dechesne, A., Smets, B. F., Albrechtsen, H.
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Enhancing the removal of pharmaceuticals in biological wastewater treatment: Is MBBR the answer?

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Organisations: Department of Environmental Engineering, Water Technologies, Environmental Chemistry, Aarhus University, AnoxKaldnes AB
Contributors: Torresi, E., Polesel, F., Escola Casas, M., Smets, B. F., Andersen, H. R., Bester, K., Christensson, M., Plösz, B. G.
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Establishing drinking water biofilms with varying alpha-diversity?

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Organisations: Department of Environmental Engineering, Water Technologies, Urban Water Systems
Contributors: Kinnunen, M., Dechesne, A., Gülay, A., Albrechtsen, H., Smets, B. F.
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Evaluating robustness of a diesel-degrading bacterial consortium isolated from contaminated soil

It is not known whether diesel-degrading bacterial communities are structurally and functionally robust when exposed to different hydrocarbon types. Here, we exposed a diesel-degrading consortium to model either alkanes, cycloalkanes or aromatic hydrocarbons as carbon sources to study its structural resistance. The structural resistance was low, with changes in relative abundances of up to four orders of magnitude, depending on hydrocarbon type and bacterial taxon. This low resistance is explained by the presence of hydrocarbon-degrading specialists in the consortium and differences in growth kinetics on individual hydrocarbons. However, despite this low resistance, structural and functional resilience were high, as verified by re-exposing the hydrocarbon-perturbed consortium to diesel fuel. The high resilience is either due to the short exposure time, insufficient for permanent changes in consortium structure and function, or the ability of some consortium members to be maintained during exposure on degradation intermediates produced by other members. Thus, the consortium is expected to cope with short-term exposures to narrow carbon feeds, while maintaining its structural and functional integrity, which remains an advantage over biodegradation approaches using single species cultures.

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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
Web of Science (2015): Impact factor 3.199
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 2.77 SJR 0.994 SNIP 1.237
Web of Science (2014): Impact factor 2.898
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 2.5 SJR 0.822 SNIP 0.966
Web of Science (2013): Impact factor 2.106
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**

State: Published  
Organisations: Department of Environmental Engineering, Water Technologies, Residual Resource Engineering, Technical University of Denmark  
Contributors: Wágner, D. S., Radovici, M., Smets, B. F., Angelidaki, I., Valverde Pérez, B., Plósz, B. G.  
Number of pages: 8  
Publication date: 2016  
Peer-reviewed: Yes

**Publication information**

Journal: Algal Research  
Volume: 20  
ISSN (Print): 2211-9264  
Ratings:  
BFI (2018): BFI-level 1  
Web of Science (2018): Indexed yes  
BFI (2017): BFI-level 1  
Scopus rating (2017): CiteScore 4.43 SJR 1.142 SNIP 1.171  
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  
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  
ISI indexed (2013): ISI indexed no  
Original language: English  
Keywords: Agronomy and Crop Science, Bioflocculation, Co-digestion, Energy recovery, Enhanced biological phosphorus removal, Green microalgae  
DOIs:  
10.1016/j.algal.2016.10.010  
Source: FindIt  
Source-ID: 2347711116  
Research output: Research - peer-review; Journal article – Annual report year: 2016

**Identifying novel nitrifying bacteria in rapid gravity sand filters using stable isotope probing**

**General information**

State: Published  
Organisations: Department of Environmental Engineering, Water Technologies, Urban Water Systems, University of Southern Denmark  
Contributors: Fowler, J., Gülay, A., Tatari, K., Thamdrup, B., Albrechtsen, H., Sørensen, S. J., Smets, B. F.  
Number of pages: 3  
Publication date: 2016  
Peer-reviewed: Yes  
Event: Abstract from MEWE and biofilms IWA specialist conference, Copenhagen, Denmark.  
Keywords: Nitrification, Comammox nitrospira, Ammonia, Nitrite  
Electronic versions:  
MEWE2016AbstractFowlerFinal.pdf  
Source: PublicationPreSubmission  
Source-ID: 126361322
Investigating comammox Nitrospira in rapid sand filters via metagenomics and single-cell genomics

General information
State: Published
Organisations: Department of Environmental Engineering, Water Technologies, Department of Bio and Health Informatics, Metagenomics, Aarhus University
Pages: 20-21
Publication date: 2016

Host publication information
Title of host publication: Microbial ecology and water engineering & biofilms specialist groups (MEWE2016)
Place of publication: Copenhagen, Denmark
Publisher: IWA
Electronic versions:
MEWE2016_AbstractBookPalomo.pdf

Linking nitrifiers diversity to the flux of their key resources

General information
State: Published
Organisations: Department of Environmental Engineering, Water Technologies, Urban Water Systems
Contributors: Diwan, V., Smets, B. F., Albrechtsen, H., Dechesne, A.
Pages: 204-205
Publication date: 2016

Host publication information
Title of host publication: Microbial ecology and water engineering & biofilms specialist groups (MEWE2016)
Place of publication: Copenhagen, Denmark
Publisher: IWA
Electronic versions:
MEWE2016_Diwan.pdf

Low-sludge age EBPR process for resource recovery – microbial and biochemical process characterization

General information
State: Published
Organisations: Department of Environmental Engineering, Water Technologies, Residual Resource Engineering, Technical University of Denmark
Number of pages: 1
Publication date: 2016
Peer-reviewed: Yes
Electronic versions:
NRR_EBPR_final.pdf
Source: PublicationPreSubmission
Source-ID: 125027354
Research output: Research - peer-review › Poster – Annual report year: 2016

Low-sludge age EBPR process for resource recovery – microbial and biochemical process characterization

General information
State: Published
Organisations: Department of Environmental Engineering, Water Technologies, Technical University of Denmark
Pages: 398-399
Publication date: 2016
Measuring community-wide conjugative plasmid permissiveness

General information
State: Published
Organisations: Department of Environmental Engineering, Water Technologies, University of Copenhagen
Contributors: Smets, B. F., Klümper, U., Dechesne, A., Riber, L., Brandt, K. K., Gülay, A., Sørensen, S. J.
Number of pages: 1
Pages: 62-62
Publication date: 2016

Host publication information
Title of host publication: International Society for Plasmid Biology Plasmid Biology 2016
Place of publication: Cambridge, UK
Electronic versions:
Measuring_community_wide_conjugative_plasmid_permissiveness.pdf
Source: PublicationPreSubmission
Source-ID: 127203168
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2016

Metagenomic analysis of rapid gravity sand filter microbial communities suggests novel physiology of Nitrospira spp

Rapid gravity sand filtration is a drinking water production technology widely used around the world. Microbially catalyzed processes dominate the oxidative transformation of ammonia, reduced manganese and iron, methane and hydrogen sulfide, which may all be present at millimolar concentrations when groundwater is the source water. In this study, six metagenomes from various locations within a groundwater-fed rapid sand filter (RSF) were analyzed. The community gene catalog contained most genes of the nitrogen cycle, with particular abundance in genes of the nitrification pathway. Genes involved in different carbon fixation pathways were also abundant, with the reverse tricarboxylic acid cycle pathway most abundant, consistent with an observed Nitrospira dominance. From the metagenomic data set, 14 near-complete genomes were reconstructed and functionally characterized. On the basis of their genetic content, a metabolic and geochemical model was proposed. The organisms represented by draft genomes had the capability to oxidize ammonium, nitrite, hydrogen sulfide, methane, potentially iron and manganese as well as to assimilate organic compounds. A composite Nitrospira genome was recovered, and amo-containing Nitrospira genome contigs were identified. This finding, together with the high Nitrospira abundance, and the abundance of atypical amo and hao genes, suggests the potential for complete ammonium oxidation by Nitrospira, and a major role of Nitrospira in the investigated RSFs and potentially other nitrifying environments.

General information
State: Published
Organisations: Department of Systems Biology, Department of Environmental Engineering, Water Technologies, Center for Biological Sequence Analysis, Metagenomics
Contributors: Palomo, A., Fowler, J., Gülay, A., Rasmussen, S., Sicheritz-Pontén, T., Smets, B. F.
Number of pages: 13
Pages: 2569–2581
Publication date: 2016
Peer-reviewed: Yes

Publication information
Journal: The I S M E Journal
Volume: 10
ISSN (Print): 1751-7362
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 9.5 SJR 4.813 SNIP 2.284
Web of Science (2017): Impact factor 9.52
Metagenomics and single-cell genomics reveal high abundance of comammox Nitrospira in a rapid gravity sand filter treating groundwater

The recent discovery of complete ammonia oxidizing (comammox) Nitrospira has revealed that the metabolic division of labor in nitrification is not obligate as was assumed during the last century. Despite the detection and enrichment of comammox Nitrospira from different nitrifying environments, the ecological relevance of comammox remains unknown. In this study, we analyzed the microbial communities from various locations within a groundwater-fed rapid sand filter (RSF), where Nitrospira were at very high relative abundances. Through metagenomics, a highly abundant composite multi-genome of Nitrospira genus was recovered harboring metabolic capacity for complete ammonia oxidation. We developed a cell extraction strategy that enables the disruption of Nitrospira cell clusters attached to the mineral coating of the sand. Individual cells were identified via fluorescent in situ hybridization (FISH) with Nitrospira-specific 16S rRNA probes and
sorted via fluorescence-activated cell sorting (FACS). Sorted cells were screened and selected Nitrospira spp. were subject to whole-genome sequencing. The single cell genomes confirmed the genomic presence of a complete ammonia oxidation pathway and revealed clear taxonomic differences with the recently described comammox Nitrospira genomes. The high abundance of comammox Nitrospira spp. together with the low abundance of canonical ammonia oxidizing prokaryotes in the investigated RSF system suggests the essential role of this novel comammox Nitrospira in the RSFs and potentially other nitrifying environments.

**General information**

**State:** Published  
**Organisations:** Department of Environmental Engineering, Water Technologies, Department of Systems Biology, Center for Biological Sequence Analysis, Metagenomics, Department of Bio and Health Informatics, Aarhus University  
**Contributors:** Palomo, A., Fowler, J., Gülay, A., Rasmussen, S., Schramm, A., Sicheritz-Pontén, T., Smets, B. F.  
**Number of pages:** 1  
**Publication date:** 2016  
**Peer-reviewed:** Yes  
**Event:** Abstract from 16th International Symposium on Microbial Ecology, Montreal, Canada.

**Microbes in biological processes for municipal landfill leachate treatment: Community, function and interaction**

Landfill leachate (LFL) contains high strength of ammonium and complex organic substances including biodegradable volatile fatty acids (VFAs), refractory aquatic humic substances (AHS) and micro-scale xenobiotic organic chemicals (XOCs), which promotes the diverse microbial community in LFL treatment bioreactors. These microbes cooperate to remove nitrogen, biodegrade organic matters, eliminate the toxicity of XOCs and produce energy. In these diverse microbes, some show dominant in the bioreactor and are prevalent in many kinds of LFL treatment bio-processes, such as Brocadia from the phylum of Planctomycetes, Nitrosomonas sp., the phylum of Proteobacteria, Bacteroidetes and Firmicutes. The bioreactor's operational parameters influence the microbial community, inversely affect the bioreactor's performance. It is practical to accumulate desirable microbes by managing the bioreactor's running condition. High ammonium loading, low DO (<2 mg l⁻¹) and optimal pH value are the practical way to accumulate the desirable AOB and realize the partial nitrification. Nitrite and organic matters inhibit the anaerobic ammonium oxidation bacteria (AnAOB). In anaerobic LFL treatment bioreactors, Methanosaeta and Methanosarcina can outcompete sulfur reducing bacteria and homoacetogens to be the dominant Archaea. Nitrite oxidizing bacteria (NOB), heterotrophic denitrifying bacteria and AnAOB compete nitrite and influenced each other. How to manage NOB, heterotrophic denitrifying bacteria and AnAOB in good cooperation condition is still an issue and need further study.

**General information**

**State:** Published  
**Organisations:** Department of Environmental Engineering, Water Technologies, Harbin Institute of Technology, Aalto University  
**Contributors:** Zhang, D., Vahala, R., Wang, Y., Smets, B. F.  
**Pages:** 88-96  
**Publication date:** 2016  
**Peer-reviewed:** Yes
Microbial and biochemical process characterization of a low-sludge age EBPR process for resource recovery

General information
State: Published
Organisations: Department of Environmental Engineering, Water Technologies, Residual Resource Engineering, Technical University of Denmark
Number of pages: 1
Publication date: 2016
Peer-reviewed: Yes
Event: Poster session presented at MEWE and biofilms IWA specialist conference, Copenhagen, Denmark.
Electronic versions:
MEWE_EBPR.pdf
Source: PublicationPreSubmission
Source-ID: 125775512
Research output: Research - peer-review › Poster – Annual report year: 2016

Microbial biodiversity enhances micropollutants biotransformation in Moving Bed Biofilm Reactors (MBBR) with controlled biofilm thickness

General information
State: Published
Organisations: Department of Environmental Engineering, Water Technologies, Environmental Chemistry, AnoxKaldnes AB
Number of pages: 1
Publication date: 2016
Peer-reviewed: Yes
Event: Abstract from International Conference on Emerging Contaminants (EmCon2016) and Micropollutants (WiOW2016) in the Environment, Sydney, Australia.
Electronic versions:
Abstract_Z_carriers_Elena_Torresi.pdf
Source: PublicationPreSubmission
Source-ID: 127257912
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2016

Optimizing nitrification in biological rapid sand filters for drinking water production

Addition of phosphate or trace metals or better management e.g. in terms of ammonium load can improve the nitrification rate and efficiency in biological rapid sand filters.

General information
State: Published
Contributors: Albrechtsen, H., Smets, B. F., Lee, C. O., Tatari, K., Nielsen, P. B., Binning, P. J., Boe-Hansen, R., Wagner, F. B.
Number of pages: 4
Publication date: 2016
Peer-reviewed: Yes
Event: Abstract from IWA World Water Congress & Exhibition 2016, Queensland, Australia.
Keywords: Nitrification, Phosphate, Tracemetals
Electronic versions:
IWA_WWCE16_Albrechtsen_Nitrification_373968_20161010_Orbit.pdf
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2016

Sammenhæng mellem aktivitet af metanoksiderende bakterier, opformeret fra sandfiltre på danske vandværker, og nedbrydningen af pesticidet bentazon

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Systems, Water Technologies
Contributors: Hedegaard, M. J., Delinere, H., Prasse, C., Dechesne, A., Smets, B. F., Albrechtsen, H.
Short-sludge age EBPR process – Microbial and biochemical process characterisation during reactor start-up and operation

The new paradigm for used water treatment suggests the use of short solid retention times (SRT) to minimize organic substrate mineralization and to maximize resource recovery. However, little is known about the microbes and the underlying biogeochemical mechanisms driving these short-SRT systems. In this paper, we report the start-up and operation of a short-SRT enhanced biological phosphorus removal (EBPR) system operated as a sequencing batch reactor (SBR) fed with preclarified municipal wastewater, which is supplemented with propionate. The microbial community was analysed via 16S rRNA amplicon sequencing. During start-up (SRT = 8 d), the EBPR was removing up to 99% of the influent phosphate and completely oxidized the incoming ammonia. Furthermore, the sludge showed excellent settling properties. However, once the SRT was shifted to 3.5 days nitrification was inhibited and bacteria of the *Thiothrix* taxon proliferated in the reactor, thereby leading to filamentous bulking (sludge volume index up to SVI = 1100 mL/g). Phosphorus removal deteriorated during this period, likely due to the out-competition of polyphosphate accumulating organisms (PAO) by sulphate reducing bacteria (SRB). Subsequently, SRB activity was suppressed by reducing the anaerobic SRT from 1.2 day to 0.68 day, with a consequent rapid SVI decrease to ~200 mL/g. The short-SRT EBPR effectively removed phosphate and nitrification was mitigated at SRT = 3 days and oxygen levels ranging from 2 to 3 mg/L.

General information

State: Published
Organisations: Department of Environmental Engineering, Water Technologies, Technical University of Denmark
Number of pages: 10
Pages: 320-329
Publication date: 2016
Peer-reviewed: Yes

Publication information

Journal: Water Research
Volume: 104
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
Sources and propagation of uncertainty in N2O model predictions

General information
State: Published
Organisations: Department of Environmental Engineering, Water Technologies, Department of Chemical and Biochemical Engineering, CAPEC-PROCESS
Spatial distribution of microbial community and N\textsubscript{2}O depth profiles in counter- and co-diffusion biofilms functioning simultaneously nitrification and denitrification

General information
State: Published
Organisations: Department of Environmental Engineering, Water Technologies, Tokyo University of Agriculture and Technology, National Institute of Advanced Industrial Science and Technology
Pages: 76-77
Publication date: 2016

Host publication information
Title of host publication: Microbial ecology and water engineering & biofilms specialist groups (MEWE2016)
Place of publication: Copenhagen, Denmark
Publisher: IWA
Electronic versions:
MEWE2016_AbstractBookterada.pdf
Research output: Research - peer-review > Conference abstract in proceedings – Annual report year: 2017

Stable isotope probing and dynamic loading experiments provide insight into the ecophysiology of novel ammonia oxidizers in rapid gravity sand filters

Nitrification is often the dominant microbial process in rapid gravity sand filters (RSF), used to treat aerated groundwater to produce drinking water. RSFs harbor diverse microbial communities including a range of ammonia oxidizing clades; Betaproteobacteria (Nitrosomonas, Nitrosospira), Archaea, diverse potentially ammonia oxidizing heterotrophs and abundant Nitrospira spp., recently shown to comprise both canonical nitrite oxidizing as well as complete ammonium oxidizing (comammox) types. We examined the contributions of the different ammonia oxidizers to in situ ammonia oxidation, and aimed to elucidate the differences in ecophysiology between the ammonia oxidizing clades that enable them to co-exist in this unique environment. Experiments were conducted using sand columns designed and operated to mimic the conditions in the full-scale parent RSF. RNA and DNA stable isotope probing based on 13C-bicarbonate incorporation during continuous feeding with either ammonium or nitrite as sole energy source implicated Nitrospira spp. and certain 'heterotrophic' bacteria in addition to Nitrosomonas spp. in autotrophy during ammonium oxidation in RSFs. Further experimentation aimed to elucidate the ecophysiology of each ammonia oxidizing clade in RSFs, in particular comammox Nitrospira for which little is currently known. Columns were fed with RSF effluent spiked with various concentrations of ammonium ranging from 0.1-5.0 mg/L delivered at different loading rates to examine the effects of both ammonium loading and oxygen limitation on ammonia oxidizers. Our observations indicate that the native conditions in the RSF used in this study foster the enrichment of comammox Nitrospira, which provides a preliminary step in the description of their ecophysiology.

General information
State: Published
Organisations: Department of Environmental Engineering, Water Technologies, Urban Water Systems, University of Copenhagen, University of Southern Denmark
Number of pages: 1
Publication date: 2016
Peer-reviewed: Yes
Event: Abstract from 16th International Symposium on Microbial Ecology, Montreal, Canada.
Electronic versions:
PS03_Nitrogen_assimilation.pdf
Source: PublicationPreSubmission
Source-ID: 126360804
Research output: Research - peer-review > Conference abstract for conference – Annual report year: 2016
Suppression of nitrite-oxidizing bacteria in intermittently aerated biofilm reactors: a model-based explanation

General information
State: Published
Organisations: Department of Environmental Engineering, Water Technologies
Contributors: Ma, Y., Domingo Felez, C., Plósz, B. G., Smets, B. F.
Number of pages: 1
Publication date: 2016
Peer-reviewed: Yes
Event: Poster session presented at MEWE and biofilms IWA specialist conference, Copenhagen, Denmark.

The formation dynamics of microbial aggregates

General information
State: Published
Organisations: Department of Environmental Engineering, Water Technologies, University of Birmingham
Contributors: Cockx, B., Clegg, R. J., Kreft, J., Smets, B. F.
Number of pages: 1
Publication date: 2016
Peer-reviewed: Yes
The impact of backwashing on nitrification in biological rapid sand filters under different ammonium loading conditions

General information
State: Published
Pages: 29-29
Publication date: 2016

Host publication information
Title of host publication: 10th annual meeting of DWF16 : Abstracts
Publisher: Danish Water Forum
Electronic versions: DWF_The_impact_of_backwashing_on_nitrification_in_biological_rapid_sand_filters_under_different_ammonium_loading_conditions.pdf
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2016

The influence of reactor staging on microbial structure and functions in pre-denitrifying MBBRs

General information
State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry, Water Technologies, Aarhus University, AnoxKaldnes AB
Contributors: Polesel, F., Torresi, E., Jensen, M. M., Escola Casas, M., Bester, K., Christensson, M., Smets, B. F.
Pages: 92-93
Publication date: 2016

Host publication information
Title of host publication: Microbial ecology and water engineering & biofilms specialist groups (MEWE2016)
Place of publication: Copenhagen, Denmark
Publisher: IWA
Electronic versions: MEWE2016_AbstractBookpolesel.pdf
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2017

The perks of agent-based modelling with iDynoMICS 2

General information
State: Published
Organisations: Department of Environmental Engineering, Water Technologies, University of Birmingham, Friedrich Schiller University Jena
Contributors: Cockx, B., Clegg, R. J., Lang, S., Smets, B. F., Kreft, J.
Number of pages: 1
Publication date: 2016
Peer-reviewed: Yes
Event: Poster session presented at MEWE and biofilms IWA specialist conference, Copenhagen, Denmark.
Electronic versions: MEWE_alternative.pdf
Source: PublicationPreSubmission
Source-ID: 127189190
Research output: Research - peer-review › Poster – Annual report year: 2016

The perks of agent-based modelling with iDynoMICS 2

General information
State: Published
Organisations: Department of Environmental Engineering, Water Technologies, University of Birmingham, Friedrich Schiller University Jena
Towards a consensus-based biokinetic model for green microalgae – The ASM-A

Cultivation of microalgae in open ponds and closed photobioreactors (PBRs) using wastewater resources offers an opportunity for biochemical nutrient recovery. Effective reactor system design and process control of PBRs requires process models. Several models with different complexities have been developed to predict microalgal growth. However, none of these models can effectively describe all the relevant processes when microalgal growth is coupled with nutrient removal and recovery from wastewaters. Here, we present a mathematical model developed to simulate green microalgal growth (ASM-A) using the systematic approach of the activated sludge modelling (ASM) framework. The process model – identified based on a literature review and using new experimental data – accounts for factors influencing photoautotrophic and heterotrophic microalgal growth, nutrient uptake and storage (i.e. Droop model) and decay of microalgae. Model parameters were estimated using laboratory-scale batch and sequenced batch experiments using the novel Latin Hypercube Sampling based Simplex (LHSS) method. The model was evaluated using independent data obtained in a 24-L PBR operated in sequenced batch mode. Identifiability of the model was assessed. The model can effectively describe microalgal biomass growth, ammonia and phosphate concentrations as well as the phosphorus storage using a set of average parameter values estimated with the experimental data. A statistical analysis of simulation and measured data suggests that culture history and substrate availability can introduce significant variability on parameter values for predicting the reaction rates for bulk nitrate and the intracellularly stored nitrogen state-variables, thereby requiring scenario specific model calibration. ASM-A was identified using standard cultivation medium and it can provide a platform for extensions accounting for factors influencing algal growth and nutrient storage using wastewater resources.
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
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
Towards an optimal experimental design for N2O model calibration during biological nitrogen removal

Process models describing nitrous oxide (N2O) production during biological nitrogen removal allow for the development of mitigation strategies of this potent greenhouse gas. N2O is an intermediate of nitrogen removal, hence its prediction is negatively affected by the uncertainty associated to its substrates. Improving experimental designs for model calibration reduces prediction uncertainties. Moreover, the individual analysis of autotrophic and heterotrophic contribution to the total NO and N2O pool was assessed for already proposed model structures under different experimental scenarios. The results show the need for information-rich experimental designs to assess the predicting capabilities of N2O models. This work represents a step further in understanding the N2O production and emissions associated to conventional wastewater treatment. Moreover, it will facilitate the development of strategies to minimize the carbon footprint of wastewater treatment plants.

General information
State: Published
Organisations: Department of Environmental Engineering, Water Technologies, Department of Chemical and Biochemical Engineering, CAPEC-PROCESS
Contributors: Domingo Felez, C., Valverde Pérez, B., Plósz, B. G., Sin, G., Smets, B. F.
Number of pages: 3
Publication date: 2016
Peer-reviewed: Yes
Event: Abstract from 5th IWA/WEF Wastewater Treatment Modelling Seminar 2016, Annecy, France.
Keywords: Modelling, N2O, Uncertainty, Production pathway, Experimental design
Electronic versions:
WWTmod2016_cadf.pdf
Source: PublicationPreSubmission
Source-ID: 127825456
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2016

Underestimation of ammonia-oxidizing bacteria abundance by amplification bias in amoA-targeted qPCR

Molecular methods to investigate functional groups in microbial communities rely on the specificity and selectivity of the primer set towards the target. Here, using rapid sand filters for drinking water production as model environment, we investigated the consistency of two commonly used quantitative PCR methods to enumerate ammonia-oxidizing bacteria (AOB): one targeting the phylogenetic gene 16S rRNA and the other, the functional gene amoA. Cloning-sequencing with both primer sets on DNA from two waterworks revealed contrasting images of AOB diversity. The amoA-based approach preferentially recovered sequences belonging to Nitrosomonas Cluster 7 over Cluster 6A ones, while the 16S rRNA one yielded more diverse sequences belonging to three AOB clusters, but also a few non-AOB sequences, suggesting broader, but partly unspecific, primer coverage. This was confirmed by an in silico coverage analysis against sequences of AOB (both isolates and high-quality environmental sequences). The difference in primer coverage significantly impacted the estimation of AOB abundance at the waterworks with high Cluster 6A prevalence, with estimates up to 50-fold smaller for amoA than for 16S rRNA. In contrast, both approaches performed very similarly at waterworks with high Cluster 7 prevalence. Our results highlight that caution is warranted when comparing AOB abundances obtained using different qPCR primer sets.

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Organisations: Department of Environmental Engineering, Water Technologies
Contributors: Dechesne, A., Musovic, S., Palomo, A., Diwan, V., Smets, B. F.
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Used water resource recovery using green microalgae

A paradigm shift is promoted in wastewater treatment whereby wastewater is considered as a source of nutrients, water and energy, rather than waste and it is referred to as used water. Microalgae cultivation on used water resources offers the potential to recover nitrogen, phosphorus, water and energy. When coupling with used water treatment, microalgae is mostly considered to produce energy through biofuel production. A novel used water resource recovery approach was presented earlier, referred to as TRENS – a fully biochemical process for the removal, recovery and reuse of used water.
resources promoting sustainable urban water management. The system consists of a low solids retention time (SRT) enhanced biological phosphorus removal and recovery (EBP2R) system that can provide optimal cultivation medium – in terms of nutrients and water – for downstream microalgal cultivation. The microalgal suspension cultivated in the photobioreactor (PBR) can be then used for e.g., “fertigation” on agricultural land whereby the water and the nutrients are recovered. Alternatively, the algal biomass can be harvested and can be used for co-digestion in existing anaerobic digesters, whereas the water content can be used for aquifer recharge.

Design and optimization of bacterial-microalgal systems requires process models that can be readily combined with consensus used water treatment models, e.g. the activated sludge models (ASM). Previous microalgal process models cannot be used for such purposes as a result of their deficiencies. Some lack e.g., accounting for the storage of nitrogen and phosphorus and for the potential for microalgae to grow heterotrophic on organic carbon that are relevant processes for used water resource recovery systems.

Therefore, the first objective of this thesis is to develop a consensus-based microalgal process model (ASM-A) accounting for photoautotrophic and heterotrophic microalgal growth, the uptake and storage of nitrogen and phosphorus and decay. The model was developed in the ASM framework as an extension to ASM-2d, thus it can be readily connected to bacterial unit processes. The process rates of the microalgal model were identified based on extensive literature review. Laboratory experiments in differently scaled batch PBRs were conducted in order to provide proper measurement data for model identification, comprising the selection of process rate equations as well as the estimation of the stoichiometric and kinetic model parameter distribution. The model identifiability analysis was conducted using the Latin Hypercube Sampling based Simplex (LHSS) method, adapted from the literature. The process model identified can effectively describe microalgal biomass concentration, soluble ammonium and phosphate concentrations as well as the phosphorus storage. The nitrogen storage is found to be affected by substrate availability, whilst the soluble nitrate concentration depends on the culture history, thereby requiring scenario specific model calibration. One of the most important factors affecting microalgal growth is the available light. Thus, for predicting the light distribution, the effect of using different simulation model structures on the model accuracy and uncertainty was assessed. Moreover, the effects of light scattering, biomass concentration and pigmentation on light attenuation in PBRs were investigated, using laboratory-scale experimental data. The light attenuation coefficient was estimated using the Lambert-Beer equation. Results suggest that light attenuation depends primarily on the pigmentation of the microalgae and also on the biomass concentration. Moreover, using a discretized layer-model to describe the light distribution in PBRs can result in more accurate prediction of the microalgal growth as well as the reduction of the uncertainty of the model predictions.

Furthermore, the effect of the variation of influent N-to-P ratio on the reactor performance was assessed in a mixed consortium of Chlorella and Scenedesmus sp. as well as in a monoculture of Chlorella sp. (both commonly used in used water treatment systems) in continuous cultivation using the treated used water from the upstream EBP2R system. When the N-to-P ratio in the influent was lowered to a sub-optimal level diatoms proliferated in the PBR cultivating the mixed green microalgal consortium. Once the ratio was increased again, the diatoms could be washed out of the system. Model predictive accuracy deteriorated as a result of the changes in culture composition due to the possible change in microalgal kinetics. The variation of the N-to-P ratio did not have an effect on the composition of the monoculture of Chlorella sp., no contamination was encountered during the 85 days of cultivation on used water. The upstream bacterial unit process in the second case was operated at a higher SRT (16 d), suggesting that longer SRT might be able to mitigate the potential of contamination by other microalgal species.

Lastly, an innovative method was developed to harvest microalgal biomass grown in suspended cultures in the TREN system. A two-step flocculation was applied, whereby in the first step cationic polymer was added to the microalgae to destabilize the cells, then in the second step the aggregation of flocs was enhanced by the addition of bacterial biomass wasted in the upstream short-SRT EBPR process. Effective recovery was obtained (97%), by the significant (40%) reduction in the amount of cationic polymer required compared to the case when only cationic polymer was used for the flocculation without the addition of bacteria, thus further reducing harvesting costs. The biomethane potential of the harvested microalgal-bacterial biomass was estimated at mesophilic conditions, obtaining synergistic effect when co-digesting the two substrates and resulting in a maximum methane yield of 560±24 mlCH4/gVS.

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Organisations: Department of Environmental Engineering, Water Technologies
Contributors: Wagner, D. S., Plósz, B. G., Smets, B. F.
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A comprehensive 454 survey provides insights into microbial diversity and community structure in rapid sand filters

General Information
An improved method to set significance thresholds for β-diversity testing in microbial community comparisons: Setting significance threshold for β-diversity

Exploring the variation in microbial community diversity between locations (β diversity) is a central topic in microbial ecology. Currently, there is no consensus on how to set the significance threshold for β diversity. Here, we describe and quantify the technical components of β diversity, including those associated with the process of subsampling. These components exist for any proposed β diversity measurement procedure. Further, we introduce a strategy to set significance thresholds for β diversity of any group of microbial samples using rarefaction, invoking the notion of a meta-community. The proposed technique was applied to several in silico generated operational taxonomic unit (OTU) libraries and experimental 16S rRNA pyrosequencing libraries. The latter represented microbial communities from different biological rapid sand filters at a full-scale waterworks. We observe that β diversity, after subsampling, is inflated by intra-sample differences; this inflation is avoided in the proposed method. In addition, microbial community evenness (Gini > 0.08) strongly affects all β diversity estimations due to bias associated with rarefaction. Where published methods to test β significance often fail, the proposed meta-community-based estimator is more successful at rejecting insignificant β diversity values. Applying our approach, we reveal the heterogeneous microbial structure of biological rapid sand filters both within and across filters.

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Contributors: Gülay, A., Smets, B. F.
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Scopus rating (2017): CiteScore 4.83 SJR 2.209 SNIP 1.31
Web of Science (2017): Impact factor 4.974
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.02 SJR 2.377 SNIP 1.383
Web of Science (2016): Impact factor 5.395
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.61 SJR 3.02 SNIP 1.571
Web of Science (2015): Impact factor 5.932
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.6 SJR 2.862 SNIP 1.599
A nitrate sensitive planar optode: performance and interferences

We present a newly developed nitrate sensitive planar optode. It exhibits a linear response to nitrate from 1 to 50 mM at pH 8.0, a fast response time below 10 s and a good lifetime, allowing for fast two dimensional nitrate measurements over long periods of time. Interference from nitrite, chloride and thiocyanate, however, limits the optode's application in environments where these are encountered, notably seawater with its high chloride content.

General information
A novel control strategy for single-stage autotrophic nitrogen removal in SBR

A novel feedforward–feedback control strategy was developed for complete autotrophic nitrogen removal in a sequencing batch reactor. The aim of the control system was to carry out the regulation of the process while keeping the system close to the optimal operation. The controller was designed based on a process model and then tested experimentally. The resulting batch-to-batch control strategy had the total nitrogen removal efficiency as controlled variable and the setting of the aeration mass flow controller as manipulated variable. Compared to manual operation mode (constant air supply), the controller resulted in a significant performance improvement: removal efficiency was kept at a stable high level in the presence of influent ammonium concentration disturbances, and the absolute deviation on removal efficiency was reduced by 40%. The successful validation of the controller in a lab-scale reactor is a promising result, which brings this control strategy one step closer to full-scale implementation.
A novel high-throughput drip-flow system to grow autotrophic biofilms of contrasting diversities

The impact of community diversity on the functioning and assembly of microbial systems remains a central question in microbial ecology. This question is often addressed by either combining a few cultures without necessarily a history of coexistence, or by using environmental communities, which are often ill controlled and thus likely to be poorly reproducible. The purpose of this work is to develop a high-throughput continuous-flow system for growing replicate microbial biofilms of varying, but controlled, average thickness and associated community diversity. With these replicate biofilms, the effect of community composition and diversity on various ecological processes can then be rigorously examined. We hypothesize that the increased loading, resulting in thicker biofilms, will decrease the drift in the community and impose limited environmental filtering by providing more diverse niches. Thus, thicker biofilms are likely to host greater diversity. A system with 40 replicates has been constructed using flow-through polypropylene columns housing a defined number of single-sized glass beads supported by a stainless steel mesh. Biofilms consisting primarily of ammonia oxidizing and nitrite oxidizing bacteria are cultivated on the beads using a drip-flow assembly by feeding a mineral medium containing ammonium-N as sole energy source. Biofilm thickness is controlled by setting the surficial loading rate to 0.168 g NH4-N/m2/day or 1.678 g NH4-N/m2/day, which should theoretically result in biofilms with average thickness of 100 or 1000 μm. We will present the differences observed in community composition between systems run at high and low loading rates for 60 days. We will also evaluate community activity by measuring nitrification efficiency and correlate
to microbial diversity. In conclusion, we hope to demonstrate a high-replicate biofilm cultivation systems that allow us, by altering the loading rate, to engineer biofilms towards prescribed differences in composition, opening new opportunities to explore community assembly processes and their link to ecosystem function.

**General information**

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Organisations: Department of Environmental Engineering, Urban Water Engineering
Contributors: Kinnunen, M., Dechesne, A., Albrechtsen, H., Smets, B. F.
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**Challenges encountered calibrating N2O dynamics from mixed cultures**

**General information**

State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering, Residual Resource Engineering, Environmental Chemistry, Department of Chemical and Biochemical Engineering, CAPEC-PROCESS, Technical University of Denmark
Contributors: Domingo Felez, C., Pellicer i Nàcher, C., Petersen, M. S., González-Combarros, R., Jensen, M. M., Sin, G., Smets, B. F.
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Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2015

**EBP2R – An innovative enhanced biological nutrient recovery activated sludge system to produce growth medium for green microalgae cultivation**

Current research considers wastewater as a source of energy, nutrients and water and not just a source of pollution. So far, mainly energy intensive physical and chemical unit processes have been developed to recover some of these resources, and less energy and resource demanding alternatives are needed. Here, we present a modified enhanced biological phosphorus removal and recovery system (referred to as EBP2R) that can produce optimal culture media for downstream micro-algal growth in terms of N and P content. Phosphorus is recovered as a P-stream by diversion of some of the effluent from the upstream anaerobic reactor. By operating the process at comparably low solids retention times (SRT), the nitrogen content of wastewater is retained as free and saline ammonia, the preferred form of nitrogen for most micro-algae. Scenario simulations were carried out to assess the capacity of the EBP2R system to produce nutrient rich organic-carbon depleted algal cultivation media of target composition. Via SRT control, the quality of the constructed cultivation media can be optimized to support a wide range of green micro-algal growth requirements. Up to 75% of the influent phosphorus can be recovered, by diverting 30% of the influent flow as a P-stream at an SRT of 5 days. Through global sensitivity analysis we find that the effluent N-to-P ratio and the P recovered are mainly dependent on the influent quality rather than on biokinetics or stoichiometry. Further research is needed to demonstrate that the system performance predicted through the model-based design can be achieved in reality.

**General information**

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Organisations: Department of Environmental Engineering, Urban Water Engineering
Contributors: Valverde Perez, B., Ramin, E., Smets, B. F., Plósz, B. G.
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**Publication information**

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Volume: 68
Evaluating Alternate Biokinetic Models for Trace Pollutant Cometabolism

Mathematical models of cometabolic biodegradation kinetics can improve our understanding of the relevant microbial reactions and allow us to design in situ or in-reactor applications of cometabolic bioremediation. A variety of models are available, but their ability to describe experimental data has not been systematically evaluated for a variety of operational/experimental conditions. Here five different models were considered: first-order; Michaelis-Menten; reductant; competition; and combined models. The models were assessed on their ability to fit data from simulated batch experiments covering a realistic range of experimental conditions. The simulated observations were generated by using the most complex model structure and parameters based on the literature, with added experimental error. Three criteria were used to evaluate model fit: ability to fit the simulated experimental data, identifiability of parameters using a collinearity analysis, and suitability of the model size and complexity using the Bayesian and Akaike Information criteria. Results show that no single model fits data well for a range of experimental conditions. The reductant model achieved best results, but required very different parameter sets to simulate each experiment. Parameter nonuniqueness was likely to be due to the parameter correlation. These results suggest that the cometabolic models must be further developed if they are to reliably simulate experimental and operational data.

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Contributors: Liu, L., Binning, P. J., Smets, B. F.
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Impact of operational conditions and reactor configuration on process performance and microbial community in short solid retention time EBPR systems

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Influence of biofilm thickness on micropolllutants removal in nitrifying MBBRs
The removal of pharmaceuticals was investigated in nitrifying Moving Bed Biofilm Reactors (MBBRs) containing carriers with different biofilm thicknesses. The biofilm with the thinnest thickness was found to have the highest nitrification and biotransformation rate for some key pharmaceuticals. Microbial analysis revealed a different relative abundance of nitrifying guilds in the different carriers, suggesting the importance of nitrite oxidizing bacteria in removal of micropolllutants.

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Organisations: Department of Environmental Engineering, Veolia Water Technologies AB
Contributors: Torresi, E., Andersen, H. R., Smets, B. F., Plósz, B. G., Christensson, M.
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Magnitude and determinants of plasmid transfer from exogenous donor strains to complex microbial communities

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Organisations: Department of Environmental Engineering, Urban Water Engineering, University of Copenhagen, Technical University of Denmark
Contributors: Klümper, U., Dechesne, A., Riber, L., Droumpali, A., Brandt, K., Sørensen, S., Smets, B. F.
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Bibliographical note
Oral Presentation.
Management of microbial community composition, architecture and performance in autotrophic nitrogen removing bioreactors through aeration regimes

Completely autotrophic nitrogen removal from nitrogen-rich wastewaters through the nitritation-plus-anamox ammonium oxidation processes can greatly reduce operational energy costs compared to traditional nitrogen removal processes. The footprint can be further reduced by process intensification in single-stage reactors. Single-stage reactors require biofilms or bioaggregates to provide the complementary redox niches for the aerobic and anaerobic bacteria that are required for nitritation and anaerobic ammonium oxidation (anamox), respectively. The nitritation/anamox process might not only reduce aeration and carbon requirements but also reduce emissions of the greenhouse gas nitrous oxide.

Successful performance of the intense energy-efficient nitritation/anamox process requires a rather narrow operational window. Outside of this window, disproportionate activities of the involved functional guilds and emergence of undesired guilds can rapidly deteriorate the performance, which will offset the reduced footprint and stability. Hence, robust operational strategies that incorporate microbial process understanding are necessary.

In this work, aeration strategies were systematically evaluated as an approach to manipulate the microbial community structure, to reach efficient nitrogen removal performance, and to reduce nitrous oxide emissions from single-stage nitritation/anamox reactors. First, an iterative protocol was developed to diagnose reactor performance based on process stoichiometry and to propose actions to enhance performance based on discretized aeration parameters, restricted by an overall ratio of oxygen to ammonium loading. The protocol was successfully applied on two bioaggregate-based single-stage sequencing batch reactors during start-up; while recovering from major disturbances such as nitrite accumulation, nitrite oxidizer proliferation, ammonium starvation, and oxygen overloading; and during nitrogen loading increases. Different mitigation methods were validated or falsified ultimately improving the proposed protocol. Differences in performance and, especially, of time resolved nitrogen species dynamics, of the two parallel systems under similar aeration regimes indicated that the aggregate size distribution and microbial community architectures profoundly affected the optimal oxygen to ammonium loadings. Size-segregated aggregates consisting of exclusively aerobic or exclusively anaerobic ammonium oxidizing guilds, could achieve removal efficiencies comparable to stratified aggregates (containing both aerobic and anaerobic ammonium oxidizing guilds), at sufficiently low oxygen to ammonium loadings. However, transient nitrite accumulation and susceptibility of anaerobic ammonium oxidizing bacteria in systems with size-segregated aggregates were considered to weaken the system robustness.

Further assessment of the interaction between aeration regime and architectural evolution of the nitritation/anamox aggregates was carried out on the two systems once they achieved steady state overall performance. With settling time, volumetric exchange ratio, sludge retention time and influent characteristics kept constant, the aeration regime, itself, caused changes in aggregate architecture and aggregate size distribution. By increasing aeration frequency, the originally size-segregated community became more redox-stratified with larger aggregates. Increasing the duration of aeration, on the other hand, did not significantly alter the original redox-stratified architecture, but allowed proliferation of unwanted nitrite oxidizing bacteria. The decrease in aeration intensity concomitant with increased duration also decreased the aggregate size. Aggregate morphology and settleability were also altered with aeration regime: increased frequencies led to compact but hollow aggregates that transiently accumulated nitrogen gas. Based on the experimental observations, a conceptual scheme was proposed to describe aggregation and architectural evolution in nitritation/anamox reactors, incorporating the possible influences of intermediates formed with intermittent aeration. Community analysis revealed an abundant fraction of heterotrophic types despite the absence of organic carbon in the feed. The aerobic and anaerobic ammonia oxidizing guilds were dominated by fast-growing Nitrosomonas spp. and Ca. Brocadia spp., while the nitrite oxidizing guild was dominated by high affinity Nitrosospira spp.

Emission of nitrous oxide (N2O) was evaluated from both reactors under dynamic aeration regimes. Contrary to the widely held notion that dynamic operation at low dissolved oxygen concentrations would increase nitrous oxide emissions, increasing the aeration frequencies reduced N2O production and emission. N2O production was observed primarily at the onset of aeration after anoxia. Nitric oxide and not free nitrous acid or nitrite correlated to production rates. The measured aerobic ammonia oxidation potential correlated to the nitrous oxide production rates. Shortening the duration of single aerated periods was an efficient way of preventing the exponential increase in N2O production rates. Correspondingly, operating nitritation/anamox reactors under limited aerobic and excess anaerobic ammonia oxidation is recommended to minimize N2O production and emission.

Aeration impacts the nitritation/anamox process in multiple dimensions. This study focused on the different oxygen delivery schemes, and some of the collateral impacts could be isolated, increasing process understanding. It was demonstrated that aeration strategy can be used as a powerful tool to manipulate the microbial community composition, its architecture and reactor performance. We suggest operation via intermittent aeration with short aerated periods to minimize nitrous oxide emission rates and sufficiently long non-aerated periods to suppress nitrite oxidizing bacteria. Under these conditions, redox-stratified aggregates can be established maintaining simultaneously aerobic and anaerobic autotrophic ammonium oxidation in an intensified single-stage reactor.

Nitritation/anamox processes have already been successfully applied to treat side stream reject waters, landfill leachates and industrial wastewater streams; now this process is being examined to replace or upgrade conventional treatment trains to treat domestic wastewaters under low temperatures in the presence of residual organic carbon. This work, by examining the interplay between macro- and micro-scale phenomena and processes, contributes to establishment of strategies that can be adopted in practice to operate the single-stage nitritation/anamox systems.
Measuring biogeochemical heterogeneity at the micro scale in soils and sediments

Steep physiochemical gradients and diffusive limitation associated with microscale features such as cracks and pores make soil and sediments remarkably heterogeneous environments, which is reflected on many environmentally important processes. If we are to understand and attempt to control the ecology of the microorganisms which inhabit these environments we must not only characterize their inhabitants, but also the complex biogeochemical landscape they live in. This includes local concentrations of electron acceptors and donors, microbial metabolites and key physical and chemical parameters such as pH and soil structure. To this end, an array of techniques for collecting data at the microscale has been developed, deployed and refined, ranging from microsensor probes to planar sensors. This review provides a general reference for and a critical comparison of microscale techniques available to the fields of soil and sediment microbial ecology. Techniques are evaluated based on their ability to provide spatially resolved data at the microscale, with focus on performance characteristics, potential for repeated measurements, degree of physical disruption they create, and accessibility. Microscale studies have given us many insights, but we outline further progress needed to make the microscale toolkit more accessible and to extend the range of analytes that can be measured simultaneously, so that we may expand our knowledge of the complex environmental microscale heterogeneity and its impact on soil and sediment ecology and functioning.
Keywords: Soil Science, Microbiology, Gradients, Microsensor, Optode, Planar sensor, Spatial, Biogeochemistry, Ecology, Metabolites, Microsensors, Soils, Heterogeneous environments, Micro-scale heterogeneity, Performance characteristics, Physical and chemical parameters, Planar sensors, Sediments

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Metagenomic analysis of microbial communities in rapid sand filter treating groundwater. Community diversity and metabolic potential

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State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering, Department of Systems Biology, Center for Biological Sequence Analysis, Metagenomics, Technical University of Denmark
Contributors: Palomo, A., Rasmussen, S., Sicheritz-Pontén, T., Smets, B. F.
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Metal specific modulation of community permissiveness towards broad host range plasmids through stress

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Contributors: Klümper, U., Brandt, K., Dechesne, A., Riber, L., Sørensen, S., Smets, B. F.
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Metal stress modulates the immediate plasmid uptake potential of soil microbes

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Organisations: Department of Environmental Engineering, Urban Water Engineering, University of Copenhagen
Contributors: Klümper, U., Dechesne, A., Riber, L., Gülay, A., Brandt, K., Sørensen, S., Smets, B. F.
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Modeling green microalgal growth, nutrient uptake and storage in the ASM framework

General information
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Modulation of microbial community permissiveness towards broad host range conjugative plasmid under metal stress

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Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2015

Permissiveness of soil microbial communities towards broad host range plasmids
Horizontal transfer of mobile genetic elements facilitates adaptive and evolutionary processes in bacteria. Among the known mobile genetic elements, plasmids can confer their hosts with accessory adaptive traits, such as antibiotic or heavy metal resistances, or additional metabolic pathways. Plasmids are implicated in the rapid spread of antibiotic resistance and the emergence of multi-resistant pathogenic bacteria, making it crucial to be able to quantify, understand, and, ideally, control plasmid transfer in mixed microbial communities. The fate of plasmids in microbial communities and the extent of bacterial phylogenetic permissiveness towards plasmid receipt are largely unknown. Historically, methods exploring the underlying genetic and environmental factors of plasmid transfer have been heavily reliant on cultivation and expression of plasmid encoded phenotypes. This has provided an incomplete and potentially cultivation biased image of the extent of plasmid transfer.

In this thesis, I investigated the extent of plasmid transfer in microbial communities at an unprecedented level of resolution and not reliant on cultivation. I focused on soil microbial communities. Their potential role as a reservoir for plasmids carrying antibiotic resistance genes is increasingly suspected to majorly contribute to the emergence of multi-resistant pathogens. More specifically, I examined what fraction of a soil microbial community is permissive to plasmids, identified the phylogenetic identity of this fraction and studied environmental factors that modulate plasmid transfer in soil microbial communities.

In order to attain these goals, I developed a high-throughput method that enabled me to evaluate the permissiveness of bacterial communities towards introduced plasmids. This new approach is based on the introduction of fluorescently tagged conjugal plasmids into a soil microbial community in solid-surface filter matings under maximized cell-to-cell contact, followed by quantification of transfer events through advanced fluorescent microscopy, isolation of transconjugants through triple-gated fluorescent activated cell sorting and finally 16S rRNA targeted pyrosequencing of the sorted transconjugal pools.

Employing this new method, I was able to map, for the first time, the diversity of all recipients in a soil microbial community for three broad host range model plasmids: RP4, pKJK5, and pIPO2tet. I found that a large fraction of soil the bacteria (up to 1 in 10,000) were able to take up any of these broad host range conjugal plasmids. The transconjugal pools comprised 11 bacterial phyla. This finding indicates that the realized transfer range of broad host range plasmids in environmental
microbial communities is much larger than previously assumed. I was able to show abundant plasmid transfer from the Gram negative donor strains to a wide diversity of Gram positive soil bacteria, formerly thought to constitute distinct clusters of gene transfer. Moreover, among the observed transconjugants, I identified a core super-permissive fraction of taxa prone to receive diverse BHR plasmids from diverse donors. This fraction comprised the proteobacterial genera Pseudomonas, Enterobacterium and Burkholderia. These taxa are known to be evolutionary interlinked through chromosomal gene exchange. Hence, I was able to show that the gene pool of microbial communities may be directly interconnected through transfer of BHR plasmids at a so far unrecognized level.

The developed method furthermore enabled me to explore how agronomic practices may affect gene transfer in soil microbial communities. I compared bacterial communities extracted from plots subjected to different treatments for their permissiveness towards the model BHR plasmids RP4, pRO101 and pPO2tet. Periodic manure introduction increased the permissiveness of the community towards these plasmids by up to 100% compared to control treatments. However, the phylogenetic composition of the transconjugal pools remained similar. The underlying mechanisms remain unclear.

Subsequently, I focused on the effect of metal cations - Cu, Ni, Zn, and Cd – on community permissiveness. These cations are common environmental stressors associated with manure application to agricultural soils. I postulate an increased permissiveness of the community as a generic stress response to acquire foreign genes potentially conferring adaptive traits. I therefore evaluated to what extent short term metal stress modulated plasmid transfer. I analyzed both the transfer frequency and the phylogeny of the transconjugal pools using model BHR plasmid pKJK5 introduced through the γ-proteobacterial donor E. coli. I found that the permissiveness towards plasmids was modified through stress on a taxon specific basis and cannot be generally predicted for the whole community.

Finally, I extended the high-throughput method to quantify the potential of a microbial community to actively mobilize and transfer exogenous mobilizable plasmids to its indigenous members. I evaluated the transfer frequency of model plasmid RSF1010 by comparing it to the community's permissiveness towards the mobilizing, conjugal plasmid RP4 and to the rate of transfer between isogenic strains. My results indicated that retromobilization takes place at frequencies only one order magnitude lower than permissiveness for conjugal RP4 transfer. Mobilizable plasmids transferred in the communities at frequencies of up to 30 times higher than the conjugal plasmid RP4 itself when co-resident with a conjugative plasmid.

In conclusion, in this thesis I developed a novel toolbox to study plasmid transfer of conjugal and mobilizable plasmids in mixed microbial communities. This method allows, for the first time, a detailed mapping of the realized transfer range of plasmids. I discovered that a previously far underestimated fraction of bacteria in natural communities is directly interconnected through BHR plasmid transfer. While a super-permissive fraction of bacteria were able to take up plasmids at high frequencies from diverse donors, I showed plasmid or donor dependence of plasmid transfer to other species. Additionally, environmental factors like stress also impact the permissiveness of phylogenetic groups towards plasmids. The developed method and results increase our ability to predict the fate and impact of plasmids in microbial communities.

Phosphorus addition can increase nitrification in biological rapid sand filters for drinking water treatment

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Reducing Diffusion Limitation Shifts the Dominant Nitrate Reduction Metabolism from Incomplete Denitrification to Dissimilatory Nitrate Reduction to Ammonium

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Organisations: Department of Environmental Engineering, Urban Water Engineering
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Taxonomic and metagenomic profiling of rapid sand filter microbiome reveals a high Nitrospira incidence

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Contributors: Palomo, A., Gülay, A., Rasmussen, S., Sicheritz-Pontén, T., Smets, B. F.
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The effect of spatial heterogeneity on nitrate reduction in soil systems
Nitrogen is not only an abundant element on earth, making up roughly 80% of the earth's atmosphere, it is also essential for life, and a functional nitrogen cycle is of great importance to human activities and our ecosystems. The nitrogen cycle ultimately returns reactive nitrogen, which was chemically or biochemically fixed from inert nitrogen, back into the atmosphere as inert nitrogen. Over the last century, the excess of anthropogenically fixed nitrogen has put increasing pressures on the nitrogen cycle. Its concentration is, on the one hand governed by formation by oxidation of ammonia-N, and on the other hand by removal a removal by two dissimilatory nitrate reduction processes: denitrification, in which nitrate is converted to the gaseous compounds dinitrogen and nitrous oxide, and dissimilatory nitrate reduction to ammonium, DNRA. While both processes bring about the reduction of nitrate, their impact on ecosystems is radically different – especially in soil environments. Nitrate itself is poorly retained in soils, and its conversion to gaseous dinitrogen and nitrous oxide through denitrification only serves to further the loss of reactive nitrogen from the system. On top of that nitrous oxide is an important air pollutant and greenhouse gas, with a global warming potential per unit mass 300 times higher than carbon dioxide. DNRA, on the other hand, converts nitrate to ammonium, which is more easily retained in soils than nitrate, and can be assimilated into organic matter, effectively bypassing both denitrification and dinitrogen fixation and conserving nitrogen in the ecosystem. It is well established that soil is an extremely heterogeneous environment, not merely on a macroscopic level, but also on a microscopic level. Spatial heterogeneity and diffusive limitations result in the formation of specialized niches. It is becoming increasingly clear that these factors are of great importance for biogeochemical processes such as the carbon cycle. Studying the heterogeneity of soil and its impact on ecological processes is not merely a fascinating scientific activity, it may very well be central to gaining insights to influence fundamental soil processes such as nitrogen metabolism, promising advancement of agricultural and pollution prevention and remediation techniques. A number of conceptual and quantitative frameworks have been developed to assess the impact of mass transfer kinetics on biotransformation rates in various environments. One such approach uses the dimensionless parameter Da3: a Damköhler number which for a given system
with a nitrogen-rich stream (referred to as N-stream). As a function of the SRT and the P-stream diversion rate, different end a phosphorus-rich stream (referred to as P-stream) is diverted from the anaerobic phase of the EBP2R and combined criterion for the EBP2R is set to meet the micro-algal nutrient requirements in terms of nitrogen and phosphorus. To this of nitrogen is preserved as ammonium, which is the preferred nitrogen source for green micro-algal growth. The effluent with a photobioreactor (PBR). The EBP2R process is operated at relatively low solid retention time (SRT). Hence the bulk TRENS. The TRENS consists of an enhanced biological phosphorus removal and recovery (EBP2R) process combined recovery. As an alternative, this thesis proposes a new fully biochemical resource recovery process, referred to as Greenland

Wastewater resource recovery via the Enhanced Biological Phosphorus Removal and Recovery (EBP2R) process coupled with green microalgal cultivation

Conventionally, the objective of wastewater treatment has been the elimination of organic and inorganic pollutants, such as nitrogen and phosphorus, from wastewater. Current research promotes a paradigm shift, whereby wastewater is considered not only as a source of pollution but also as a source of nutrients, fresh water and renewable energy. This new approach redefines the conventional wastewater treatment plant (WWTP) as a biorefinery from where different streams can be split, each of them rich in different resources. Since many wastewater treatment infrastructures were built about 30 years ago, there is an opportunity of including these novel technologies as part of the future retrofitting and enlargements of the plants. Nevertheless, most of the proposed resource recovery strategies suffer from intensive use of chemicals or energy. In extreme cases, the environmental impact of the technology by itself completely counters the benefit of resource recovery. As an alternative, this thesis proposes a new fully biochemical resource recovery process, referred to as TRENs. The TRENs consists of an enhanced biological phosphorus removal and recovery (EBP2R) process combined with a photobioreactor (PBR). The EBP2R process is operated at relatively low solid retention time (SRT). Hence the bulk of nitrogen is preserved as ammonium, which is the preferred nitrogen source for green micro-algal growth. The effluent criterion for the EBP2R is set to meet the micro-algal nutrient requirements in terms of nitrogen and phosphorus. To this end a phosphorus-rich stream (referred to as P-stream) is diverted from the anaerobic phase of the EBP2R and combined with a nitrogen-rich stream (referred to as N-stream). As a function of the SRT and the P-stream diversion rate, different
nitrogen-to-phosphorus ratios (N-to-P ratio) can be produced, thereby meeting the nutrient requirements of different micro-
agal species. Organic carbon oxidation is minimized due to the low SRT. Therefore, most of the organic carbon is
incorporated to the sludge via microbial assimilation or storage and conveyed to the anaerobic digester for biogas
production. The fraction of nitrogen which cannot be recovered is removed via completely autotrophic nitrogen removal
(CANR). First, a feasibility assessment of the EBPR process as an algal culture media generator was carried out using
continuous-flow and sequencing batch reactor (SBR) configurations. Systems were modelled using the activated sludge
model 2d (ASM-2d). Regardless of the process configuration, factors that can potentially limit nutrient recovery comprise
the system SRT and the nitrate recirculated to the anaerobic phase/reactor. Additionally, continuous-flow EBPR systems
can suffer from phosphorus starvation in the aerobic reactors as a result of excessive P-stream diversion. Furthermore, in
continuous-flow mode, the P-stream diversion increases the aerobic SRT, while the system SRT is kept. Consequently,
nitrifying bacteria can proliferate in the continuous system oxidizing ammonia to nitrate. Therefore, at high P-stream flow
diversions polyphosphate accumulating organisms (PAOs) may be outcompeted by denitrifying bacteria. The sequencing
EBPR yielded to higher phosphorus recovery than the continuous flow system. For each of the EBPR configurations a
control structure has been developed and tested using a set of dynamic influent disturbance scenarios. The sequencing
EBPR was found to be sensitive to large input disturbances. Special care should be taken when tuning the
controllers for the sequencing EBPR to avoid too aggressive control actions that can potentially destabilize the system.
Under dynamic conditions, the sequencing EBPR show better performance in terms of phosphorus recovery and effluent
quality (i.e. optimal N-to-P ratio fed to the PBR) than the continuous flow system. Second, two short SRT EBPR systems
were implemented as laboratory-scale continuous-flow and SBR reactor systems. Both systems suffered from extreme
filamentous bulking (sludge volume index, SVI>1000 ml/g). Via 16rRNA amplicon sequencing we identified Thiothrix as
the main filamentous bacteria driving activated sludge settleability. Thiothrix proliferated in the reactors when sulphate
was reduced to sulphur reduced compounds, such as sulphide, by sulphate reducing bacteria (SRBs). Phosphorus removal
was poor during the filamentous bulking event, which was a consequence of the interactions between SRBs and PAOs in
the anaerobic phase. SRBs can compete with PAOs for volatile fatty acids under anaerobic conditions. Additionally,
sulphide can inhibit phosphorus release by PAOs. As a result, PAOs were washed out from the systems. Filamentous
bulking was mitigated and phosphorus removal was restored by reducing the anaerobic SRT of the SBR. However, this
strategy failed when applied to the continuous flow system, where only the SVI could be improved. When extending the
aforementioned studies to include the PBR, we identified the lack of a model suitable to describe resource recovery from
wastewater via green micro-algal cultivation. Furthermore, neither of models published in literature were compatible to
interface with ASM-2d. Therefore, the third part of the PhD project focusses on the development of a process model for
micro-algal growth and substrate storage kinetics (referred to as ASM-A). To facilitate the integration in already well-

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Aeration Strategies To Mitigate Nitrous Oxide Emissions from Single-Stage Nitritation/Anammox Reactors

Autotrophic nitrogen removal is regarded as a resource efficient process to manage nitrogen-rich residual streams. However, nitrous oxide emissions of these processes are poorly documented and strategies to mitigate emissions unknown. In this study, two sequencing batch reactors performing single-stage nitritation/anammox were operated under different aeration strategies, gradually adjusted over six months. At constant but limiting oxygen loading, synthetic reject water was fed (0.75g-N/L.d) and high nitrogen removal efficiencies (83 +/- 5 and 88 +/- 2%) obtained. Dynamics of liquid phase nitrous (N2O) and nitric oxide (NO) concentrations were monitored and N2O emissions calculated. Significant decreases in N2O emissions were obtained when the frequency of aeration was increased while maintaining a constant air flow rate (from >6 to 1.7% Delta N2O/Delta TN). However, no significant effect on the emissions was noted when the duration of aeration was increased while decreasing air flow rate (10.9 +/- 3.2% Delta N2O/Delta TN). The extant ammonium oxidation activity (mgNH(4)(+)-N/gVSS.min) positively correlated with the specific N2O production rate (mgN(2)O-N/gVSS.min) of the systems. Operating under conditions where anaerobic exceeds aerobic ammonium oxidation activity is proposed to minimize N2O emissions from single-stage nitritation/anammox reactors; increasing the frequency of aeration cycling is an efficient way of obtaining those conditions.
A Green Micro-Algal Growth Model developed in the Activated Sludge Modeling Framework

General information
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Organisations: Department of Environmental Engineering, Urban Water Engineering, Residual Resource Engineering, Technical University of Denmark
A model framework to describe growth-linked biodegradation of trace-level pesticides in the presence of coincidental carbon substrates and microbes

Pollutants such as pesticides and their degradation products occur ubiquitously in natural aquatic environments at trace concentrations (μg L–1 and lower). Microbial biodegradation processes have long been known to contribute to the attenuation of pesticides in contaminated environments. However, challenges remain in developing engineered remediation strategies for pesticide-contaminated environments because the fundamental processes that regulate growth-linked biodegradation of pesticides in natural environments remain poorly understood. In this research, we developed a model framework to describe growth-linked biodegradation of pesticides at trace concentrations. We used experimental data reported in the literature or novel simulations to explore three fundamental kinetic processes in isolation. We then combine these kinetic processes into a unified model framework. The three kinetic processes described were: the growth-linked biodegradation of micropollutant at environmentally relevant concentrations; the effect of coincidental assimilable organic carbon substrates; and the effect of coincidental microbes that compete for assimilable organic carbon substrates.

We used Monod kinetic models to describe substrate utilization and microbial growth rates for specific pesticide and degrader pairs. We then extended the model to include terms for utilization of assimilable organic carbon substrates by the specific degrader and coincidental microbes, growth on assimilable organic carbon substrates by the specific degrader and coincidental microbes, and endogenous metabolism. The proposed model framework enables interpretation and description of a range of experimental observations on micropollutant biodegradation. The model provides a useful tool to identify environmental conditions with respect to the occurrence of assimilable organic carbon and coincidental microbes that may result in enhanced or reduced micropollutant biodegradation.

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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
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Scopus rating (2013): CiteScore 5.52 SJR 2.952 SNIP 2.102
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Scopus rating (2003): SJR 2.54 SNIP 2.065
Web of Science (2003): Indexed yes
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An Activated Sludge Model for Mixed Green Microalgae (ASM-A): model identification and calibration

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An Innovative Activated Sludge System for Enhanced Nutrient Recovery via Downstream Cultivation of Green Microalgae

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Broad host range plasmids can invade an unexpectedly diverse fraction of a soil bacterial community

Conjugal plasmids can provide microbes with full complements of new genes and constitute potent vehicles for horizontal gene transfer. Conjugal plasmid transfer is deemed responsible for the rapid spread of antibiotic resistance among microbes. While broad host range plasmids are known to transfer to diverse hosts in pure culture, the extent of their ability to transfer in the complex bacterial communities present in most habitats has not been comprehensively studied. Here, we isolated and characterized transconjugants with a degree of sensitivity not previously realized to investigate the transfer range of IncP- and IncPromA-type broad host range plasmids from three proteobacterial donors to a soil bacterial community. We identified transfer to many different recipients belonging to 11 different bacterial phyla. The prevalence of transconjugants belonging to diverse Gram-positive Firmicutes and Actinobacteria suggests that inter-Gram plasmid transfer of IncP-1 and IncPromA-type plasmids is a frequent phenomenon. While the plasmid receiving fractions of the community were both plasmid- and donor-dependent, we identified a core super-permissive fraction that could take up different plasmids from diverse donor strains. This fraction, comprising 80% of the identified transconjugants, thus has the potential to dominate IncP- and IncPromA-type plasmid transfer in soil. Our results demonstrate that these broad host range plasmids have a hitherto unrecognized potential to transfer readily to very diverse bacteria and can, therefore, directly connect large proportions of the soil bacterial gene pool. This finding reinforces the evolutionary and medical significances of these plasmids.

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Colony morphology and transcriptome profiling of Pseudomonas putida KT2440 and its mutants deficient in alginate or all EPS synthesis under controlled matric potentials

Pseudomonas putida is a versatile bacterial species adapted to soil and its fluctuations. Like many other species living in soil, P. putida often faces water limitation. Alginate, an exopolysaccharide (EPS) produced by P. putida, is known to create hydrated environments and alleviate the effect of water limitation. In addition to alginate, P. putida is capable of producing cellulose (bcs), putida exopolysaccharide a (pea), and putida exopolysaccharide b (peb). However, unlike alginate, not much is known about their roles under water limitation. Hence, in this study we examined the role of different EPS components under mild water limitation. To create environmentally realistic water limited conditions as observed in soil, we used the Pressurized Porous Surface Model. Our main hypothesis was that under water limitation and in the absence of alginate other exopolysaccharides would be more active to maintain homeostasis. To test our hypothesis, we investigated colony morphologies and whole genome transcriptomes of P. putida KT2440 wild type and its mutants deficient in synthesis of either alginate or all known EPS. Overall our results support that alginate is an important exopolysaccharide under water limitation and in the absence of alginate other tolerance mechanisms are activated.
Diagnostics in biological rapid sand filters treating groundwater – governing factors for nitrification
To improve the insight in the processes in biological rapid sand filters a range of methods were developed to diagnose the microbial mediated processes – particularly nitrification.

Does microbial cm-scale heterogeneity impact pesticide degradation in and leaching from loamy agricultural soils?
The potential for pesticide degradation varies greatly at the cm-scale in agricultural soil. Three dimensional numerical simulations were conducted to evaluate how such small-scale spatial heterogeneity may affect the leaching of the biodegradable pesticide 2-methyl-4-chlorophenoxyacetic acid (MCPA) in the upper metre of a variably-saturated, loamy soil profile. To incorporate realistic spatial variation in degradation potential, we used data from a site where 420 mineralization curves over 5 depths have been measured. Monod kinetics was fitted to the individual curves to derive initial degrader biomass values, which were incorporated in a reactive transport model to simulate heterogeneous biodegradation. Six scenarios were set up using COMSOL Multiphysics to evaluate the difference between models having different degrader biomass distributions (homogeneous, heterogeneous, or no biomass) and either matrix flow or preferential flow through a soil matrix with a wormhole. MCPA leached, within 250 days, below 1 metre only when degrader biomass was absent and preferential flow occurred. Both biodegradation in the plough layer and the microbially active lining of the wormhole contributed to reducing MCPA-leaching below one metre. The spatial distribution of initial degrader biomass within each soil matrix layer, however, had little effect on the overall MCPA-leaching.
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Web of Science (2016): Impact factor 4.9
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Scopus rating (2014): CiteScore 4.2 SJR 1.635 SNIP 1.843
Web of Science (2014): Impact factor 4.099
Web of Science (2014): Indexed yes
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Scopus rating (2013): CiteScore 3.73 SJR 1.527 SNIP 1.745
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ISI indexed (2013): ISI indexed yes
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Scopus rating (2012): CiteScore 3.7 SJR 1.749 SNIP 1.82
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ISI indexed (2012): ISI indexed yes
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BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 3.61 SJR 1.802 SNIP 1.676
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ISI indexed (2011): ISI indexed yes
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Scopus rating (2010): SJR 1.651 SNIP 1.506
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Web of Science (2010): Indexed yes
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Scopus rating (2009): SJR 1.576 SNIP 1.6
BFI (2008): BFI-level 2
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Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.393 SNIP 1.473
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.512 SNIP 1.586
Web of Science (2006): Indexed yes
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Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.126 SNIP 1.299
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.156 SNIP 1.35
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.175 SNIP 1.359
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.054 SNIP 1.076
Web of Science (2001): Indexed yes
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Effects of dynamic operating conditions on nitrification in biological rapid sand filters for drinking water treatment

Biological rapid sand filters are often used to remove ammonium from groundwater for drinking water supply. They often operate under dynamic substrate and hydraulic loading conditions, which can lead to increased levels of ammonium and nitrite in the effluent. To determine the maximum nitrification rates and safe operating windows of rapid sand filters, a pilot scale rapid sand filter was used to test short-term increased ammonium loads, set by varying either influent ammonium concentrations or hydraulic loading rates. Ammonium and iron (flock) removal were consistent between the pilot and the full-scale filter. Nitrification rates and ammonia-oxidizing bacteria and archaea were quantified throughout the depth of the filter. The ammonium removal capacity of the filter was determined to be $3.4 \text{ g NH}_4^–\text{N m}^{-3}\text{ h}^{-1}$, which was 5 times greater than the average ammonium loading rate under reference operating conditions. The ammonium removal rate of the filter was determined by the ammonium loading rate, but was independent of both the flow and influent ammonium concentration individually. Ammonia-oxidizing bacteria and archaea were almost equally abundant in the filter. Both ammonium removal and ammonia-oxidizing bacteria density were strongly stratified, with the highest removal and ammonia-oxidizing bacteria densities at the top of the filter. Cell specific ammonium oxidation rates were on average $0.6 \times 10^2 \pm 0.2 \times 10^2 \text{ fg NH}_4^–\text{N h}^{-1} \text{ cell}^{-1}$. Our findings indicate that these rapid sand filters can safely remove both nitrite and ammonium over a larger range of loading rates than previously assumed.

**General information**

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Scopus rating (2014): CiteScore 6.13 SJR 2.946 SNIP 2.702
Web of Science (2014): Impact factor 5.528
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Effects of Filamentous Bulking on Activated Sludge Rheology and Compression Settling Velocity

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Organisations: Department of Environmental Engineering, Urban Water Engineering, Department of Chemical and Biochemical Engineering, The Danish Polymer Centre
Fine scale spatial variability of microbial pesticide degradation in soil: scales, controlling factors, and implications

Pesticide biodegradation is a soil microbial function of critical importance for modern agriculture and its environmental impact. While it was once assumed that this activity was homogeneously distributed at the field scale, mounting evidence indicates that this is rarely the case. Here, we critically examine the literature on spatial variability of pesticide biodegradation in agricultural soil. We discuss the motivations, methods, and main findings of the primary literature. We found significant diversity in the approaches used to describe and quantify spatial heterogeneity, which complicates inter-studies comparisons. However, it is clear that the presence and activity of pesticide degraders is often highly spatially variable with coefficients of variation often exceeding 50% and frequently displays non-random spatial patterns. A few controlling factors have tentatively been identified across pesticide classes: they include some soil characteristics (pH) and some agricultural management practices (pesticide application, tillage), while other potential controlling factors have more conflicting effects depending on the site or the pesticide. Evidence demonstrating the importance of spatial heterogeneity on the fate of pesticides in soil has been difficult to obtain but modeling and experimental systems that do not include soil's full complexity reveal that this heterogeneity must be considered to improve prediction of pesticide biodegradation rates or of leaching risks. Overall, studying the spatial heterogeneity of pesticide biodegradation is a relatively new field at the interface of agronomy, microbial ecology, and geosciences and a wealth of novel data is being collected from these different disciplinary perspectives. We make suggestions on possible avenues to take full advantage of these investigations for a better understanding and prediction of the fate of pesticides in soil.

General information

State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering, Geological Survey of Denmark and Greenland
Contributors: Dechesne, A., Badawi, N., Aamand, J., Smets, B. F.
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Journal: Frontiers in Microbiology
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Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 4.19 SJR 1.699 SNIP 1.174
Web of Science (2017): Impact factor 4.019
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 4.16 SJR 1.759 SNIP 1.161
Web of Science (2016): Impact factor 4.076
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 4.15 SJR 1.869 SNIP 1.193
Web of Science (2015): Impact factor 4.165
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Internal Porosity of Mineral Coating Supports Microbial Activity in Rapid Sand Filters for Groundwater Treatment

A mineral coating develops on the filter grain surface when groundwater is treated via rapid sand filtration in drinking water production. The coating changes the physical and chemical properties of the filter material, but little is known about its effect on the activity, colonization, diversity, and abundance of microbiota. This study reveals that a mineral coating can positively affect the colonization and activity of microbial communities in rapid sand filters. To understand this effect, we investigated the abundance, spatial distribution, colonization, and diversity of all and of nitrifying prokaryotes in filter material with various degrees of mineral coating. We also examined the physical and chemical characteristics of the mineral coating. The amount of mineral coating correlated positively with the internal porosity, the packed bulk density, and the biologically available surface area of the filter material. The volumetric NH₄⁺ removal rate also increased with the degree of mineral coating. Consistently, bacterial 16S rRNA and amoA abundances positively correlated with increased mineral coating levels. Microbial colonization could be visualized mainly within the outer periphery (60.6 ± 35.6 μm) of the mineral coating, which had a thickness of up to 600 ± 51 μm. Environmental scanning electron microscopic (E-SEM) observations suggested an extracellular polymeric substance-rich matrix and submicron-sized bacterial cells. Nitrifier diversity profiles were similar irrespective of the degree of mineral coating, as indicated by pyrosequencing analysis. Overall, our results demonstrate that mineral coating positively affects microbial colonization and activity in rapid sand filters, most likely due to increased volumetric cell abundances facilitated by the large surface area of internal mineral porosity accessible for microbial colonization.

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering, Center for Electron Nanoscopy
Contributors: Gülay, A., Tatari, K., Musovic, S., Mateiu, R. V., Albrechtsen, H., Smets, B. F.
Pages: 7010–7020
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Peer-reviewed: Yes

Publication information
Journal: Applied and Environmental Microbiology
Volume: 80
Issue number: 22
ISSN (Print): 0099-2240
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
Long-term manure exposure increases soil bacterial community potential for plasmid uptake

Microbial communities derived from soils subject to different agronomic treatments were challenged with three broad host range plasmids, RP4, pIP02tet and pRO101, via solid surface filter matings to assess their permissiveness. Approximately 1 in 10,000 soil bacterial cells could receive and maintain the plasmids. The community permissiveness increased up to 100% in communities derived from manured soil. While the plasmid transfer frequency was significantly influenced by both the type of plasmid and the agronomic treatment, the diversity of the transconjugal pools was purely plasmid dependent and was dominated by β- and γ-Proteobacteria.
Metal stress alters a bacterial community’s permissiveness towards plasmids

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering, University of Copenhagen
Contributors: Klümper, U., Brandt, K. K., Dechesne, A., Riber, L., Sørensen, S. J., Smets, B. F.
Pages: 25-26
Publication date: 2014

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Electronic versions:
Abstract Book
Source: PublicationPreSubmission
Source-ID: 101353324
Research output: Research - peer-review » Conference abstract in proceedings – Annual report year: 2014

Metal stress alters a bacterial community's permissiveness towards plasmids

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering, University of Copenhagen
Contributors: Klümper, U., Brandt, K. K., Dechesne, A., Riber, L., Sørensen, S. J., Smets, B. F.
Number of pages: 1
Publication date: 2014
Peer-reviewed: Yes
Event: Poster session presented at The Danish Microbiological Society Annual Congress 2014, Copenhagen, Denmark.
Source: PublicationPreSubmission
Source-ID: 103381407
Research output: Research - peer-review » Poster – Annual report year: 2014
Metal stress response influences a soil bacterial community's permissiveness towards a broad-host-range plasmid

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering, University of Copenhagen
Contributors: Klümper, U., Brandt, K. K., Dechesne, A., Riber, L., Sørensen, S. J., Smets, B. F.
Number of pages: 1
Pages: 20-20
Publication date: 2014

Host publication information
Title of host publication: The danish microbiological society - Annual congress 2014 : Program & abstracts
Publisher: American Society for Microbiology
Electronic versions:
Sammelmappe1.pdf
Source: PublicationPreSubmission
Source-ID: 103083950
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2014

Methanotrophs assisted bentazone degradation

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering
Contributors: Papadopoulou, A., Hedegaard, M. J., Dechesne, A., Albrechtsen, H., Smets, B. F.
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Event: Poster session presented at International Biodegradation and Biodeterioration Symposium , Lodz, Poland.
Electronic versions:
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Research output: Research - peer-review › Poster – Annual report year: 2014

Microbial diversity and identification of core taxa in rapid sand filters treating groundwaters

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering
Contributors: Gülay, A., Musovic, S., Albrechtsen, H., Waleed, A. A., Sørensen, S. J., Smets, B. F.
Number of pages: 1
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Peer-reviewed: Yes
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2014

Mineral coating creates internal porosity and supports microbial activity in rapid sand filters treating groundwaters

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering, Center for Electron Nanoscopy
Contributors: Gülay, A., Tatari, K., Musovic, S., Mateiu, R. V., Albrechtsen, H., Smets, B. F.
Number of pages: 1
Publication date: 2014
Peer-reviewed: Yes
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2014

Mineral coating supports microbial activity in rapid sand filters for drinking water production

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering, Center for Electron Nanoscopy
Contributors: Gülay, A., Tatari, K., Musovic, S., Mateiu, R. V., Albrechtsen, H., Smets, B. F.
**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  
Number of pages: 1  
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Peer-reviewed: Yes  

**Modelling N2O dynamics in the engineered N cycle: Evaluation of alternate model structures**

Research on nitrous oxide (N2O) formation in engineered wastewater systems has experienced an exponential development in the recent years due to the important environmental impact of this greenhouse gas. These efforts have crystallized in a large number of publications that aim to identify the importance of the main microbial processes responsible for its production and consumption. The conceptualization of these pathways in mathematical models has the potential to become a key tool to increase our understanding on the complex interrelationships within these ecosystems and develop strategies to minimize the carbon footprint of wastewater treatment plants. The present contribution aims to summarize the recent developments in this field and makes use of standard indentifiability measures to show how the choice of experimental protocols and model structures can potentially impact their calibration.

**Modelling the Impact of Filamentous Bacteria Abundance in a Secondary Settling Tank: CFD Sub-models Optimization Using Long - term Experimental Data**

**General information**  
State: Published  
Organisations: Department of Environmental Engineering, Urban Water Engineering, Department of Chemical and Biochemical Engineering, The Danish Polymer Centre, DHI Denmark, Aalborg University  
Number of pages: 14  
Publication date: 2014  
Host publication information
**Novel assay to measure the plasmid mobilizing potential of mixed microbial communities**

Mobilizable plasmids lack necessary genes for complete conjugation and are therefore non-self-transmissible. Instead, they rely on the conjugation system of conjugal plasmids to be horizontally transferred to new recipients. While community permissiveness, the fraction of a mixed microbial community that can receive self-transmissible conjugal plasmids, has been studied, the intrinsic ability of a community to mobilize plasmids that lack conjugation systems is unexplored. Here, we present a novel framework and experimental method to estimate the mobilization potential of mixed communities. We compare the transfer frequency of a mobilizable plasmid to that of a mobilizing and conjugal plasmid measured for a model strain and for the assayed community. With Pseudomonas putida carrying the gfp-tagged mobilizable RSF1010 plasmid as donor strain, we conducted solid surface mating experiments with either a P. putida strain carrying the mobilizing plasmid RP4 or a model bacterial community that was extracted from the inner walls of a domestic shower conduit. Additionally, we estimated the permissiveness of the same community for RP4 using P. putida as donor strain. The permissiveness of the model community for RP4 (at 1.16x10^-4 transconjugants per recipient (T/R)) was similar to that previously measured for soil microbial communities. RSF1010 was mobilized by the model community at a frequency of 1.16x10^-5 T/R, only one order of magnitude lower than its permissiveness to RP4. This mobilization frequency is unexpectedly high considering that (i) mobilization requires the presence of mobilizing conjugal plasmids within the permissive fraction of the recipients; (ii) in pure culture experiments with P. putida retromobilization of RSF1010 through RP4 only took place in approximately half of the donors receiving the conjugal plasmid in the first step. Further work is needed to establish how plasmid mobilization potential varies within and across microbial communities.

**General information**

State: Published  
Organisations: Department of Environmental Engineering, Urban Water Engineering, Water Technologies  
Contributors: Klümper, U., Droumpali, A., Dechesne, A., Smets, B. F.
Processes effecting nitrification performance in biological rapid sand filters

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering, Water Resources Engineering, Krüger A/S
Contributors: Lee, C. O., Binning, P. J., Albrechtsen, H., Smets, B. F., Boe-Hansen, R.
Number of pages: 61
Protocol for Evaluating the Permissiveness of Bacterial Communities Toward Conjugal Plasmids by Quantification and Isolation of Transconjugants

The transfer of conjugal plasmids is the main bacterial process of horizontal gene transfer to potentially distantly related bacteria. These extrachromosomal, circular DNA molecules host genes that code for their own replication and transfer to other organisms. Because additional accessory genes may encode catabolic pathways, virulence factors, and antibiotic or metal resistances, it is of environmental, evolutionary, and medical relevance to track and monitor the fate of plasmids in mixed microbial community. When assessing the short-term and long-term implications of conjugal plasmid transfer, the ability of a plasmid to invade a mixed community is crucial. The main parameter that controls the possible extent of horizontal plasmid transfer (HGT) in a bacterial community is the in situ community permissiveness for the considered plasmid. Permissiveness describes the fraction of a microbial community able to receive an introduced plasmid at both quantitative and phylogenetic levels. In this chapter, we describe a protocol for simultaneous quantification of plasmid transfer frequency to and high-throughput isolation of transconjugants from a mixed bacterial community after introducing a gfp-tagged plasmid in a mCherry red fluorescently tagged donor strain repressing gfp expression. We take advantage of fluorescent marker genes to microscopically detect plasmid transfer events and use subsequent high-throughput fluorescence-activated cell sorting (FACS) to isolate these transconjugants from the complex community.

QPCR quantification of ammonia oxidizing bacteria: What should the target be?

Ammonia oxidizing bacteria (AOB) perform the first step of nitrification, a key step in the Nitrogen cycle in both natural and engineered systems. In addition to their well-known role in wastewater treatment, they are also essential in rapid sand filters at waterworks treating anaerobic groundwater for drinking water production. Being able to quantify precisely the abundance of this functional group is thus important to be able monitor these processes.

AOB are moderately diverse Beta-Proteobacteria that all carry the amoA gene coding for the ammonia monooxigenase. Therefore, molecular quantification can be carried out by targeting either the 16S rRNA gene or amoA, for which standard primer sets are widely used. Using these two approaches to quantify AOB abundance across three Danish rapid sand filters (RSFs) revealed a significant discrepancy: in two RSFs, the amoA-based qPCR consistently yielded estimate ~50 fold lower than that obtained with the 16S one. We carried out cloning sequencing and coverage analysis of the primer sets to explain this observation. Result showed that the primer sets have an adequate specificity but differ in their coverage. In silico analysis indicated that the amoA primer set has a narrower coverage than the 16S rRNA one and thus led to an underestimation of AOB in RSFs hosting broad AOB diversity. This highlights the importance of the choice of primer set to quantify functional groups in environmental samples.
Seasonal and spatial variations in microbial activity at various phylogenetic resolutions at a groundwater – surface water interface

We investigated the seasonal and spatial variation in activity and density of the metabolically active in situ microbial community (AIMC) at a landfill leachate-impacted groundwater – surface water interface (GSI). A series of AIMC traps were designed and implemented for AIMC sampling and microbial activity and density examinations. Measurements were made not only at the level of bacterial domain but also at the levels of alphaproteobacterial Rhizobiales order and gammaproteobacterial Pseudomonas genus, both of which included a large number of iron-oxidizing bacteria as revealed from previous analysis. Consistently higher microbial activities with less variation in depth were measured in the AIMC traps than in the ambient sediments. Flood disturbance appeared to control AIMC activity distributions at the gradually elevated GSI. The highest AIMC activities were generally obtained from locations closest to the free surface water boundary except during the dry season when microbial activities were similar across the entire GSI. A clone library of AIMC 16S rRNA genes was constructed, and it confirmed the predominant role of the targeted alphaproteobacterial group in AIMC activity and composition. This taxon constituted 2%–14% of all bacteria with similar activity distribution profiles. The Pseudomonas group occupied only 0.1%–0.5% of the total bacterial density, but its activity was 27 times higher than the bacterial average. Of the 16S rRNA sequences in the AIMC clone library, 7.5% were phylogenetically related to putative IOB, supporting the occurrence and persistence of active microbial iron oxidation across the studied iron-rich GSI ecosystem.

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BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.52 SJR 0.579 SNIP 0.561
Web of Science (2017): Impact factor 1.243
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.48 SJR 0.551 SNIP 0.6
Web of Science (2016): Impact factor 1.462
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.27 SJR 0.545 SNIP 0.585
Web of Science (2015): Impact factor 1.335
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.31 SJR 0.554 SNIP 0.575
Web of Science (2014): Impact factor 1.221
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 1.25 SJR 0.532 SNIP 0.541
Web of Science (2013): Impact factor 1.182
Seasonal Arsenic Accumulation in Stream Sediments at a Groundwater Discharge Zone

Seasonal changes in arsenic and iron accumulation rates were examined in the sediments of a brook that receives groundwater discharges of arsenic and reduced iron. Clean glass bead columns were deployed in sediments for known periods over the annual hydrologic cycle to monitor changes in arsenic and iron concentrations in bead coatings. The highest accumulation rates occurred during the dry summer period (July-October) when groundwater discharges were likely greatest at the sample locations. The intermediate flow period (October-March), with higher surface water levels, was associated with losses of arsenic and iron from bead column coatings at depths below 2-6 cm. Batch incubations indicated iron releases from solids to be induced by biological reduction of iron (oxy)hydroxide solids. Congruent arsenic releases during incubation were limited by the high arsenic sorption capacity (0.536 mg(As)/mg(Fe)) of unreacted iron oxide solids. The flooded spring (March-June) with high surface water flows showed the lowest arsenic and iron accumulation rates in the sediments. Comparisons of accumulation rates across a shoreline transect were consistent with greater rates at regions exposed above surface water levels for longer times and greater losses at locations submerged below surface water. Iron (oxy)hydroxide solids in the shallowest sediments likely serve as a passive barrier to sorb arsenic released to pore water at depth by biological iron reduction.

General information
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Organisations: Department of Environmental Engineering, Urban Water Engineering, University of Connecticut, Environmental Remediation Company, Southeast University
Number of pages: 10
Sequentially aerated membrane biofilm reactors for autotrophic nitrogen removal: microbial community composition and dynamics

Membrane-aerated biofilm reactors performing autotrophic nitrogen removal can be successfully applied to treat concentrated nitrogen streams. However, their process performance is seriously hampered by the growth of nitrite oxidizing bacteria (NOB). In this work we document how sequential aeration can bring the rapid and long-term suppression of NOB and the onset of the activity of anaerobic ammonium oxidizing bacteria (AnAOB). Real-time quantitative polymerase chain reaction analyses confirmed that such shift in performance was mirrored by a change in population densities, with a very drastic reduction of the NOB Nitrospira and Nitrobacter and a 10-fold increase in AnAOB numbers. The study of biofilm sections with relevant 16S rRNA fluorescent probes revealed strongly stratified biofilm structures fostering aerobic ammonium oxidizing bacteria (AOB) in biofilm areas close to the membrane surface (rich in oxygen) and AnAOB in regions neighbouring the liquid phase. Both communities were separated by a transition region potentially populated by denitrifying heterotrophic bacteria. AOB and AnAOB bacterial groups were more abundant and diverse than NOB, and dominated by the r-strategists Nitrosomonas europaea and Ca. Brocadia anammoxidans, respectively. Taken together, the present work presents tools to better engineer, monitor and control the microbial communities that support robust, sustainable and efficient nitrogen removal.

General information
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Organisations: Department of Environmental Engineering, Technical University of Denmark, University of Girona, Tokyo University of Agriculture and Technology, University of Copenhagen
Contributors: Pellicer i Nàcher, C., Franck, S., Gülay, A., Ruscalleda, M., Terada, A., Abu Al-Soud, W., Asser Hansen, M., Sørensen, S. J., Smets, B. F.
Number of pages: 12
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Peer-reviewed: Yes

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Journal: Microbial Biotechnology
Volume: 7
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Web of Science (2018): Indexed yes
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Scopus rating (2017): CiteScore 3.99
Structure, composition, and strength of nitrifying membrane-aerated biofilms

Membrane-aerated biofilm reactors (MABRs) are a novel technology based on the growth of biofilms on oxygen-permeable membranes. Hereby, MABRs combine all the advantages of biofilm growth with a more flexible and efficient control of the oxygen load. In the present work, flow cell operation to achieve full nitrification revealed a significantly different structure of nitrifying MABR biofilms with respect to its co-diffusion counterparts reported in the literature (up to now assumed to have similar properties). Different levels of shear stress and oxygen loadings during MABR operation also affected these biofilm parameters. Furthermore, reactor operation at higher oxygen loads resulted in an increase of the biofilm cohesiveness, which depended on the EPS mass in the biofilms and the type of stress applied (more cohesive against normal than shear stresses). The EPS in the strongest biofilms had a higher content of proteins and a lower level of carbohydrates. Staining analyses revealed that the EPS in the stronger biofilm regions had hydrophilic nature and distributed around dense microbial aggregates, whereas it was homogeneously distributed in the weaker strata. Overall, the obtained results provide input parameters to future modelling efforts and operating conditions to support more robust autotrophic N conversions in MABRs.
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
DOIs:
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Source: dtu
Source-ID: u::10897
Research output: Research - peer-review › Journal article – Annual report year: 2014

Taxonomic and functional diversity of microbial communities in rapid sand filters for groundwater treatment

General information
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Organisations: Department of Environmental Engineering, Urban Water Engineering
Contributors: Gülay, A., Smets, B. F., Albrechtsen, H.
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Publication date: 2014

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Place of publication: Kgs. Lyngby
Publisher: DTU Environment
Original language: English
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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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Publication date: 2014
Peer-reviewed: Yes
Electronic versions:
155681.pdf
Source: PublicationPreSubmission
Source-ID: 101977961
Research output: Research - peer-review › Poster – Annual report year: 2014
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.

General information
State: Published
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.
Number of pages: 5
Publication date: 2013
Peer-reviewed: Yes
Source: dtu
Source-ID: u::9445
Research output: Research - peer-review › Paper – Annual report year: 2013

An operational protocol for facilitating start-up of single-stage autotrophic nitrogen-removing reactors based on process stoichiometry

Start-up and operation of single-stage nitritation–anammox sequencing batch reactors (SBRs) for completely autotrophic nitrogen removal can be challenging and far from trivial. In this study, a step-wise procedure is developed based on stoichiometric analysis of the process performance from nitrogen species measurements to systematically guide start-up and normal operation efforts (instead of trial and error). The procedure is successfully applied to laboratory-scale SBRs for start-up and maintained operation over an 8-month period. This analysis can serve as a strong decision-making tool to take appropriate actions with respect to reactor operation to accelerate start-up or ensure high-rate N removal via the nitritation–anammox pathway.

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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

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Keywords: Anammox, Autotrophic nitrogen removal, Decision-making, Start-up operation, Stoichiometry
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10.2166/wst.2013.157
A novel bench-scale column assay to investigate site-specific nitrification biokinetics in biological rapid sand filters

A bench-scale assay was developed to obtain site-specific nitrification biokinetic information from biological rapid sand filters employed in groundwater treatment. The experimental set-up uses granular material subsampled from a full-scale filter, packed in a column, and operated with controlled and continuous hydraulic and ammonium loading. Flowrates and flow recirculation around the column are chosen to mimic full-scale hydrodynamic conditions, and minimize axial gradients. A reference ammonium loading rate is calculated based on the average loading experienced in the active zone of the full-scale filter. Effluent concentrations of ammonium are analyzed when the bench-scale column is subject to reference loading, from which removal rates are calculated. Subsequently, removal rates above the reference loading are measured by imposing short-term loading variations. A critical loading rate corresponding to the maximum removal rate can be inferred. The assay was successfully applied to characterize biokinetic behavior from a test rapid sand filter; removal rates at reference loading matched those observed from full-scale observations, while a maximum removal capacity of 6.9 g NH4+–N/m3 packed sand/h could easily be determined at 7.5 g NH4+–N/m3 packed sand/h. This assay, with conditions reflecting full-scale observations, and where the biological activity is subject to minimal physical disturbance, provides a simple and fast, yet powerful tool to gain insight in nitrification kinetics in rapid sand filters.

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering, Residual Resource Engineering
Contributors: Tatari, K., Smets, B. F., Albrechtsen, H.
Pages: 6380-6387
Publication date: 2013
Peer-reviewed: Yes

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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 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
Assessing the permissiveness of complex bacterial communities towards conjugal plasmids - A novel method

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering, University of Copenhagen
Pages: 24-25
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Place of publication: Copenhagen
Publisher: DMS
Assessing the permissiveness of complex bacterial communities towards conjugal plasmids - A novel method

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering, University of Copenhagen
Number of pages: 1
Publication date: 2013
Peer-reviewed: Yes
Event: Poster session presented at Danish Microbiological Society 2013, Copenhagen, Denmark.
Research output: Research - peer-review › Poster – Annual report year: 2013

Assessing the permissiveness of complex bacterial communities towards conjugal plasmids – Development of a novel method

General information
State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry, Urban Water Engineering, University of Copenhagen
Number of pages: 1
Publication date: 2013
Peer-reviewed: Yes
Event: Poster session presented at 12th Symposium on Bacterial Genetics and Ecology (BAGECO12), Ljubljana, Slovakia.
Electronic versions:
ULIK BAGECO Poster.pdf
Source: dtu
Source-ID: u::7817
Research output: Research - peer-review › Poster – Annual report year: 2013

Assessing the permissiveness of complex bacterial communities towards conjugal plasmids – Development of a novel method

General information
State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry, Urban Water Engineering, University of Copenhagen
Number of pages: 2
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Publication date: 2013

Host publication information
Title of host publication: 12th Symposium on Bacterial Genetics and Ecology (BAGECO 12) : Networking and plasticity of microbial communities: The secret to success
Place of publication: Ljubljana, Slovenia
Electronic versions:
BAGECO2013_HP_WEB

Bibliographical note
P19
Source: dtu
Source-ID: u::10016
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2013

Bibliographical note
P3
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2013
Autotrophic Nitrogen Removal in a Membrane-Aerated Biofilm Reactor Under Continuous Aeration: A Demonstration

This work describes the successful coupling of partial nitrification (nitritation) and anaerobic ammonium oxidation in a membrane-aerated biofilm reactor (MABR) with continuous aeration. Controlling the relative surface loadings of oxygen versus ammonium prevented complete nitrite oxidation and allowed anaerobic ammonium-oxidizing bacteria (AnaerAOB) to develop and be retained for > 250 days. Daily autotrophic nitrogen removal of 1.7 g N/m² (75% of influent N load) was achieved at an oxygen/nitrogen surface loading ratio of 2.2, with up to 85% of the influent N proceeding through AnaerAOB. During early nitritation, nitrogen oxide (NO(g), NO₂(g), and N₂O(g)) emissions comprised up to 10% of the removed influent nitrogen, but emissions disappeared after proliferation of AnaerAOB. Microbial communities were radially stratified, with aerobic ammonium-oxidizing bacteria (AerAOB) colonizing nearest to and AnaerAOB furthest from the membrane. Despite the presence of nitrite-oxidizing bacteria, this work demonstrated that these autotrophic processes can be successfully coupled in an MABR with continuous aeration, achieving the benefits of competitive specific N removal rates and the elimination of gaseous nitrogen oxide emissions.

General information
State: Published
Organisations: Department of Environmental Engineering, Virginia Polytechnic Institute and State University, University of Michigan, John F. Kennedy Space Center
Pages: 38-45
Publication date: 2013
Peer-reviewed: Yes

Publication information
Journal: Environmental Engineering Science
Volume: 30
Issue number: 1
ISSN (Print): 1092-8758
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.5 SJR 0.602 SNIP 0.577
Web of Science (2017): Impact factor 1.547
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.6 SJR 0.602 SNIP 0.673
Web of Science (2016): Impact factor 1.426
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.19 SJR 0.501 SNIP 0.603
Web of Science (2015): Impact factor 1.481
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.06 SJR 0.494 SNIP 0.609
Web of Science (2014): Impact factor 0.991
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 1.04 SJR 0.453 SNIP 0.574
Web of Science (2013): Impact factor 0.933
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 1.14 SJR 0.636 SNIP 0.685
Web of Science (2012): Impact factor 1.154
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 1.08 SJR 0.551 SNIP 0.655
Web of Science (2011): Impact factor 0.877
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Barriers to bacterial motility on unsaturated surfaces

Our knowledge of the spatial organization and spatial dynamics of microbial populations in soil at a scale close to that of the microorganisms is scarce. While passive dispersal via water flow or soil biota is probably a major dispersal route, it is reasonable to consider that active dispersal also contributes to microbial spatial dynamics. In bacteria, active dispersal is enabled by a diversity of appendages and, in the case of swarming motility, by the secretion of surface active biomolecules. It is however unclear to which degree different types of motility can take place in the soil pores, a habitat characterized by complex 3D geometry and variable hydration. To approach these questions we take advantage of the Porous Surface Model (PSM) a unique experimental platform that allows direct monitoring of microbial motion under precisely controlled matric potential. Using gfp-tagged Pseudomonas strains and their isogenic mutants unable to express various types of motility we aimed to quantify the physical limits of bacterial motility. Our results demonstrate how hydration controls bacterial motility under unsaturated conditions. They can form the base of improved biodegradation models that include microbial dispersal processes.
Calibration and validation of a model describing complete autotrophic nitrogen removal in a granular SBR system

BACKGROUND: A validated model describing the nitritation-anammox process in a granular sequencing batch reactor (SBR) system is an important tool for: a) design of future experiments and b) prediction of process performance during optimization, while applying process control, or during system scale-up. RESULTS: A model was calibrated using a step-wise procedure customized for the specific needs of the system. The important steps in the procedure were initialization, steady-state and dynamic calibration, and validation. A fast and effective initialization approach was developed to approximate pseudo steady-state in the biofilm system. For oxygen mass transfer coefficient (kLa) estimation, long-term data, removal efficiencies, and the stoichiometry of the reactions were used. For the dynamic calibration a pragmatic model fitting approach was used - in this case an iterative Monte Carlo based screening of the parameter space proposed by Sin et al. (2008) - to find the best fit of the model to dynamic data. Finally, the calibrated model was validated with an independent data set. CONCLUSION: The presented calibration procedure is the first customized procedure for this type of system and is expected to contribute to achieve a fast and effective model calibration, an important enabling tool for various biochemical engineering design, control and operation problems.
Control of a Biological Nitrogen Removal Process in an Intensified Single Reactor Configuration

The nitrogen removing granular sludge process is a novel and intensified process. However, its stable operation and control remains a challenging problem. In this contribution, a new process oriented approach is used to develop, evaluate and benchmark control strategies to ensure stable operation and rejection of disturbances. Three control strategies were developed: a feedforward control (case 1), a rule-based feedback control (case 2), and a feedforward-feedback controller, in which the feedback loop updates the set point of the feedforward loop (case 3). The case 1 controller, based on influent measurements, was giving the best performance against disturbances in the ammonium concentration, whereas case 2 was providing the best performance against disturbances in the organic carbon concentration. The case 3 controller rejected both disturbances satisfactorily. Thus, this controller provided versatility towards disturbance rejection, however through a less tight control, which meant a bigger offset from the removal efficiency.

General information
State: Published
Organisations: Computer Aided Process Engineering Center, Department of Chemical and Biochemical Engineering, Center for Process Engineering and Technology, Department of Environmental Engineering
Contributors: Vangsgaard, A. K., Mauricio Iglesias, M., Gernaey, K., Smets, B. F., Sin, G.
Pages: 769-774
Publication date: 2013

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Title of host publication: 23rd European Symposium on Computer Aided Process Engineering – ESCAPE 23
Publisher: Elsevier
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DOIs:
Bibliographical note
Reviewed Conference proceeding
Source: dtu
Source-ID: u::8706
Research output: Research - peer-review › Article in proceedings – Annual report year: 2013

Control of a Biological Nitrogen Removal Process in an Intensified Single Reactor Configuration

General information
State: Published
Organisations: Computer Aided Process Engineering Center, Department of Chemical and Biochemical Engineering, Center for Process Engineering and Technology, Department of Environmental Engineering
Contributors: Vangsgaard, A. K., Mauricio Iglesias, M., Gernaey, K., Smets, B. F., Sin, G.
Publication date: 2013

Event information
Event: 18th Nordic Process Control Workshop
Location: University of Oulu, Oulu, Finland

Bibliographical note
Oral conference presentation.
Number of pages: 19
Source: dtu
Source-ID: u::9139
Research output: Research - peer-review › Sound/Visual production (digital) – Annual report year: 2013

Critical assessment of extracellular polymeric substances extraction methods from mixed culture biomass
Extracellular polymeric substances (EPS) have a presumed determinant role in the structure, architecture, strength, filterability, and settling behaviour of microbial solids in biological wastewater treatment processes. Consequently, numerous EPS extraction protocols have recently been published that aim to optimize the trade off between high EPS recovery and low cell lysis. Despite extensive efforts, the obtained results are often contradictory, even when analysing similar biomass samples and using similar experimental conditions, which greatly complicates the selection of an extraction protocol. This study presents a rigorous and critical assessment of existing physical and chemical EPS extraction methods applied to mixed-culture biomass samples (nitrifying, nitritation-anammox, and activated sludge biomass). A novel fluorescence-based method was developed and calibrated to quantify the lysis potential of different EPS extraction protocols. We concluded that commonly used methods to assess cell lysis (DNA concentrations or G6PDH activities in EPS extracts) do not correlate with cell viability. Furthermore, we discovered that the presence of certain chemicals in EPS extracts results in severe underestimation of protein and carbohydrate concentrations by using standard analytical methods. Keeping both maximum EPS extraction yields and minimal biomass lysis as criteria, it was identified a sonication-based extraction method as the best to determine and compare tightly-bound EPS fractions in different biomass samples. Protein was consistently the main EPS component in all analysed samples. However, EPS from nitrifying enrichments was richer in DNA, the activated sludge EPS had a higher content in humic acids and carbohydrates, and the nitritation-anammox EPS, while similar in composition to the nitrifier EPS, had a lower fraction of hydrophobic biopolymers. In general, the easily-extractable EPS fraction was more abundant in carbohydrates and humic substances, while DNA could only be found in tightly bound EPS fractions. In conclusion, the methodology presented herein supports the rational selection of analytical tools and EPS extraction protocols in further EPS characterization studies.

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Pellicer i Nàcher, C., Domingo Felez, C., Mutlu, A. G., Smets, B. F.
Pages: 5564-5574
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Publication information
Journal: Water Research
Volume: 47
Issue number: 15
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General information
State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry, Novo Nordisk Foundation Center for Biosustainability, CFB - Core Flow
Pages: 3-16
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Peer-reviewed: Yes

Publication information
Journal: Microbial Biotechnology
Volume: 6
Issue number: 1
ISSN (Print): 1751-7907
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 3.99
Web of Science (2017): Impact factor 3.913
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 3.56
Web of Science (2016): Impact factor 3.513
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 3.59 SJR 1.333 SNIP 1.066
Web of Science (2015): Impact factor 3.991
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 3.19 SJR 1.368 SNIP 1.191
Web of Science (2014): Impact factor 3.081
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 3 SJR 1.183 SNIP 0.997
Web of Science (2013): Impact factor 3.023
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Diversity of total and functional microbiome of anammox reactors fed with complex and synthetic nitrogen-rich wastewaters

There are few comparative studies of microbial structure, composition and phylogenetic diversity of the anammox reactors as a function of substrate complexity exist, representing a large gap in the scientific literature. In this study, we applied 16S rRNA gene (rDNA) tag-based 454 pyrosequencing as a deep sequencing approach to 59 biomass samples from 24 different anammox bioreactors together with proper biological replication in order to compare their total and functional (wrt anaerobic ammonium oxidation) microbial diversity. Among 24 sampled bioreactors, 10 of them were full scale implementations treating complex nitrogen-rich wastewaters and 14 were lab-scale implementations treating synthetic wastewaters. We found that nitritation/anammox bioreactors treating complex nitrogen-rich wastewaters were more diverse in terms of total microbial diversity but less diverse at anammox functional diversity than the bioreactors treating synthetic wastewaters inferred from observed OTUs0.03, Chao1, Shannon index and Phylogenetic distance calculations. Differences in total microbial diversity agreed with the ecological theory concerning the positive correlation between substrate complexity and biodiversity (Parrott 2010), but, not (Harris et al. 2012) in the anammox functional guild diversity (functional diversity term was used based on phylogenetic groups known to harbor the anammox metabolic pathway). Classifying the microbial structure of bioreactors according to substrate complexity using weighted UniFrac algorithm explained 29% of the variance where the bioreactor samples of complex nitrogen-rich wastewater feeding was clearly separated from the bioreactor samples of synthetic feeding.

Here we examined and compared for the first time microbial diversity of nitritation-anammox reactors that are designed and built individually for treating complex nitrogen-rich and synthetic wastewaters across the world using 16 rRNA gene pyrosequencing. With the aid of replicated genetic snapshots, we revealed the relationship between the microbial diversity of nitritation-anammox reactors operated by different substrate complexity in terms of microbial composition, structure, richness and phylogenetic diversity from two points of view: total and functional diversity.
Driving towards stratified aggregation in single-stage nitritation/anammox reactors by varying aeration regimes

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering, Computer Aided Process Engineering Center, Department of Chemical and Biochemical Engineering, Technical University of Denmark
Publication date: 2013
Peer-reviewed: Yes
Event: Poster session presented at IWA 9th international Conference on Biofilm Reactors, Paris, France.
Source: dtu
Source-ID: u::9138
Research output: Research - peer-review › Poster – Annual report year: 2013

Examining biological sand filters for drinking water treatment as biofilm reactors: experimental and modeling approach

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering, Krüger A/S
Contributors: Tatari, K., Smets, B. F., Lee, C. O., Nielsen, P. B., Albrechtsen, H.
Number of pages: 2
Publication date: 2013
Peer-reviewed: Yes
Source: dtu
Source-ID: u::9346
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2013

Impact of wormholes and cm-scale distribution of biodegradation potential on simulated pesticide leaching through loamy agricultural soil

General information
State: Published
Contributors: Rosenbom, A. E., Binning, P. J., Aamand, J., Dechesne, A., Smets, B. F., Risbjerg Johnsen, A.
Number of pages: 1
Pages: 26-26
Publication date: 2013

Host publication information
Title of host publication: 3rd BioHydrology Conference : Abstract Book
Place of publication: Germany
Electronic versions: Biohydrology_2013_Abstract_Book_2_.pdf
Source: dtu
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Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2014
Innovative Two-stage Engineering Solutions for Resource Recovery via Downstream Cultivation of Green Microalgae

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering
Contributors: Valverde Perez, B., Smets, B. F., Plósz, B.
Number of pages: 1
Pages: 67
Publication date: 2013

Host publication information
Title of host publication: 9th IWA international Conference and Exhibition on Watereuse : Proceedings Book
Place of publication: Windhoek, Namibia
Publisher: IWA Publishing

Bibliographical note
IWA-13059
Source: dtu
Source-ID: u::9399
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2013

Interactions between microbial activity and distribution and mineral coatings on sand grains from rapid sand filters treating groundwater

Rapid sand filtration is a traditional and widespread technology for drinking water purification which combines biological, chemical and physical processes together. Granular media, especially sand, is a common filter material that allows several oxidized compounds to accumulate on its surface. Preliminary, we detected a strong relation between the amount of DNA and mineral coating mass. We hypothesized that the accumulated mineral coatings have a positive effect on amount of bacterial biomass, its spatial distribution and substrate removal rates. In this study, we combined molecular, microscopic, physico-chemical and biokinetic techniques to determine the interaction between attached bacteria and attached minerals in rapid sand filters as well as the causality of the relation. Strong pairwise correlations revealed the strong relation between mineral physical properties and bacterial activity and abundance indicated that attached minerals are an important factor controlling bacterial colonization, growth, distribution and substrate utilization in these systems.

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering, Department of Micro- and Nanotechnology
Contributors: Gülay, A., Tatari, K., Musovic, S., Mateiu, R. V., Albrechtsen, H., Smets, B. F.
Number of pages: 4
Publication date: 2013
Peer-reviewed: Yes
Event: Abstract from 5th International Conference Microbial Ecology and Water Engineering, Michigan, United States.

Bibliographical note
Oral presentation
Source: dtu
Source-ID: u::10274
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2013

Microalgae Biorefinery - Industrial Symbiosis

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering, Urban Water Engineering, National Food Institute, Division of Industrial Food Research, Kalundborg Kommune
Number of pages: 1
Publication date: 2013
Peer-reviewed: Yes
Event: Poster session presented at Copenhagen Bioscience Conference: Cell Factories and Biosustainability, Denmark.
Electronic versions: posterb.pdf
Microbial activity catalyzes oxygen transfer in membrane-aerated nitritating biofilm reactors

The remarkable oxygen transfer efficiencies attainable in membrane-aerated biofilm reactors (MABRs) are expected to favor their prompt industrial implementation. However, tests in clean water, currently used for the estimation of their oxygen transfer potential, lead to wrong estimates once biofilm is present, significantly complicating reactor modelling and control. This study shows for the first time the factors affecting oxygen mass transfer across membranes during clean water tests and reactor operation via undisturbed microelectrode inspection and bulk measurements. The mass transfer resistance of the liquid boundary layer developed at the membrane-liquid interface during clean water tests accounted for two thirds of the total mass transfer resistance, suggesting a strong underestimation of the oxygen transfer rates when it is absent (e.g., after biofilm growth). Reactor operation to attain partial nitritation showed that predicted oxygen transfer rates are enhanced up to six times with biofilm activity. The higher availability of ammonia at the biofilm base drives this process. Such behavior can be captured with the addition of two terms (depending on system characteristics and reactor loading) to existing model structures. Overall, we provide tools to better estimate, model, and optimize oxygen transfer supporting a more energy-efficient approach to MABR operation.

General information
State: Published
Organisations: Department of Environmental Engineering, Karlsruhe Institute of Technology
Contributors: Pellicer i Nàcher, C., Domingo Felez, C., Lackner, S., Smets, B. F.
Number of pages: 7
Pages: 465-471
Publication date: 2013
Peer-reviewed: Yes

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Journal: Journal of Membrane Science
Volume: 446
ISSN (Print): 0376-7388
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 6.93 SJR 2.4 SNIP 1.898
Web of Science (2017): Impact factor 6.578
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 6.13 SJR 2.087 SNIP 1.731
Web of Science (2016): Impact factor 6.035
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.89 SJR 1.978 SNIP 1.763
Web of Science (2015): Impact factor 5.557
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.42 SJR 2.436 SNIP 1.924
Web of Science (2014): Impact factor 5.056
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 5.38 SJR 2.451 SNIP 1.994
Web of Science (2013): Impact factor 4.908
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 4.37 SJR 2.185 SNIP 1.962
Web of Science (2012): Impact factor 4.093
ISI indexed (2012): ISI indexed yes
Microbial community structure and a core microbiome in biological rapid sand filters at Danish waterworks

Rapid sand filtration is a traditional and common technology for drinking water purification from groundwater. Despite its wide scale and long-term use, the diversity and characterization of microbial communities in these engineered systems have remained unexplored and their roles in removal performances yet to be discovered. In order to explore the microbial ecology of these systems, we conducted 16S rRNA gene (rDNA) based 454 pyrosequencing as a deep sequencing approach to 94 sample cores retrieved from 5 different waterworks including proper biological replication. This comprehensive sampling of replicate rapid sand filters across many waterworks together with high-throughput sequencing provides a first glimpse into the microbial communities in rapid sand filters and their potential roles in the treatment process.

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering
Contributors: Gülay, A., Musovic, S., Albrechtsen, H., Smets, B. F.
Number of pages: 4
Publication date: 2013
Peer-reviewed: Yes
Event: Abstract from 5th International Conference Microbial Ecology and Water Engineering, Michigan, United States.
Electronic versions: IWA-12814Gulay-.pdf
Model-based evaluation of the role of Anammox on nitric oxide and nitrous oxide productions in membrane aerated biofilm reactor

A multispecies one-dimensional biofilm model considering nitric oxide (NO) and nitrous oxide (N2O) productions for membrane aerated biofilm reactor (MABR) that remove nitrogen autotrophically through aerobic ammonia oxidation followed by Anammox is used to study the role of Anammox activity on the total nitrogen (TN) removal and the productions of NO and N2O. The model is applied to evaluate how periodic aeration as a control parameter reduces NO and N2O production but maintains high TN removal in MABR. The simulation results show over 3.5% of the removed TN could be attributed to NO and N2O production in MABR under the operational conditions optimal for TN removal (72%). An analysis of factors governing the Anammox activity in MABR shows that enhancing Anammox activity not only helps to achieve a high level of nitrogen removal but also reduces NO and N2O productions. Comparison of aeration strategies (periodic aeration vs. continuous aeration) reveals that periodic aeration can reduce NO and N2O production while maintaining a high level of nitrogen removal through promoting Anammox growth. Application of periodic aerations with different cycle frequencies to the MABR indicates that an increase in the cycle frequency of the periodic aeration can further maximize TN removal and minimize the NO and N2O production in membrane aerated biofilm. The information of this paper will be useful for understanding the indirect role of Anammox on NO and N2O productions and for optimizing the design and operation of MABR systems.
Complete autotrophic nitrogen removal (CANR) is a novel process that can increase the treatment capacity for wastewaters containing high concentrations of nitrogen and low organic carbon to nitrogen ratios, through an increase of the volumetric removal rate by approximately five times. This process is convenient for treating anaerobic digester liquor, landfill leachate, or special industrial wastewaters, because costs related to the need for aeration and carbon addition are lowered by 60% and 100%, respectively, compared to conventional nitrification denitrification treatment. Energy and capital costs can further be reduced by intensifying the process and performing it in a single reactor, where all processes take place simultaneously, e.g. in a granular sludge reactor, which was studied in this project. This process intensification means on the other hand an increased complexity from an operation and control perspective, due to the smaller number of actuators available.

In this work, an integrated modeling and experimental approach was used to improve the understanding of the process, and subsequently use this understanding to design novel control strategies, providing alternatives to the current ones available. First, simulation studies showed that the best removal efficiency was almost linearly dependent on the volumetric oxygen to nitrogen loading ratio. This finding among others, along with experimental results from start-up of laboratory-scale reactors, served as the basis for development of three single-loop control strategies, having oxygen supply as the actuator and removal efficiency as the controlled variable. These were investigated through simulations of an experimentally calibrated and validated model. A feedforward-feedback control strategy was found to be the most versatile
towards the disturbances at the expense of slightly slower dynamic responses and additional complexity of the control structure. The functionality of this strategy was tested experimentally in a lab-scale reactor, where it showed the ability to reject disturbances in the incoming ammonium concentrations. However, during high ammonium loadings, when the capacity of the present sludge was reached, an oscillatory response was observed. Proper tuning of the controller is therefore of essential importance.

In this thesis, it was demonstrated that proactive use of model simulations, in an integrated methodology with experimentation, resulted in improved process understanding and novel control ideas. This will contribute to moving this promising technology from a case-by-case ad hoc approach to a more systematic knowledge based approach.

General information
State: Published
Organisations: Department of Chemical and Biochemical Engineering, Computer Aided Process Engineering Center, Center for Process Engineering and Technology, Department of Environmental Engineering
Contributors: Vangsgaard, A. K., Sin, G., Gernaey, K., Smets, B. F.
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Anna Katrine Vangsgaard_PEC13-50.pdf
Source: dtu
Source-ID: u::9165

Modelling N\textsubscript{2}O dynamics in the engineered N cycle: Observations, assumptions, knowns, and unknowns
Research on nitrous oxide formation in engineered wastewater systems has experienced an exponential development in the recent years due to the important environmental impact of this greenhouse gas. These efforts have crystallized in a large number of publications that aim to identify the importance of the main microbial processes responsible for its production and consumption. The conceptualization of these pathways in mathematical models has the potential to become a key tool to increase our understanding on the complex interrelationships within these ecosystems and develop strategies to minimize the carbon footprint of wastewater treatment plants. Unfortunately, existing model structures are limited to describe the emissions of individual microbial pathways in an attempt to decrease their complexity and facilitate their calibration. The present contribution summarizes the recent developments in this field and makes use of sensitivity analyses, and an in-depth study of model uncertainties to establish experimental protocols that facilitate the calibration and predictive ability of a new generation of more realistic models describing N\textsubscript{2}O production during wastewater treatment.

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Organisations: Department of Environmental Engineering, Department of Chemical and Biochemical Engineering, Computer Aided Process Engineering Center
Number of pages: 1
Publication date: 2013
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Event: Abstract from ICON3: 3rd international conference on Nitrification, Tokoy, Japan.
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Neutrophilic iron-oxidizing bacteria: occurrence and relevance in biological drinking water treatment
Rapid sand filtration (RSF) is an economical way to treat anoxic groundwater around the world. It consists of groundwater aeration followed by passage through a sand filter. The oxidation and removal of ferrous iron, which is commonly found in anoxic groundwaters, is often believed to be a fully physicochemical process. However, persistently low temperatures in RSF across Denmark may negatively affect the kinetics of chemical oxidation. The slower chemical oxidation of ferrous
Iron may increase the chances for iron bioconversion by neutrophilic iron-oxidizing bacteria (FeOB), which are found naturally in many environments. In this study, we used a combination of a cultivation-based opposing gradient enrichment technique and 16S rRNA gene targeted molecular tools to isolate, quantify and identify FeOB from a RSF. The microscopic quantification of selectively enriched FeOB cells revealed that in RSF, neutrophilic iron oxidizers were present at the level of up to 7 × 10^5 cells g⁻¹ sediment. The spatial abundance and diversity of FeOB inferred by denaturing gradient gel electrophoresis fingerprinting differed greatly both between and within individual sand filters. The results suggest a larger than assumed role of FeOB in iron removal at waterworks using RSF technologies.

**General information**

State: Published  
Organisations: Department of Environmental Engineering, Residual Resource Engineering, Urban Water Engineering  
Contributors: Gülay, A., Musovic, S., Albrechtsen, H., Smets, B. F.  
Pages: 1295-1301  
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Web of Science (2017): Impact factor 0.674  
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BFI (2016): BFI-level 1  
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Web of Science (2016): Impact factor 0.573  
BFI (2015): BFI-level 1  
Scopus rating (2015): CiteScore 0.64 SJR 0.295 SNIP 0.473  
Web of Science (2015): Impact factor 0.532  
Web of Science (2015): Indexed yes  
BFI (2014): BFI-level 1  
Scopus rating (2014): CiteScore 0.47 SJR 0.273 SNIP 0.456  
Web of Science (2014): Impact factor 0.394  
BFI (2013): BFI-level 1  
Scopus rating (2013): CiteScore 0.57 SJR 0.41 SNIP 0.384  
Web of Science (2013): Impact factor 0.505  
ISI indexed (2013): ISI indexed no  
Web of Science (2013): Indexed yes  
BFI (2012): BFI-level 1  
Scopus rating (2012): CiteScore 0.51 SJR 0.316 SNIP 0.404  
ISI indexed (2012): ISI indexed no  
BFI (2011): BFI-level 1  
Scopus rating (2011): CiteScore 0.53 SJR 0.372 SNIP 0.359  
ISI indexed (2011): ISI indexed no  
BFI (2010): BFI-level 1  
Scopus rating (2010): SJR 0.303 SNIP 0.379  
Web of Science (2010): Indexed yes  
BFI (2009): BFI-level 1  
Scopus rating (2009): SJR 0.235 SNIP 0.295  
BFI (2008): BFI-level 1  
Scopus rating (2008): SJR 0.304 SNIP 0.366  
Scopus rating (2007): SJR 0.303 SNIP 0.235
Nitrous Oxide and Nitric Oxide Emissions From Single-Stage Nitritation/Anammox Reactors Under Varying Aeration Regimes

N2O production dynamics in nitrifying/denitrifying activated sludge under defined environmental conditions

Nitrification activity stratifies in a rapid sand filter for drinking water treatment - A study in two Danish waterworks
Nitrifier-denitrification was proposed as the main pathway catalyzing the conversion of fixed nitrogen to N₂O. Heterotrophic denitrification rates were one order of magnitude lower than nitrification rates and contributed marginally to the overall N₂O production. Further data analysis allowed derivation of the overall mass transfer coefficients describing gaseous stripping and revealed that a minor portion of the N₂O produced was actually released to the gas phase. This work represents a step further in the use and calibration of process models to control and understand better N₂O production and emissions during conventional wastewater treatment.

**General information**
State: Published
Organisations: Department of Environmental Engineering
Contributors: Pellicer i Nàcher, C., Jensen, M. M., Petersen, M. S., Smets, B. F.
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Publication date: 2013
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Event: Abstract from ICON3: 3rd international conference on Nitrification, Tokyo, Japan.
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Source-ID: u::8822
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2013

**Performance of an autotrophic nitrogen removing reactor: Diagnosis through fuzzy logic**
Autotrophic nitrogen removal through nitritation-anammox in one stage SBRs is an energy and cost efficient alternative to conventional treatment methods. Intensification of an already complex biological system challenges our ability to observe, understand, diagnose, and control the system. A fuzzy logic diagnosis tool was developed, utilizing stoichiometric and concentration ratio measurements and removal efficiencies, along with rules derived from process knowledge. The tool could accurately determine the overall performance of the system and can therefore serve as a powerful tool to provide input for future control applications.

**General information**
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Organisations: Computer Aided Process Engineering Center, Department of Chemical and Biochemical Engineering, Center for Process Engineering and Technology, Department of Environmental Engineering, Residual Resource Engineering
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Publication date: 2013
Peer-reviewed: Yes
Event: Abstract from 11th IWA conference on instrumentation control and automation, Narbonne, France.
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**Phosphate limitation in biological rapid sand filters used to remove ammonium from drinking water**
Removing ammonium from drinking water is important for maintaining biological stability in distribution systems. This is especially important in regions that do not use disinfectants in the treatment process or keep a disinfectant residual in the distribution system. Problems with nitrification can occur with increased ammonium loads caused by seasonal or operational changes and can lead to extensive periods of elevated ammonium and nitrite concentrations in the effluent. One possible cause of nitrification problems in these filters maybe due to phosphate limitation. This was investigated using a pilot scale sand column which initial analysis confirmed performed similarly to the full scale filters. Long term increased ammonium loads were applied to the pilot filter both with and without phosphate addition. Phosphate was added at a concentration of 0.5 mg PO₄-P/L to ensure that it was not the limiting substrate. Preliminary results showed an increased nitrification capacity both with and without phosphate addition although the addition of phosphate doubled the ammonium and nitrite removal capacity of the filter compared to non-phosphate dosing conditions. Phosphate addition also increased the total number of ammonium oxidizing bacteria in the column. © 2013 American Water Works Association AWWA WQTC Conference Proceedings All Rights Reserved.

**General information**
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Autotrophic nitrogen removal has become the process of choice to treat nitrogen-rich wastewaters due to its significantly lower operation costs. This technology makes use of stratified biofilm or bioaggregate structures to enrich aerobic and anaerobic ammonium oxidizing bacteria that catalyse the conversion of ammonium to nitrogen gas via nitrite in a single reactor. Recent work on membrane-aerated biofilm reactors (MABRs) has shown that this concept can be taken even further by growing these biocatalysts on aeration membranes, hereby significantly lowering aeration costs and greenhouse gas emissions without compromising performance. Preliminary experimental work manifested the difficulty of reducing the activity of Nitrite Oxidizing Bacteria (NOB), which lowered the removal efficiency of the system. Advanced molecular biology tools were used to confirm that periodic aeration of MABRs can serve as a control strategy to outcompete NOB and stimulate the metabolism of anaerobic ammonium oxidizing bacteria. Furthermore, it could be observed that the accurate control of the oxygen load, unique for MABRs, allowed the construction of a highly stratified biofilm structure with aerobic ammonium oxidizing bacteria (AOB) growing on the membrane surface, and anaerobic ammonium oxidizing bacteria (AnAOB) distributed in a very thin stratum by the liquid phase. AOB and AnAOB communities, both dominated by fast-growing genera, were relatively more diverse than observed in other conventional biofilm reactors performing the same process. Our results suggested that the detachment of large amounts of biofilm could seriously impair reactor performance due to the washout of AnAOB, growing in the outer anaerobic regions of the biofilm. It has been suggested that the excretion of extracellular polymeric substances (EPS) can enhance biofilm strength under certain conditions. Despite their crucial importance, there is currently no agreement within the scientific community on a protocol that optimizes EPS recovery from microbial samples without significantly compromising the viability of the embedded bacterial cells. Thus, we performed a rigorous benchmarking study on the effect of a wide range of published EPS extraction techniques on cell lysis and biopolymer extraction yields. According to our results, ultrasonic treatments could retrieve a larger amount of EPS from most studied samples, was less biased by molecular interactions, and did not have a significant impact on cell integrity. Further experimental work partially rejected the possibility of enhancing the strength of a model autotrophic MABR biofilm by either modifying the shear stress or the oxygen supply rates under cultivation. Overall, the biofilm layers closer to the biofilm-liquid interface displayed relatively lower cohesion forces against shear stresses, but still higher than observed in other conventional biofilms grown under similar environmental conditions. None of the biofilms tested detached completely from the substratum and proved to have very high adhesion strengths. Microscopic observations confirmed that this adhesion layer was dominated by very compact cell structures encapsulated in a dense layer of protein and carbohydrate. Observations at various scales were further used to confirm that a higher level of shear in the bulk liquid made the biofilms thinner, denser (less porous), more homogeneous, and with a higher content of volatile material than the rest of assayed conditions. The factors impacting oxygen transfer with and without biofilm, unclear until now, were successfully identified using sophisticated microprofiling investigations under undisturbed reactor operation. It could be concluded that conventional methods to characterize oxygen transfer rates in clean water underestimated those observed when a biofilm was present considerably. Higher degrees of bacterial activity at the biofilm base catalysed oxygen transfer. This behaviour was described with the addition of two terms (depending on system characteristics and reactor loading conditions) to existing model structures. In conclusion, we presented control strategies to engineer the microbial communities catalysing autotrophic nitrogen removal in MABRs, proposed methods to minimise the risk and effect of bacterial sloughing, and developed novel strategies to characterize, optimize, and better regulate oxygen transfer. Overall, the present work should serve to better design reactors supporting a cleaner, more robust, and cost-effective nitrogen removal. Furthermore, the large dataset of structural biofilm data reported here should facilitate the calibration of process models for the implementation of advanced process control.
Relating dynamic conditions to the performance of biological rapid sand filters used to remove ammonium, iron, and manganese from drinking water

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Publisher: The Danish Water Research and Innovation Platform
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Reply to Comment on "Modeling Nitrous Oxide Production during Biological Nitrogen Removal via Nitrification and Denitrification: Extensions to the General ASM Models"

General information
State: Published
Organisations: Department of Environmental Engineering, Technical University of Denmark
Contributors: Ni, B., Ruscalleda, M., Pellicer i Nácher, C., Smets, B. F.
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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
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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
Stratification of nitrification activity in rapid sand filters for drinking water treatment

Rapid sand filters used in groundwater treatment remove ammonium, iron and manganese from the water. Ammonium is removed biologically by nitrifying microorganisms attached on the sand surface. Nitrification kinetics and activity is strongly affected by filter design and operation, which are the key parameters in process optimization. Nitrification optimization needs a detailed insight of the process and the way it takes place in the filter. Filters are often considered in a "black box" approach, where data are only available for influent and effluent and the entire filter is assumed homogenous. The aim of this study is to investigate nitrification activity in a rapid sand filter, with focus on its homogeneity and how it relates to filter performance.
Two groundwater treatment plants in Denmark were selected for the experimental investigations. Plant 1 operates a single line of pre and after filters and has been well performing over the last years. Plant 2 consists of two separate lines, each one with pre and after filtration steps. Plant 2 has experienced challenges in removing ammonium below the 0.05 mg/L regulatory limit especially in one of the two lines. Sand core samples were taken from the after filter in Plant 1 and the after filters in both lines of plant 2. Core samples were divided according to depth and nitrification activity was measured in a lab scale assay. The method consists in a continuous flow mini-column where influent and effluent are monitored for all nitrogen species. Kinetics and maximum nitrification capacity are derived and used to quantify nitrification activity. Nitrification activity was concentrated at the top 10 cm of filter depth, and maximum nitrification capacity was 7 g NH4+-N/m3 sand/h compared with 0.8-0.4 g NH4+-N/m3 sand/h in the middle and bottom layers. A water sampler was installed in the full scale filter of plant 1 to observe the ammonium profile with depth. Ammonium was removed within the upper 15 cm with a removal rate ranging of 3.6-7.7 g NH4+-N/m3 sand/h. Full scale observations fit with the lab scale activity measurements showing that the upper layer of the filter is where nitrification mostly happens. Deeper layers that are less active, provide extra nitrifying capacity in case ammonium is not removed within the top 15 cm. qPCR counts for ammonium oxidizing bacteria showed a decrease from 5*10^7 cells /gr sand at the top of the filter to 2*10^5 cells /gr sand in the lowest 20 cm. From this study results that rapid sand filters are not homogenous in terms of biological activity. This can be an important consideration when modeling these units and as a basis for process optimization.

General information
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Organisations: Department of Environmental Engineering, Urban Water Engineering, Krüger A/S, Københavns Energi A/S
Contributors: Tatari, K., Smets, B. F., Musovic, S., Nielsen, P. B., Lind, S., Albrechtsen, H.
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An operation protocol for facilitating start-up of single-stage autotrophic nitrogen removing reactors based on process stoichiometry
Start-up and operation of single-stage nitritation/anammox reactor employing complete autotrophic nitrogen can be difficult. Keeping the performance criteria and monitoring the microbial community composition may not be easy or fast enough to take action on time. In this study, a control strategy is developed based on stoichiometric analysis of monitored nitrogen species. This analysis can serve as a strong decision-making tool to take appropriate actions with respect to the operational conditions to accelerate start up or attainment of near complete nitritation-anammox performance.

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Organisations: Department of Environmental Engineering, Environmental Chemistry, Department of Chemical and Biochemical Engineering, Computer Aided Process Engineering Center
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Publication date: 2012

Host publication information
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Source: dtu
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Research output: Research - peer-review » Article in proceedings – Annual report year: 2012

An operation protocol for facilitating start-up of single-stage autotrophic nitrogen removing reactors based on process stoichiometry

General information
State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry, Department of Chemical and Biochemical Engineering, Computer Aided Process Engineering Center
Biological removal of iron and manganese in rapid sand filters - Process understanding of iron and manganese removal

In Denmark and many other European countries, drinking water is exclusively or mainly based on groundwater. Treatment of the groundwater is rather simple, only including aeration and a subsequent filtration process. The filtration process may take place over to steps. Step 1: Filtration in a pre-filter, where iron is removed. Step 2: Filtration in an after-filter where e.g. ammonium and manganese is removed. The treatment relies on microbial processes and may present an alternative, greener and more sustainable approach for drinking water production spending less chemicals and energy than chemical (e.g. flocculation) and physical (e.g. membrane filtration) based technologies.

The removal of dissolved manganese and iron is important. If manganese and iron enter the distribution system, the water will become coloured and have a metallic taste, and it may cause problems in the distribution network due to precipitation and corrosion.

Manganese and iron can either be removed physico-chemically or biologically or combined. The physico-chemical oxidation and precipitation of manganese can theoretically be achieved by aeration, but this process is slow unless pH is raised far above neutral, making the removal of manganese by simple aeration and precipitation under normal drinking water treatment conditions insignificant. Manganese may also be oxidized autocatalytically. Iron is usually easier to remove. First, iron is rapidly chemically oxidized by oxygen at neutral pH followed by precipitation and filtration. The start-up of new filters is often based on “rules of thumb” procedures. New filters are often inoculated with sand from existing filters or backwash sludge, but this result in unpredictable start-up of filter performances. To obtain a well-functioning filter with biological manganese or iron removal, it is essential to ensure that the required microorganisms are present and that both the physical and the nutritional requirements of those organisms are fulfilled. However, the knowledge on the microbiology and processes in rapid sand filters is limited, especially on which parameters that affect the biological processes and the interaction between them. Some studies have indicated a direct competition between iron and ammonium removal when oxygen is limited, and both processes may have a negative effect on the manganese removal (de Vet et al., 2009; Tekerlekopoulou et al., 2008). However the reasons for these effects remain unclear.

The aim of this study was to develop a batch assay to quantify microbial manganese and iron removal and to investigate the effect of interactions between the manganese and iron removal processes. The assay is now developed and allows testing of various parameters as well as distinguishing between biological and non-biological removal processes. Results with filter material from a water works, Islevbro, showed that there was a significant difference in manganese removal when oxygen is limited, and both processes may have a negative effect on the manganese removal (de Vet et al., 2009; Tekerlekopoulou et al., 2008). However the reasons for these effects remain unclear.

The results also showed that pH and oxygen level are important parameters. When filter material was treated with sodium azide to inhibit microbial activity, less iron(II) was adsorbed to the filter material, indicating that iron oxidizing bacteria contributed to the oxidation of iron(II) to iron(III).
Biological Removal of Manganese and Iron in Rapid Sand Filters

Calibration and validation of a model describing complete autotrophic nitrogen removal in granular sludge

Calibration and validation of model describing complete autotrophic nitrogen removal in granular sludge
Effect of surface loading fluctuations in rapid sand-filters used to remove ammonium from drinking water

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering, Environmental Chemistry
Contributors: Tatari, K., Smets, B. F., Albrechtsen, H.
Number of pages: 1
Publication date: 2012
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Event: Abstract from 2012 Water Quality Technology Conference and Exposition (WQTC), Toronto, Ontario, Canada.
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Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2012

Effect of surface loading fluctuations on ammonium removal during rapid sand filtration

General information
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Contributors: Tatari, K., Smets, B. F., Nielsen, P. B., Lind, S., Albrechtsen, H.
Number of pages: 1
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Effect of the kinetics of ammonium and nitrite oxidation on nitritation success or failure for different biofilm reactor geometries

The effect of biokinetics on nitritation was investigated in two biofilm geometries, the Membrane Aerated Biofilm Reactor (MABR) and a conventional biofilm system. A 1D biofilm model was used and evaluated by global sensitivity analysis using the variance based Sobol method. The main focus was on the influence of key biokinetic parameters (maximum specific growth rates, oxygen and nitrogen affinity constants of AOB (ammonium oxidizing bacteria) and NOB (nitrite oxidizing bacteria)) and their ratios on nitritation efficiency in these geometries. This exhaustive simulation study revealed that nitritation strongly depends on the chosen kinetic parameters of AOB and NOB. The maximum specific growth rates ($\mu_{\text{max},\text{AOB}}$ and $\mu_{\text{max},\text{NOB}}$) had the strongest impact on nitritation efficiency (NE). In comparison, the counter-diffusion geometry yielded more parameter combinations (27.5%) that resulted in high NE than the co-diffusion geometry (7.9%). The oxygen concentrations at the relevant biofilm interfaces (membrane/biofilm for counter-diffusion or bulk/biofilm for co-diffusion) were not predictive of NE. However, the maximum allowable oxygen concentration to maintain higher NE was higher for the counter-diffusion geometry.

General information
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Organisations: Department of Environmental Engineering, Environmental Chemistry, Karlsruhe Institute of Technology
Contributors: Lackner, S., Smets, B. F.
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Peer-reviewed: Yes
Efficient Total Nitrogen Removal in an Ammonia Gas Biofilter through High-Rate OLAND

Ammonia gas is conventionally treated in nitrifying biofilters; however, addition of organic carbon to perform post-denitrification is required to obtain total nitrogen removal. Oxygen-limited autotrophic nitrification/denitrification (OLAND), applied in full-scale for wastewater treatment, can offer a cost-effective alternative for gas treatment. In this study, the OLAND application thus was broadened toward ammonia loaded gaseous streams. A down flow, oxygen-saturated biofilter (height of 1.5 m; diameter of 0.11 m) was fed with an ammonia gas stream (248 ± 10 ppmv) at a loading rate of 0.86 ± 0.04 kg N m–3 biofilter d–1 and an empty bed residence time of 14 s. After 45 days of operation a stable nitrogen removal rate of 0.67 ± 0.06 kg N m–3 biofilter d–1, an ammonia removal efficiency of 99%, a removal of 75–80% of the total nitrogen, and negligible NO/N2O productions were obtained at water flow rates of 1.3 ± 0.4 m3 m–2 biofilter section d–1. Profile measurements revealed that 91% of the total nitrogen activity was taking place in the top 36% of the filter. This study demonstrated for the first time highly effective and sustainable autotrophic ammonia removal in a gas biofilter and therefore shows the appealing potential of the OLAND process to treat ammonia containing gaseous streams.

General information
State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry, Ghent University
Contributors: De Clippeleir, H., Courtens, E., Mosquera, M., Vlaeminck, S. E., Smets, B. F., Boon, N., Verstraete, W.
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BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 6.26 SJR 2.559 SNIP 1.902
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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
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Web of Science (2013): Impact factor 5.481
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
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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
Energibesparende biologisk proces til kvælstoffjernelse i spildevand

General information
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Organisations: Department of Chemical and Biochemical Engineering, Computer Aided Process Engineering Center, Center for Process Engineering and Technology, Department of Environmental Engineering, Environmental Chemistry
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ISI indexed (2012): ISI indexed no
Evaluation on the microbial interactions of anaerobic ammonium oxidizers and heterotrophs in Anammox biofilm

Anaerobic ammonium oxidation (Anammox) is a cost-effective new process to treat high-strength nitrogenous wastewater. In this work, the microbial interactions of anaerobic ammonium oxidizers and heterotrophs through the exchange of soluble microbial products (SMP) in Anammox biofilm and the affecting factors were evaluated with both experimental and modeling approaches. Fluorescent in situ hybridization (FISH) analysis illustrated that Anammox bacteria and heterotrophs accounted for 77% and 23% of the total bacteria, respectively, even without addition of an external carbon source. Experimental results showed the heterotrophs could grow both on SMP and decay released substrate from the metabolism of the Anammox bacteria. However, heterotrophic growth in Anammox biofilm (23%) was significantly lower than that of nitrifying biofilm (30–50%). The model predictions matched well with the experimental observations of the bacterial distribution, as well as the nitrogenous transformations in batch and continuous experiments. The modeling results showed that low nitrogen surface loading resulted in a lower availability of SMP leading to low heterotrophic growth in Anammox biofilm, but high nitrogen surface loading would lead to relative stable biomass fractions although the absolute heterotrophic growth increased. Meanwhile, increasing biofilm thickness increased heterotrophic growth but has little influence on the relative biomass fractions.
Increased insight in microbial processes in rapid sandfilters in drinking water treatment (DW BIOFILTERS)

The aim of this research project is to improve our knowledge on biological rapid sand filters as they are present in thousands groundwater based water works. This includes molecular investigations of the microorganisms responsible for the individual processes (e.g. nitrification); and detailed monitoring and experiments in the filters and laboratory to provide insight in the process mechanisms, kinetics and effect of environmental factors. Management of the filters (e.g. backwashing, flow rate, carrier type) will be investigated at pilot and full scale, supported by mathematical models. The sustainability and climate friendliness are evaluated by life cycle assessment (LCA). Molecular methods based on qPCR...
are being developed and implemented to quantify bacteria in different functional groups, such as those responsible for nitrification. This allows for development of diagnostic tools to detect if essential or core members are present or absent in a malfunctioning filter. It is meaningful to optimize the management of the filter only if they are present at relevant concentrations. Furthermore, to get insight in the complexity of the microbial community, the full microbial community is being investigated by deep sequencing. This will also contribute to a verification of whether the selected qPCR probes include all important groups. Filters from three water works have been sampled and are currently being processed to investigate depth profiles and horizontal variation in filters. Assays for essential microbial processes such as nitrification and oxidation of manganese are currently being established. They will provide identification of controlling parameters, bottle necks or inhibition of manganese removal of the bulk compound and the effect of filter management. Finally, a pilot plant has been established at Islelevro Water Works (operated by Copenhagen Energy) with material from the full-scale afterfilter. After validation that the pilot plant is mimicking the full scale filter, it will be used to investigate processes at larger scales such as backwashing procedures and effect of increased load of e.g. ammonium, manganese and ferrous iron. This filter will also be used to validate the mathematical models build for the biological filters at full scale.

In-situ microbial activity in membrane-aerated biofilms for autotrophic nitrogen conversion

Isolation of 2-methyl-4-chlorophenoxyacetic acid degrading bacteria from groundwater sediments using a novel low substrate flux approach
Microbial Abundance, Distribution and Diversity in Rapid Sand Filters

General information
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Organisations: Urban Water Engineering, Department of Environmental Engineering, Environmental Chemistry
Contributors: Musovic, S., Gülay, A., Albrechtsen, H., Smets, B. F.
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AWWA WQTC 2012.pdf
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Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2012

Micro-scale spatial expansion of microbial cells and mobile genetic elements.
Microbes can actively explore their local spatial environment when sufficiently hydrated pathways are present - mobile gene elements can also travel in local environments when cellular density is sufficient. In this presentation, I will present our efforts at predicting the dynamics of these two processes, and how they are affected by physical and biological constraints, using spatially-explicit agent-based models.

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Organisations: Department of Environmental Engineering, Environmental Chemistry
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Peer-reviewed: Yes
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Source: dtu
Source-ID: u::6451
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2012

Modeling the Performance of Biological Rapid Sand Filters Used to Remove Ammonium, Iron, and Manganese From Drinking Water
Although biological rapid sand filters are a well established technology for treating drinking water, there is still a lack of scientific understanding of the processes controlling their performance. For example, the distribution and role of microorganisms in contaminant removal in the filter has not been described. As a result, the design and operation of these filters is based on rules of thumb rather than firm scientific understanding. The goal of this research is to characterize the underlying processes that control the biological performance of biological rapid sand filters in order to link filter management to performance.

Biological rapid sand filters are used for the dual purpose of particle removal (including microorganisms) and contaminant removal through biological activity on the filter media. For drinking water treatment in the United States, biological filters use granular activated carbon and are often used following ozonation to remove additional biodegradable organics created during ozonation. In Europe, biological filters are also used to remove ammonium and reduced forms of iron and manganese. These compounds can cause biological instability in the distribution system and can lead to many problems including the growth of pathogens and aesthetic problems (taste, odor, and color). All of these compounds can be removed through chemical oxidation with oxidants such as chlorine, but biological filters can be used to remove these compounds and thereby reduce the need for chlorine addition following treatment. Under the normal conditions found in many water treatment plants, reduced iron can be oxidized through aeration and the precipitates can be captured by the filter media. Ammonium and manganese can be removed biologically.

This research uses both pilot and full scale studies to determine how operating conditions affect the performance of the filters. Substrate concentrations, particle/precipitate accumulation, and biomass kinetics are monitored throughout the
depth of the filter and over the operational cycle of the filter. Tracer tests, using a conservative salt tracer, are performed during an operational cycle of a filter to examine how the filter flow changes with time. The data is used to validate a mathematical model that can both predict process performance and to gain an understanding of how dynamic conditions can influence filter performance. The mathematical model developed is intended to assist in the design of new filters, set up of pilot plant studies, and as a tool to troubleshoot existing problems in full scale filters. Unlike previous models, the model developed accounts for the effects of particle/precipitate accumulation and its effects on the biological performance of the filter.

**General information**

State: Published
Contributors: Lee, C., Albrechtsen, H., Smets, B. F., Binning, P. J.
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Peer-reviewed: Yes
Event: Abstract from AWWA Annual Conference and Exposition 2012 (ACE12), United States.

**Neutrophilic iron oxidizers adapted to highly oxic environments**

Rapid sand filtration is an economical way to treat anoxic groundwaters and involves aeration followed by particulate and soluble substrate removal via deep bed filtration. The anoxic source groundwater can contain several potential electron donors (CH4, Fe2+, Mn2+, NH4+ and assimilable organic carbon) while oxygen (O2) is the electron acceptor provided during the aeration process. Numerous previous studies have described neutrophilic iron oxidizers as a bacterial guild with a special niche preference, especially the transition zone between aerobic and anoxic regions, where abiotic chemical oxidation of iron would be retarded. For that reason, no attempts have been documented to describe the density and diversity of iron oxidizing bacteria (FeOB) in oxic neutrophilic environments. Under low temperatures (5 to 10°C) conditions, as typically found in groundwater, extremely low rates of chemical iron oxidation (t1/2: 315min.) have been documented. This assumed slow chemical oxidation of Fe2+ in rapid sand filters may allow certain bacteria to oxidize iron concurrently with the ongoing slow chemical oxidation. Hence, we aimed to investigate the abundance, diversity, and spatial distribution of iron oxidizing bacterial in the highly oxic environments found in typical rapid sand filters.

The neutrophilic FeOB were enriched by the Fe2+/O2 opposing gradient technique and quantified by MPN methodology. Diversity fingerprints of the enrichment cultures were obtained with a 16S rRNA targeted DGGE technique, and dominant bands were isolated and sequenced for identification of dominant enrichment members. Enrichment were microscopically examined via CSLM in combination with FeOB specific or generic cytostains to verify enrichments, check cell morphologies and quantify cell densities. Our results indicate that neutrophilic iron oxidizers in highly oxic environments like drinking water treatment systems can be abundant (5 E+04 to 7 E+05 cells per gram of wet sand material). It was furthermore observed that the diversity of the cultivated dominant iron oxidizers differs substantially from those typically observed in aerobic/anoxic transition zones.

**General information**

State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry, Urban Water Engineering
Contributors: Gülay, A., Musovic, S., Albrechtsen, H., Smets, B. F.
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Peer-reviewed: Yes
Event: Abstract from 14th International Symposium on Microbial Ecology, Copenhagen, Denmark.

**Neutrophilic Iron Oxidizing Bacteria: Occurrence and Relevance in Biological Drinking Water Treatment**

Rapid sand filtration (RSF) is an economical way to treat anoxic groundwater around the world. It consists of groundwater aeration followed by passage through a sand filter. The oxidation and removal of ferrous iron, which is commonly found in anoxic groundwaters, is often believed to be a fully physicochemical process. However, persistently low temperatures in RSF across Denmark may negatively affect the kinetics of chemical oxidation. The slower chemical oxidation of ferrous iron may increase the chances for iron biocconversion by neutrophilic iron-oxidizing bacteria (FeOB), which are found naturally in many environments.
In this study, we used a combination of a cultivation-based opposing gradient enrichment technique and 16S rRNA gene targeted molecular tools to isolate, quantify and identify FeOB from a RSF. The microscopic quantification of selectively enriched FeOB cell revealed that in RSF, neutrophilic iron oxidizers were present at the level of up to 7 10^5 cells per gram sediment. The spatial abundance and diversity of FeOB inferred by DGGE fingerprinting differed greatly both between and within individual sand filters. The results suggest a larger than assumed role of FeOB in iron removal at waterworks using RSF technologies.

**General information**
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Organisations: Department of Environmental Engineering, Environmental Chemistry, Urban Water Engineering
Contributors: Gülay, A., Musovic, S., Albrechtsen, H., Smets, B. F.
Number of pages: 8
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Keywords: Iron oxidizing bacteria, IOB, FeOB, Diversity, Neutrophilic, Rapid sand filtration
Source: dtu
Source-ID: u::6517
Research output: Research - peer-review › Paper – Annual report year: 2012

**Permissiveness of soil microbial communities toward receipt of mobile genetic elements**

**General information**
State: Published
Organisations: Urban Water Engineering, Department of Environmental Engineering, Environmental Chemistry, University of Copenhagen
Contributors: Musovic, S., Klümper, U., Lundin, L., Sørensen, S. J., Smets, B. F.
Number of pages: 1
Publication date: 2012
Peer-reviewed: Yes
Event: Abstract from 14th International Symposium on Microbial Ecology, Copenhagen, Denmark.
Electronic versions:
ISME 2012 - Mobility of Genes and the Species Concept.pdf
Source: dtu
Source-ID: u::6479
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2012

**Pseudomonad Swarming Motility Is Restricted to a Narrow Range of High Matric Water Potentials**

Using a novel experimental system that allows control of the matric potential of an agar slab, we explored the hydration conditions under which swarming motility is possible. If there is recognition that this physical parameter is a key determinant of swarming, it is usually neither controlled nor measured rigorously but only manipulated through proxies, namely, the agar concentration and the drying time of “soft” agar plates (swarming plates). We contend that this not only obscures the biophysical mechanisms underlying swarming but also impedes a full assessment of its clinical and environmental significances. Our results indicate that swarming motility is restricted to a narrow range of high matric water potentials in the three pseudomonads tested (Pseudomonas sp. DSS73, Pseudomonas syringae B728a, and Pseudomonas aeruginosa PA14). The threshold below which no swarming was observed was about –0.45 kPa for the first and about –0.1 kPa for the latter two. Above the threshold, the expansion rate of DSS73 swarms increased exponentially with the matric potential. Mutants deficient in surfactant production were totally or partially unable to expand rapidly on the surface of the agar slab. Our results thus suggest that swarming motility in pseudomonads is restricted to (micro)sites where ambient humidity is very high (relative humidity of >99.99%). The spatiotemporal occurrence of such sites is limited in many types of terrestrial environments.

**General information**
State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry
Contributors: Dechesne, A., Smets, B. F.
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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
Recent trends in modelling and simulation of biological nutrient removal systems

General information
State: Published
Organisations: Department of Chemical and Biochemical Engineering, Computer Aided Process Engineering Center, Department of Environmental Engineering, Environmental Chemistry, Center for Process Engineering and Technology, Lund University, Universitat Autonoma de Barcelona
Publication date: 2012
Peer-reviewed: Yes

Recent trends in modelling and simulation of nutrient removal systems

General information
State: Published
Organisations: Department of Chemical and Biochemical Engineering, Computer Aided Process Engineering Center, Department of Environmental Engineering, Environmental Chemistry, Center for Process Engineering and Technology, Lund University, Universitat Autonoma de Barcelona
Pages: 29-32
Publication date: 2012

Host publication information
Title of host publication: Proceedings of IWA Nutrient Removal and Recovery 2012 : Trends in NRR
Keywords: Wastewater treatment, Modelling, Nutrient removal, Benchmark simulation

Redox stratified biofilms to support completely autotrophic nitrogen removal: Principles and results
After 10 years of pilot and full-scale studies, completely autotrophic nitrogen via coupled aerobic and anaerobic ammonium oxidation is now firmly established in the wastewater treatment community. The reasons for the popularization of the technology are numerous, but the most attractive are probably the savings in energy consumption due to reduced aeration, the possibility of running the process without addition of an external carbon source and the low amounts of sludge generated.
Membrane-aerated biofilm reactors (MABRs) have been used in practice for more than 20 years in order to treat concentrated wastewaters. This technology consists of the installation of aeration membrane modules in completely mixed reactors. The purpose of the installed modules is not only to supply the electron acceptor required for completing a certain biochemical reaction, but also to serve as substratum for biofilm development. This unique configuration allows higher oxygen transfer efficiencies than conventional aerators. The resulting biofilms differ from conventional co-diffusion biofilms found in MBBRs or RBCs in the fact that the oxic biofilm region is in contact with the biofilm substratum and not with the bulk liquid. If operated properly, MABRs yield compact and homogeneous redox-stratified biofilms capable of hosting side-
by-side aerobic and anaerobic microbial communities. We have recently demonstrated that completely autotrophic nitrogen removal is feasible in MABRs at nitrogen removal rates as high as 5.5 g-N/m²/day in lab-scale reactors loaded with synthetic wastewater (8 g-N/m²/day) and compressed air (1.6 atm) with N2O emissions 100-fold lower than conventional co-diffusion systems. A detailed study of the microbial community with Fluorescence In-Situ Hybridization revealed a very stratified biofilm structure with aerobic ammonium oxidizing bacteria dominating the areas of the biofilm closer to the membrane surface while anaerobic oxidizing bacteria populated mainly the outer biofilm region. The biofilm was approximately 500 m thick and featured both aerobic and anaerobic ammonium oxidizing bacteria in compact reaction zones about 100 m thick separated by an intermediate zone with low or null metabolic activity. Both identified microbial communities showed a very low diversity and were dominated by halophilic and halotolerant Nitrosomonas sp. and Candidatus Brocadia anammoxidans. The continuous and sustained inoculation of metabolically active anaerobic oxidizing bacteria from a biofilm reactor placed in the recirculation line of our MABRs showed to shorten considerably the onset of autotrophic nitrogen removal. However, the main hurdle keeping MABRs from attaining high removal efficiencies was the presence of active nitrite oxidizing bacteria in the aerobic regions of the biofilm. Reactor conditions like operation at high pH and NH4+ concentrations, low DO concentrations, and temperatures between 30-33 °C can favor the growth of aerobic ammonium oxidizing bacteria over nitrite oxidizing bacteria, but not in MABR biofilms because their presence at the biofilm base, once established, provides spatial protection. During our study we could demonstrate that intermittent aeration of MABRs for completely autotrophic nitrogen removal (even at high pulsing frequencies) prevented the outgrowth of nitrite oxidizing bacteria communities. Autotrophic nitrogen removal is already revealing itself as a cheap alternative to treat concentrated nitrogen streams. However, we believe that this concept can be taken a step further in MABRs and become an even more cost-effective, compact and environmentally friendly solution.

**General information**

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Organisations: Environmental Chemistry, Department of Environmental Engineering
Contributors: Pellicer i Nàcher, C., Smets, B. F.
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Electronic versions: 18.pdf

**Bibliographical note**

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**Relating dynamic conditions to the performance of biological rapid sand filters used to remove ammonium, iron, and manganese from drinking water**

Biological rapid sand filters are used throughout the world to remove both particulates and dissolved compounds from drinking water and is a proven and effective treatment technique for providing safe and secure drinking water. However, experience has shown that some filters have problems consistently meeting regulatory guidelines for compounds like ammonium and reduced forms of iron and manganese. These compounds can cause biological instability in the distribution system and can lead to many problems including the growth of pathogens and aesthetic problems (taste, odor, and color). When problems occur in these filters, current solutions are often based on rules of thumb and guess work rather than on firm scientific principle. The goal of this research is to characterize the underlying processes that control the biological performance of biological rapid sand filters in order to link filter management to performance.

This research uses both pilot and full scale studies conducted at Islevbro water works, a drinking water plant in west Copenhagen, to determine how operating conditions and substrate loading affect the performance of the biological rapid sand filters. The pilot columns consist of two columns that are run in parallel and fed with influent water from the water works. The sand in the pilot columns was taken from one of the full scale filters and matches the depth profile of the full scale filter. The pilot columns were initially operated for approximately 2 and a half months at similar operating conditions as the full scale filter to validate the performance of the pilot columns. After this, the pilot columns were fed with varying loading rates of iron, ammonium, and manganese. To fully examine the changes in filter performance several parameters were analyzed. Water and media samples were collected throughout the depth of the column and over the operational cycle of the columns. Substrate analysis included ammonium, nitrite, nitrate, iron, and manganese. QPCR analysis were also performed to quantify ammonium oxidizing bacteria (AOBs), ammonium oxidizing archaea (AOAs), nitrite oxidizing bacteria (NOBs), and total bacteria with both depth and time. Similar analyses were performed in the full scale filters. The data is used to validate a mathematical model that can both predict process performance and is used to gain an understanding of how dynamic conditions can influence filter performance. The results presented will show how these varying conditions affect both the biological distribution and performance of these filters and will increase the understanding of biological rapid sand filters used to treat drinking water. This research helps to extend the knowledge on
the roles of both Ammonium oxidizing bacteria (AOBs) and Ammonium oxidizing archea (AOAs) in the biological removal of ammonium in rapid sand filters and how varying substrate loadings and operating conditions can affect the biological performance of these filters.

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Contributors: Lee, C., Albrechtsen, H., Smets, B. F., Binning, P. J.
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Event: Abstract from AWWA Water Quality Technology Conference (WQTC), Toronto, Canada.
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Sensitivity analysis of autotrophic N removal by a granule based bioreactor: Influence of mass transfer versus microbial kinetics
A comprehensive and global sensitivity analysis was conducted under a range of operating conditions. The relative importance of mass transfer resistance versus kinetic parameters was studied and found to depend on the operating regime as follows: Operating under the optimal loading ratio of 1.90 (gO2/m3/d)/(gN/m3/d), the system was influenced by mass transfer (10% impact on nitrogen removal) and performance was limited by AOB activity (75% impact on nitrogen removal), while operating above, AnAOB activity was limiting (68% impact on nitrogen removal). The negative effect of oxygen mass transfer had an impact of 15% on nitrogen removal. Summarizing such quantitative analyses led to formulation of an optimal operation window, which serves a valuable tool for diagnosis of performance problems and identification of optimal solutions in nitritation/anammox applications.

General information
State: Published
Organisations: Department of Chemical and Biochemical Engineering, Computer Aided Process Engineering Center, Center for Process Engineering and Technology, Department of Environmental Engineering, Environmental Chemistry
Contributors: Vangsgaard, A. K., Mauricio Iglesias, M., Gernaey, K., Smets, B. F., Sin, G.
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Peer-reviewed: Yes

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Web of Science (2017): Impact factor 5.807
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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
The Role of Microbial Heterogeneity in Pesticide Degradation in Agricultural Soils

General information
State: Published
Transcriptome Dynamics of Pseudomonas putida KT2440 under Water Stress

Water deprivation can be a major stressor to microbial life in surface and subsurface soil. In unsaturated soils, the matric potential (Ψm) is often the main component of the water potential, which measures the thermodynamic availability of water. A low matric potential usually translates into water forming thin liquid films in the soil pores. Little is known of how bacteria respond to such conditions, where, in addition to facing water deprivation that might impair their metabolism, they have to adapt their dispersal strategy as swimming motility may be compromised. Using the pressurized porous surface model (PPSM), which allows creation of thin liquid films by controlling Ψm, we examined the transcriptome dynamics of Pseudomonas putida KT2440. We identified the differentially expressed genes in cells exposed to a mild matric stress (~0.4 MPa) for 4, 24, or 72 h. The major response was detected at 4 h before gradually disappearing. Upregulation of alginate genes was notable in this early response. Flagellar genes were not downregulated, and the microarray data even suggested increasing expression as the stress prolonged. Moreover, we tested the effect of polyethylene glycol 8000 (PEG 8000), a nonpermeating solute often used to simulate Ψm, on the gene expression profile and detected a different profile than that observed by directly imposing Ψm. This study is the first transcriptome profiling of KT2440 under directly controlled Ψm and also the first to show the difference in gene expression profiles between a PEG 8000-simulated and a directly controlled Ψm.
An individual-based approach to explain plasmid invasion in bacterial populations

We present an individual-based experimental framework to identify and estimate the main parameters governing bacterial conjugation at the individual cell scale. From this analysis, we have established that transient periods of unregulated plasmid transfer within newly formed transconjugant cells, together with contact mechanics arising from cellular growth and division, are the two main processes determining the emergent inability of the pWW0 TOL plasmid to fully invade spatially structured Pseudomonas putida populations. We have also shown that pWW0 conjugation occurs mainly at advanced stages of the growth cycle and that nongrowing cells, even when exposed to high nutrient concentrations, do not display conjugal activity. These results do not support previous hypotheses relating conjugation decay in the deeper cell layers of bacterial biofilms to nutrient depletion and low physiological activity. We observe, however, that transient
periods of elevated plasmid transfer in newly formed transconjugant cells are offset by unfavorable cell-to-cell contact mechanics, which ultimately precludes the pWWO TOL plasmid from fully invading tightly packed multicellular P. putida populations such as microcolonies and biofilms.
Assessing the impact of physical and physiological factors on the oxygen mass transfer process in membrane-aerated biofilm reactors

General information
State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry, Pôle Biotechnologies et Agronomie Veolia Environment Research and Innovation
Contributors: Pellicer i Nàcher, C., Syron, E., Gaval, G., Ochoa, J., Smets, B. F.
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Peer-reviewed: Yes
Event: Poster session presented at Specialist Conference on Membrane Technology for Water & Wastewater Treatment, Eurogress Aachen, Germany,
Keywords: Nitrification, Membrane aerated biofilm reactors, Oxygen transfer test, Aeration
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Poster presentation
Source: orbit
Source-ID: 278287
Research output: Research - peer-review ▶ Poster – Annual report year: 2011

Biological Nitrogen Removal from Domestic Wastewater

General information
State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry, University of Girona, Tongji University
Contributors: Ruscalleda Beylier, M., Balaguer, M. D., Pellicer i Nàcher, C., Smets, B. F., Sun, S., Wang, R.
Pages: 329-340
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Publisher: Elsevier
Editor: Moo-Young, M.
Edition: 2
DOIs:
10.1016/B978-0-08-088504-9.00533-X
Research output: Research - peer-review ▶ Book chapter – Annual report year: 2012
Cm-scale Heterogeneity in Degradation - Potential Impact on Leaching of MCPA through a Variably-Saturated Macroporous Clayey Till

Recent research has revealed a large variation in pesticide mineralization potentials, but little is known about the scale at which these heterogeneities impact the spreading of contaminants. A modeling study aiming at quantifying how heterogeneous degradation potentials in agricultural soil will affect MCPA degradation and leaching was conducted. 2D-distributions (96-well micro plate mineralization assay) of the mineralization potentials of phenoxy acid herbicides (MCPA, 2,4-D) representing layers in the upper meter of variably-saturated clayey till were applied. The rapid mineralization measured was represented by Monod mineralization kinetics, whereas the rest were either represented by slow 0-order mineralization kinetics or no degradation. Five 3D-modelling scenarios were set up using the COMSOL Multiphysics 4.1 toolbox (COMSOL Inc., Burlington, MA, USA): 1) simple matrix flow of water with no biodegradation of the MCPA at all nodes; 2) preferential flow (including a wormhole) of water with no biodegradation of the MCPA at all nodes; 3) simple matrix flow of water with average biodegradation of the MCPA at all nodes, which corresponds to results derived from a conventional homogenized soil sample; 4) simple matrix flow of water with the observed high variation in biodegradation of the MCPA corresponding to random variation in degradation; and 5) vertical structure in water flow combined with vertically structured degradation (defined hot spots and cold spots), which corresponds to a situation where both flow and degradation are associated with macropores/wormholes. Results show that cm-scale heterogeneity in degradation potential with simple matrix flow has a negligible effect on MCPA leaching at one meter below soil surface. By introducing a wormhole in the low-permeable 3D-soil modeling domain, however, the risk of MCPA-leaching below one meter depth increase drastically with low degradation potential along the wall of macropores/wormholes.

General information
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Contributors: Rosenbom, A. E., Johnsen, A. R., Aamand, J., Binning, P. J., Dechesne, A., Smets, B. F.
Publication date: 2011
Peer-reviewed: Yes
Electronic versions:
prod11324883902322.2011_Rosenbom_AGUFall.pdf
Source: orbit
Source-ID: 316033
Research output: Research - peer-review > Poster – Annual report year: 2011

Design of microbial communities in membrane bioreactors: the next generation of environmental biotechnologies (EcoDesign-MBR)

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering, Aalborg University
Contributors: Nielsen, P. H., Nielsen, J. L., Keiding, K., Smets, B. F.
Number of pages: 38
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Publication date: 2011

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Source: orbit
Source-ID: 275137
Research output: Research - peer-review > Conference abstract in proceedings – Annual report year: 2011

Effects of PAH-Contaminated Soil on Rhizosphere Microbial Communities

Bacterial associations with plant roots are thought to contribute to the success of phytoremediation. We tested the effect of addition of a polycyclic aromatic hydrocarbon contaminated soil on the structure of the rhizosphere microbial communities of wheat (Triticum aestivum), lettuce (Lactuca sativa var. Tango), zucchini (Cucurbita pepo ssp. pepo var. Black Beauty), and pumpkin (C. pepo ssp. pepo var. Howden) 16S rDNA terminal restriction fragment length polymorphism (T-RFLP) profiles of rhizosphere microbial communities from different soil/plant combinations were compared with a pairwise Pearson correlation coefficient. Rhizosphere microbial communities of zucchini and pumpkin grown in the media amended with highest degree of contaminated soil clustered separately, whereas communities of these plants grown in unamended or amended with lower concentrations of contaminated soil, grouped in a second cluster. Lettuce communities grouped similarly to cucurbits communities, whereas wheat communities did not display an obvious clustering. The variability of 16S rDNA T-RFLP profiles among the different plant/soil treatments were mostly due to the difference in relative abundance rather than presence/absence of T-RFLP fragments. Our results suggest that in highly contaminated soils, the rhizosphere microbial community structure is governed more by the degree of contamination rather than the plant host type.
Framework for Construction of Multi-scale Models for Biological Wastewater Treatment Processes

In wastewater treatment technologies, employing biofilms or granular biomass, processes might occur at very different spatial and temporal scales. Model development for such systems is typically a tedious, complicated, and time-consuming task, which involves selecting appropriate model equations for the different scales, making appropriate and simplifying assumptions, connecting them through a defined linking scheme, analyzing and solving the model equations numerically, and performing parameter estimations if necessary. In this study, a structured framework for modeling such systems is developed. It aims to support the user at the various steps and to reduce the time it takes to generate a model ready for application. An implementation of the framework is illustrated using a simple case study, which considers treatment of a nitrogen-rich wastewater via nitrification.

Framework for Construction of Multi-scale Models for Biological Wastewater Treatment Processes - Case Study: Autotrophic Nitrogen Conversion

In wastewater treatment technologies, employing biofilms or granular biomass, processes might occur at very different spatial and temporal scales. Model development for such systems is typically a tedious, complicated, and time-consuming task, which involves selecting appropriate model equations for the different scales, making appropriate and simplifying assumptions, connecting them through a defined linking scheme, analyzing and solving the model equations numerically, and performing parameter estimations if necessary. In this study, a structured framework for modeling such systems is developed. It aims to support the user at the various steps and to reduce the time it takes to generate a model ready for application. An implementation of the framework is illustrated using a simple case study, which considers treatment of a nitrogen-rich wastewater via nitrification.

Growth dependence of conjugation explains limited plasmid invasion in biofilms: an individual-based modelling study

Plasmid invasion in biofilms is often surprisingly limited in spite of the close contact of cells in a biofilm. We hypothesized that this poor plasmid spread into deeper biofilm layers is caused by a dependence of conjugation on the growth rate (relative to the maximum growth rate) of the donor. By extending an individual-based model of microbial growth and interactions to include the dynamics of plasmid carriage and transfer by individual cells, we were able to conduct in silico tests of this and other hypotheses on the dynamics of conjugal plasmid transfer in biofilms. For a generic model plasmid, we find that invasion of a resident biofilm is indeed limited when plasmid transfer depends on growth, but not so in the absence of growth dependence. Using sensitivity analysis we also find that parameters related to timing (i.e. a lag before the transconjugant can transfer, transfer proficiency and scan speed) and spatial reach (EPS yield, conjugal pilus length) are more important for successful plasmid invasion than the recipients' growth rate or the probability of segregational loss. While this study identifies one factor that can limit plasmid invasion in biofilms, the new individual-based framework introduced in this work is a powerful tool that enables one to test additional hypotheses on the spread and role of plasmids in microbial biofilms.
Individual-based modelling of biofilms accounts for the fact that individual organisms of the same species may well be in a different physiological state as a result of environmental gradients, lag times in responding to change, or noise in gene expression, which we have become increasingly aware of with the advent of single-cell microbiology. But progress in developing and using individual-based modelling has been hampered by different groups writing their own code and the lack of an available standard model. We therefore set out to merge most features of previous models and incorporate various improvements in order to provide a common basis for further developments. Four improvements stand out: the biofilm pressure field allows for shrinking or consolidating biofilms; the continuous-in-time extracellular polymeric substances excretion leads to more realistic fluid behaviour of the extracellular matrix, avoiding artefacts; the stochastic chemostat mode allows comparison of spatially uniform and heterogeneous systems; and the separation of growth kinetics from the individual cell allows condition-dependent switching of metabolism. As an illustration of the model's use, we used the latter feature to study how environmentally fluctuating oxygen availability affects the diversity and composition of a community of denitrifying bacteria that induce the denitrification pathway under anoxic or low oxygen conditions. We tested the hypothesis that the existence of these diverse strategies of denitrification can be explained solely by assuming that faster response incurs higher costs. We found that if the ability to switch metabolic pathways quickly incurs no costs the fastest responder is always the best. However, if there is a trade-off where faster switching incurs higher costs, then there is a strategy with optimal response time for any frequency of environmental fluctuations, suggesting that different types of denitrifying strategies win in different environments. In a single environment, biodiversity of denitrifiers is higher in biofilms than chemostats, higher with than without costs and higher at intermediate frequency of change. The highly modular nature of the new computational model made this case study straightforward to implement, and reflects the sort of novel studies that can easily be executed with the new model.
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 4.83 SJR 2.209 SNIP 1.31
Web of Science (2017): Impact factor 4.974
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.02 SJR 2.377 SNIP 1.383
Web of Science (2016): Impact factor 5.395
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.61 SJR 3.02 SNIP 1.571
Web of Science (2015): Impact factor 5.932
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.6 SJR 2.862 SNIP 1.599
Web of Science (2014): Impact factor 6.201
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 6.37 SJR 3.273 SNIP 1.823
Web of Science (2013): Impact factor 6.24
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.94 SJR 3.165 SNIP 1.639
Web of Science (2012): Impact factor 5.756
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 6.1 SJR 3.368 SNIP 1.7
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ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.775 SNIP 1.551
Web of Science (2010): Impact factor 5.537
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 2.502 SNIP 1.378
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.495 SNIP 1.322
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 2.303 SNIP 1.498
Scopus rating (2006): SJR 2.451 SNIP 1.517
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 2.431 SNIP 1.519
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 2.08 SNIP 1.239
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.794 SNIP 1.241
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 2.378 SNIP 1.028
Scopus rating (2001): SJR 1.317 SNIP 1.228
Web of Science (2001): Indexed yes
Isolation of herbicide-degrading bacteria from a groundwater aquifer using novel enrichment and isolation techniques

Micro2-Managed Microbial Communities: Next Generation Environmental Bio/Technologies

Modeling Nitrous Oxide Production during Biological Nitrogen Removal via Nitrification and Denitrification: Extensions to the General ASM Models
have been added. The validity and applicability of the model is demonstrated by comparing simulations with experimental data on N2O production from four different mixed culture nitrification and denitrification reactor study reports. Modeling results confirm that hydroxylamine oxidation by ammonium oxidizers (AOB) occurs 10 times slower when NO2–participates as final electron acceptor compared to the oxic pathway. Among the four denitrification steps, the last one (N2O reduction to N2) seems to be inhibited first when O2 is present. Overall, N2O production can account for 0.1–25% of the consumed N in different nitrification and denitrification systems, which can be well simulated by the proposed model. In conclusion, we provide a modeling structure, which adequately captures N2O dynamics in autotrophic nitrification and heterotrophic denitrification driven biological N removal processes and which can form the basis for ongoing refinements.

General information
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Organisations: Department of Environmental Engineering, Residual Resource Engineering, University of Girona
Contributors: Ni, B., Ruscalleda, M., Pellicer i Nàcher, C., Smets, B. F.
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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
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ISI indexed (2013): ISI indexed yes
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BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.17 SJR 3.115 SNIP 2.043
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ISI indexed (2012): ISI indexed yes
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BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 5.16 SJR 3.18 SNIP 1.945
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Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 2.979 SNIP 1.726
Production and mitigation of N2O in sequentially membrane-aerated redox-stratified nitritation/anammox biofilms

Combining partial nitritation with anaerobic ammonium oxidation maybe a cost- and energy-efficient alternative to remove reduced nitrogen from nitrogen rich waste streams. However, increased N2O emissions (upto several % of the incoming N flux) have been observed for reactors performing partial nitritation, which is likely due to the stimulatory effect of combined elevated nitrite and ammonium concentrations and reduced oxygen concentrations on nitrous oxide formation by ammonium oxidizing bacteria. Because increased N2O emission may be inherent to partial nitrification systems, we have explored how these emissions can be mitigated by performing autotrophic nitrogen removal in one reactor systems by combining aerobic and anaerobic ammonium oxidizing bacteria within one redox-stratified biofilm. In such biofilms, a section of the biofilm is at all times maintained under anaerobic (free of oxygen invasion) conditions. Although anaerobic ammonium oxidizing bacteria are not known to metabolize N2O, we speculate that the existence of oxygen free zone would permit complete expression of a denitrification pathway by heterotrophic bacteria- and hence remove any N2O which is transiently produced in the inner (aerobic) sections of the biofilm. We have successfully operated such membrane-aerated redox-stratified biofilm reactors performing completely autotrophic N removal and have monitored N2O dynamics. Successful community control required periodic aeration. N2O emissions were detected, but only in the inner cores of the fiber bundles, and only transiently, upon initiation or cessation of aeration. Bulk phase N2O concentrations were significantly lower than expected based on transient evolution rates, suggesting a removal mechanism. Emitted N2O fluxes represented less than 0.02 % of the converted ammonium N. Anoxic batch incubations with biofilm samples revealed a significant N2O assimilatory activity. Anoxic incubations with N-15 enriched nitrite, nitrate, or ammonium, in presence or absence of acetate revealed the following: a very high conversion of original nitrite or nitrate N to N2O over N2, no stimulatory activity of acetate addition, a very different isotopic abundance in the formed N2 and N2O, and no conversion of ammonium N to N2O. These results confirm that N2O production was most likely to ammonium oxidizers, and that the heterotrophs contributed to N2O attenuation. The spatial structure of these biofilms may, therefore, be especially suitable to minimize N2O emissions.

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State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering, University of Southern Denmark, Swiss Federal Institute of Aquatic Science and Technology
Simultaneous removals of azo dye and nitrogenous compounds by a membrane-aerated biofilm

General information
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Organisations: Environmental Chemistry, Department of Environmental Engineering, Tokyo University of Agriculture and Technology
Contributors: Terada, A., Kawashima, S., Nishikawa, M., Zhou, S., Smets, B. F., Hosomi, M.
Publication date: 2011
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Event: Abstract from IWA Biofilm Conference 2011, Shanghai, China.
Electronic versions:
prod21324202645264.Biofilm2011_Abstract_Terada.pdf
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Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2011

Structure and activity of lacustrine sediment bacteria involved in nutrient and iron cycles.
Knowledge of the bacterial community structure in sediments is essential to better design restoration strategies for eutrophied lakes. In this regard, the aim of this study was to quantify the abundance and activity of bacteria involved in nutrient and iron cycling in sediments from four Azorean lakes with distinct trophic states (Verde, Azul, Furnas and Fogo). Inferred from quantitative PCR, bacteria performing anaerobic ammonia oxidation were the most abundant in the eutrophic lakes Verde, Azul and Furnas (4.5-16.6%), followed by nitrifying bacteria (0.8-13.0%), denitrifying bacteria (DNB) (0.5-6.8%), iron-reducing bacteria (0.2-1.4%) and phosphorus-accumulating organisms (PhoA+)

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Organisations: Department of Environmental Engineering, Urban Water Engineering, Environmental Chemistry, University of Minho, University of Santiago de Compostela
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Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 3.85
Web of Science (2016): Impact factor 12.198
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3.77
Web of Science (2015): Indexed yes
Swarming motility is restricted to a narrow range of water matric potential

General information
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Organisations: Environmental Chemistry, Department of Environmental Engineering
Contributors: Dechesne, A., Smets, B. F.
Publication date: 2011
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Event: Poster session presented at 4th Congress of European Microbiologists, Geneva, Switzerland.
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http://www2.kenes.com/fems2011/Pages/Home.aspx
Source: orbit
Source-ID: 280746
Research output: Research - peer-review › Journal article – Annual report year: 2011
Udvidelser til ASM Process Modeller til at bestemme lattergas emission fra renseanlæg

Lattergas (N2O) er en betydningsfuld drivhusgas idet opvarmningspotentialet for et N2O molekyle er omkring 300 gange større end for CO2. Lattergas dannes under fjernelsen af kvælstof i biologiske rensningsanlæg. Vi har udviklet den første matematiske model der beskriver lattergas produktion og forbrug via nitrifikation og denitrifikation i aktiv slam. Den pseudo-mekanistiske model er baseret på eksperimentelle data fra fire forskellige reaktor studier med blandede nitrificerende og denitrificerende bakteriekulturer. Modellens resultater viste at lattergas produktionen via det første trin i nitrifikationsprocessen - ammonium oxidation - er mere betydningsfuld end lattergas produktionen fra de denitrificerende bakterier, hvilket var i overensstemmelse med de eksperimentelle observationer. N2O produktion kan tegne sig for 0,1% til 25% af den forbrugte N i forskellige Nitrifikation / Denitrifikation konfigurationer. Vi kan således konkludere, at modellen på tilfredsstillende vis simulerer lattergas dynamikken ved biologisk kvælstoffjernelse (nitrifikation-denitrifikation). Modellen kan bruges som et redskab i optimering af målsætning for kvaliteten af vand og luft i spildevandsrensningsanlæg.

**General information**
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Organisations: Environmental Chemistry, Department of Environmental Engineering
Contributors: Smets, B. F.
Publication date: 2011
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Electronic versions:
prod21324202912815.Danva.pdf
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Source-ID: 314827
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2011

**Who is who?: Assessing the microbial diversity in wastewater treatment biofilms for completely autotrophic nitrogen removal**

**General information**
State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry, University of Girona, Tokyo University of Agriculture and Technology, Technical University of Denmark
Contributors: Pellicer i Nàcher, C., Franck, S., Ruscalleda, M., Terada, A., Smets, B. F.
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Peer-reviewed: Yes
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Keywords: Biofilm, Anammox, FISH, Nitritation, Membrane-aerated biofilm reactor
URLs:
http://www.iwabiofilm2011.com/

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**Individual-based analysis and prediction of the fate of plasmids in spatially structured bacterial populations**

**General information**
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Organisations: Department of Environmental Engineering
Contributors: Seoane, J. M., Smets, B. F.
Publication date: Dec 2010

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Transfer of conjugative plasmids among bacteria under environmentally relevant conditions

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Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Musovic, S., Smets, B. F.
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ENV2010_054.pdf
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Research output: Research › Ph.D. thesis – Annual report year: 2010

Aggregate size and architecture determine biomass activity for one-stage partial nitritation and anammox
In partial nitritation/anammox systems, aerobic and anoxic ammonium-oxidizing bacteria (AerAOB and AnAOB) remove ammonium from wastewater. In this process, large granular microbial aggregates enhance the performance, but little is known about this type of granulation so far. In this study, aggregates of three reactors (A, B, C) with different inoculation and operation were studied. The test objectives were to quantify the AerAOB and AnAOB abundance and the activity balance for the different aggregate sizes, and to relate aggregate morphology, size distribution, and architecture putatively to the inoculation and operation of the reactors. Fluorescent in-situ hybridization (FISH) was applied on aggregate sections to quantify AerAOB and AnAOB, as well as to visualize the aggregate architecture. The activity balance of the aggregates was calculated as the nitrite accumulation rate ratio (NARR), i.e. the net aerobic nitrite production rate divided by the anoxic nitrite consumption rate, with all rates determined in aerobic and anoxic batch tests. The space occupied by extracellular polymeric substances (EPS) was calculated from transmission electron micrographs. All smallest aggregates were flocs and nitrite sources (NARR, > 1.7). Large A and C aggregates were granules capable of autonomous nitrogen removal (NARR, 0.6 to 1.1) with internal AnAOB zones surrounded by an AerAOB rim. Around 50% of the autotrophic space in these granules consisted of AerAOB- and AnAOB-specific EPS. Large B aggregates were thin film-like nitrite sinks (NARR, <0.5) in which AnAOB were not shielded by an AerAOB layer. Voids and channels occupied 13 to 17% of the anoxic zone of AnAOB-rich aggregates (B and C). Inoculation and operation of an OLAND reactor influences the aggregate size distribution, activity balance, morphology and architecture. Hypothesized granulation pathways include granule replication by division and budding.

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Vlaeminck, S., Terada, A., Smets, B. F., De Clippeleir, H., Carballa, M., Verstraete, W.
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Source-ID: 267679
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2010

Aggregate Size and Architecture Determine Microbial Activity Balance for One-Stage Partial Nitritation and Anammox
Aerobic ammonium-oxidizing bacteria (AerAOB) and anoxic ammonium-oxidizing bacteria (AnAOB) cooperate in partial nitritation/anammox systems to remove ammonium from wastewater. In this process, large granular microbial aggregates enhance the performance, but little is known about granulation so far. In this study, three suspended-growth oxygen-limited autotrophic nitrification-denitrification (OLAND) reactors with different inoculation and operation (mixing and
aeration) conditions, designated reactors A, B, and C, were used. The test objectives were (i) to quantify the AerAOB and AnAOB abundance and the activity balance for the different aggregate sizes and (ii) to relate aggregate morphology, size distribution, and architecture putatively to the inoculation and operation of the three reactors. A nitrite accumulation rate ratio (NARR) was defined as the net aerobic nitrite production rate divided by the anoxic nitrite consumption rate. The smallest reactor A, B, and C aggregates were nitrite sources (NARR, > 1.7). Large reactor A and C aggregates were granules capable of autonomous nitrogen removal (NARR, 0.6 to 1.1) with internal AnAOB zones surrounded by an AerAOB rim. Around 50% of the autotrophic space in these granules consisted of AerAOB- and AnAOB-specific extracellular polymeric substances. Large reactor B aggregates were thin film-like nitrite sinks (NARR, <0.5) in which AnAOB were not shielded by an AerAOB layer. Voids and channels occupied 13 to 17% of the anoxic zone of AnAOB-rich aggregates (reactors B and C). The hypothesized granulation pathways include granule replication by division and budding and are driven by growth and/or decay based on species-specific physiology and by hydrodynamic shear and mixing.
A New Extant Respirometric Assay to Estimate Intrinsic Growth Parameters Applied to Study Plasmid Metabolic Burden

Start-Lip phenomena in microbial biokinetic assays are not captured by the most commonly used growth-related equations. In this Study we propose a new respirometric experimental design to estimate intrinsic growth parameters that allow us to avoid these limitations without data omission, separate mathematical treatment, or wake-up pulses prior to the analysis. Identifiability and sensitivity analysis were performed to confirm the robustness of the new approach for obtaining unique and accurate estimates of growth kinetic parameters. The new experimental design was applied to establish the metabolic burden caused by the carriage of a pWW0 TOL plasmid in the model organism Pseudomonas putida KT2440. The metabolic burden associated was manifested as a reduction in the yield and the specific growth rate of the host, with both plasmid maintenance and the over-expression of recombinant proteins from the plasmid contributing equally to the overall effect. Biotechnol. Bioeng. 2010;105: 141-149. (C) 2009 Wiley Periodicals, Inc.

General information
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Organisations: Department of Environmental Engineering, Computer Aided Process Engineering Center, Department of Chemical and Biochemical Engineering, Environmental Chemistry
Contributors: Seoane, J. M., Sin, G., Lardon, L., Gernaey, K., Smets, B. F.
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Journal: Biotechnology and Bioengineering (Print)
Biodegradation in a Partially Saturated Sand Matrix: Compounding Effects of Water Content, Bacterial Spatial Distribution, and Motility

Bacterial pesticide degraders are generally heterogeneously distributed in soils, leaving soil volumes devoid of degradation potential. This is expected to have an impact on degradation rates because the degradation of pollutant molecules in such zones will be contingent either on degraders colonizing these zones or on pollutant mass transfer to neighboring zones containing degraders. In a model system, we quantified the role exerted by water on mineralization rate in the context of a heterogeneously distributed degradation potential. Alginate beads colonized by Pseudomonas putida KT2440 were inserted at prescribed locations in sand microcosms so that the initial spatial distribution of the mineralization potential was controlled. The mineralization rate was strongly affected by the matric potential (decreasing rate with decreasing matric potential) and by the initial distribution of the degraders (more aggregated distributions being associated with lower rates). The mineralization was diffusion-limited, as confirmed with a mathematical model. In wet conditions, extensive cell dispersal was observed for the flagellated wild type and, albeit to a lesser extent, for a nonflagellated mutant, partially relieving the diffusion limitation. Dry conditions, however, sustained low mineralization rates through the combined effects of low pollutant diffusivity and limited degrader dispersal.

General information
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Organisations: Department of Environmental Engineering, Quantitative Sustainability Assessment, Department of Management Engineering, Universite de Bretagne-Sud
Contributors: Dechesne, A., Owsiianik, M., Bazire, A., Grundmann, G. L., Binning, P. J., Smets, B. F.
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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
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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
Effective Biological Nitrogen Removal Treatment Processes for Domestic Wastewaters with Low C/N Ratios: A Review

Discharge of nitrogenous components to water bodies can cause eutrophication, deterioration of water quality, toxicity to aquatic life, and pose a potential hazard to human and animal health. Biological nitrogen removal can remove nitrogenous components via conversion to harmless nitrogen gas with high efficiency and relative low costs. However, the removal of nitrogen from domestic wastewater with low carbon/nitrogen (C/N) ratio is often limited in municipal wastewater treatment plants (WWTPs) because organic carbon is a limiting factor for denitrification. The present work reviews innovative bacterial nitrogen removal pathways such as shortcut nitrification/denitrification, simultaneous nitrification/denitrification, and the nitritation Anammox process, which can remove nitrogen with low or zero dosage of organic carbon sources. We conclude that advanced process control and some new biological treatment processes including the modified anaerobic/anoxic/oxic (A(2)/O) process, the step-feed multistage anaerobic/oxic (A/O) process, and new reactors like the membrane bioreactors (MBRs) and the membrane-aerated biofilm reactors (MABRs) can support the innovative biological nitrogen removal pathways. They can effectively be used for nitrogen removal from low C/N domestic wastewater without external carbon addition. In addition, conventional and alternative carbon sources for enhanced biological nitrogen removal were also reviewed. We conclude that alternative carbon sources such as wine distillery effluent, the leachate of food waste, digested piggery manure, hydrolyzed molasses, biologically hydrolyzed or mechanically disintegrated sludge offer the same or better performance for nitrogen removal at reduced costs. Finally, we suggest that (1) these new processes and technologies are implemented at large scale for nitrogen removal from low C/N domestic wastewater, (2) further method logic are explored to introduce the Anammox pathway into domestic wastewater treatment, and (3) alternative carbon sources are explored and optimized for supporting the denitrification. With these efforts, cost-effective nitrogen removal from low C/N ratio domestic wastewater can be obtained in the near future.
Evaluation of Bioaugmentation with Entrapped Degrading Cells as a Soil Remediation Technology

Soil augmentation with microbial degraders immobilized on carriers is evaluated as a potential remediation technology using a mathematical model that includes degradation within spatially distributed carriers and diffusion or advection-dispersion as contaminant mass transfer mechanisms. The total volume of carriers is a critical parameter affecting biodegradation performance. In the absence of advection, 320 and 20,000 days are required to mineralize 90% of the herbicide linuron by Variovorax sp. SRS16 encapsulated in 2 mm beads with 5 and 20 mm spacings, respectively. Given that many pesticide degraders have low intrinsic degradation rates and that only limited carrier to soil volume ratios are practically feasible, bioaugmented soils are characterized by low effective degradation rates and can be considered fully mixed. A simple exponential model is then sufficient to predict biodegradation as verified by comparisons with published experimental data. By contrast, the full spatially distributed model is needed to adequately model the degradation of faster degrading contaminants such as naphthalene and benzene which can be mass-transfer limited. Dimensionless Damköhler numbers are proposed to determine whether the spatially distributed model is required. Results show that field scale applications of immobilized degraders will be limited by the amount of carriers required to reach acceptable degradation rates.
General information
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Organisations: Quantitative Sustainability Assessment, Department of Management Engineering, Department of Environmental Engineering, Geological Survey of Denmark and Greenland
Contributors: Owsianniak, M., Dechesne, A., Binning, P. J., Chambon, J. C. C., Sørensen, S. R., Smets, B. F.
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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): 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
Scopus rating (2009): SJR 2.86 SNIP 1.809
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Flagellar motility and differential gene expression of Pseudomonas putida KT2440 under partially hydrated conditions: a study with the novel Pressurized Porous Surface Model (PPSM)

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering, Center for Biological Sequence Analysis, Department of Systems Biology
Contributors: Gülez, G., Dechesne, A., Workman, C., Smets, B. F.
Publication date: 2010
Peer-reviewed: Yes

Bibliographical note
Oral presentation
Source: orbit
Source-ID: 317258
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2010

Flagellar Motility and Gene Expression in Unsaturated Zones

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Gülez, G., Dechesne, A., Smets, B. F.
Number of pages: 11
Publication date: 2010

Host publication information
Title of host publication: CREAM and RECETO Symposium "Microbial Degradation of Soil Pollutants - Processes and Impact", KU-LIFE, Copenhagen, 3-4 November 2009
Place of publication: Copenhagen
Publisher: Copenhagen University
Source: orbit
Gene expression dynamics of pseudomonas putida KT2440 biofilms under water deprivation

In soil, bacteria can form colonies that are exposed to changing hydration conditions, exerting a stress to which the bacteria should adjust. Some of the phenotypes associated with water deprivation, such as the production extracellular polymeric substance (EPS) and the limitation of motility, have previously been observed. However, it is not known how these responses are regulated and temporally expressed. Here, we aimed to investigate the gene level responses by identifying the differentially expressed genes at -0.4 MPa water stress compared to non-stressed condition. We hypothesized that under water stress flagellar and EPS genes would be significantly differentially expressed, the former being down- and the latter being up-regulated. The novel Pressurized Porous Surface Model (PPSM) was used to expose KT2440 colonies to -0.4 MPa water stress for 4, 24, and 72 hours. Agilent whole genome 1-color cDNA-microarray was used for gene expression profiling. The genes with log2-fold change >=1.5 and adjusted P-value.

High-rate autotrophic nitrogen removal with novel biofilm reactor technology

Flagellar motility, a mode of active motion shared by many prokaryotic species, is recognized as a key mechanism enabling population dispersal and resource acquisition in microbial communities living in marine, freshwater, and other liquid-replete habitats. By contrast, its role in variably hydrated habitats, where water dynamics result in fragmented aquatic habitats connected by micrometric films, is debated. Here, we quantify the spatial dynamics of Pseudomonas putida KT2440 and its nonflagellated isogenic mutant as affected by the hydration status of a rough porous surface using an experimental system that mimics aquatic habitats found in unsaturated soils. The flagellar motility of the model soil bacterium decreased sharply within a small range of water potential (0 to −2 kPa) and nearly ceased in liquid films of effective thickness smaller than 1.5 μm. However, bacteria could rapidly resume motility in response to periodic increases in hydration. We propose a biophysical model that captures key effects of hydration and liquid-film thickness on individual cell velocity and use a simple roughness network model to simulate colony expansion. Model predictions match experimental results reasonably well, highlighting the role of viscous and capillary pinning forces in hindering flagellar motility. Although flagellar motility seems to be restricted to a narrow range of very wet conditions, fitness gains conferred by fast surface colonization during transient favorable periods might offset the costs associated with flagella synthesis and explain the sustained presence of flagellated prokaryotes in partially saturated habitats such as soil surfaces.
Inoculum effects on community composition and nitritation performance of autotrophic nitrifying biofilm reactors with counter-diffusion geometry

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Terada, A., Lackner, S., Kristensen, K., Smets, B. F.
Pages: 2858-2872
Publication date: 2010
Peer-reviewed: Yes

Publication information
Journal: Environmental Microbiology
Volume: 12
Issue number: 10
ISSN (Print): 1462-2912
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 4.83 SJR 2.209 SNIP 1.31
Web of Science (2017): Impact factor 4.974
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.02 SJR 2.377 SNIP 1.383
Web of Science (2016): Impact factor 5.395
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.61 SJR 3.02 SNIP 1.571
Web of Science (2015): Impact factor 5.932
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.6 SJR 2.862 SNIP 1.599
Web of Science (2014): Impact factor 6.201
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 6.37 SJR 3.273 SNIP 1.823
Web of Science (2013): Impact factor 6.24
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Inoculum Effects on Community Composition and Nitritation Success of Nitrifying Biofilm Grown on a Gas-Permeable Membrane

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Terada, A., Lackner, S., Kristensen, K., Smets, B. F.
Publication date: 2010

Host publication information
Volume: CD-ROM
Place of publication: Alexandria, VA
Publisher: Water Environment Federation
Source: orbit
Source-ID: 268236
**Microbial community stratification in Membrane-Aerated Biofilm Reactors for Completely Autotrophic Nitrogen Removal**

Due to the necessity of a source of nitrite, most of the processes involving Anaerobic Ammonium Oxidation (Anammox) are based on a separated two-step process with a previous partial-nitritation reactor. However, these two processes can occur simultaneously in the same reactor by taking advantage of bacterial granules or biofilms. In this sense, completely autotrophic nitrogen removal from high ammonium strength wastewater was achieved in a Membrane-Aerated Biofilm Reactor (MABR) in a single step. Here, a biofilm containing nitrifiers (Aerobic Ammonium and Nitrite Oxidizing Bacteria, AOB and NOB, respectively) and Anaerobic Ammonium Oxidizing Bacteria (AnAOB) is grown on bubbleless aeration membranes to remove ammonium. Since oxygen permeates through the membrane-biofilm interface while ammonium diffuses into the biofilm from the biofilm-liquid interface, oxygen gradients can be established across the biofilm, allowing nitrogen removal in a single reactor by simultaneous activity of the mentioned biocatalysts. This work consists on the analysis of the microbial community existing in two laboratory-scale reactors operated for more than 300 days, which removed up to 5.5 g-N/m²/day. The system contained 1028 hollow fiber membranes (200/280 µm inner/outer diameter) covered homogeneously by biofilm. Samples (low, middle and upper part of the biofilm) were collected, fixed, embedded in OCT compound for cryosection and later Fluorescence In-Situ Hybridization (FISH). Emphasis was put on elucidating the radial and longitudinal distribution and quantification of the involved microbial communities along the membranes. Our observations confirmed that the oxygen gradient was conditioning the spatial distribution of each population inside the biofilm. Thus, AOB were mainly located in the adjacent zone to the membrane, while AnAOB were localized next to them in areas where no oxygen was available. NOB were detected in very low amounts. Results proved the feasibility of developing biofilm structures for high-rate completely autotrophic nitrogen removal.

**General information**

State: Published  
Organisations: Department of Environmental Engineering, Urban Water Engineering, Residual Resource Engineering, Technical University of Denmark  
Contributors: Pellicer i Nàcher, C., Ruscalleda, M., Terada, A., Smets, B. F.  
Publication date: 2010  
Peer-reviewed: Yes  
Keywords: Nitrogen removal, Membrane-Aerated Biofilm Reactor, Anammox, biofilms stratification, Anaerobic Ammonium Oxidization  
Electronic versions: Poster_Wat_res_CAPN.pdf  
Source: orbit  
Source-ID: 262395  
Research output: Research - peer-review » Poster – Annual report year: 2010

**Modelling bioaugmentation in unsaturated porous media: The linuron herbicide example**

To protect groundwater resources against pesticides, bioaugmentation with microorganisms immobilized in solid carriers has been considered as a soil remediation strategy. We have developed a mathematical model to assess this bioremediation approach to remove the pesticide linuron from soils at various water saturation levels. A bacterium mineralizing linuron is heterogeneously distributed within a 3-D model domain in spherical hotspots of 2-mm diameter size. Diffusion and advection due to infiltration are the transport processes, and microbial growth follows first order kinetics. Without advection, a bead spacing distance of 5 mm at saturated conditions is required to achieve a bioremediation goal of 90% linuron mineralization in 1 year. The gas phase is an important parameter affecting the transport of linuron, however, linuron biodegradation is growth kinetics limited within a broad water saturation range. It is hypothesized that the selection of faster degraders can compensate for high amounts of required beads.

**General information**

State: Published  
Organisations: Quantitative Sustainability Assessment, Department of Management Engineering, Department of Environmental Engineering  
Contributors: Owssianiak, M., Dechesne, A., Binning, P. J., Smets, B. F.  
Publication date: 2010  
Host publication information  
Title of host publication: GQ10 : CD-ROM  
Volume: Keynote S6  
Publisher: IAHS Press  
Source: orbit  
Source-ID: 264915  
Research output: Research - peer-review » Conference abstract in proceedings – Annual report year: 2010
Novel assay to assess permissiveness of a soil microbial community toward receipt of mobile genetic elements

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Musovic, S., Dechesne, A., Sørensen, J., Smets, B. F.
Pages: 4813-4818
Publication date: 2010
Peer-reviewed: Yes

Publication information
Journal: Applied and Environmental Microbiology
Volume: 76
Issue number: 14
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
Presence, distribution, and diversity of iron-oxidizing bacteria at a landfill leachate-impacted groundwater surface water interface

We examined the presence of iron-oxidizing bacteria (IOB) at a groundwater surface water interface (GSI) impacted by reduced groundwater originating as leachate from an upgradient landfill. IOB enrichments and quantifications were obtained, at high vertical resolution, by an iron/oxygen opposing gradient cultivation method. The depth-resolved soil distribution profiles of water content, Fe$^{2+}$, and total Fe indicated sharp gradients within the top 10 cm sediments of the GSI, where the IOB density was the highest. In addition, the vertical distribution of iron-reducing bacteria at the same sampling site mirrored the IOB distribution. Clone libraries from two separate IOB enrichments indicated a stratified IOB community with clear differences at short vertical distances. Alpha- and Betaproteobacteria were the dominant phylotypes. Clones from the near-surface sediment (1-2 cm below ground surface) were dominated by members of the Bradyrhizobiaceae and Comamonadaceae; clones from the deeper sediments were phylogenetically more diverse, dominated by members of the Rhodocyclaceae. The iron deposition profiles indicated that active iron oxidation occurred only within the near-to-surface GSI sediments. The match between the iron deposition profiles and the IOB abundance...
profiles strongly hints at the contribution of the IOB community to Fe oxidation in this Fe-rich GSI ecosystem.
Sequential Aeration of Membrane-Aerated Biofilm Reactors for High-Rate Autotrophic Nitrogen Removal: Experimental Demonstration

One-stage autotrophic nitrogen (N) removal, requiring the simultaneous activity of aerobic and anaerobic ammonium oxidizing bacteria (AOB and AnAOB), can be obtained in spatially redox-stratified biofilms. However, previous experience with Membrane-Aerated Biofilm Reactors (MABRs) has revealed a difficulty in reducing the abundance and activity of nitrite oxidizing bacteria (NOB), which drastically lowers process efficiency. Here we show how sequential aeration is an effective strategy to attain autotrophic N removal in MABRs: Two separate MABRs, which displayed limited or no N removal under continuous aeration, could remove more than 5.5 g N/m²/day (at loads up to 8 g N/m²/day) by controlled variation of sequential aeration regimes. Daily averaged ratios of the surficial loads of O\textsubscript{2} (oxygen) to NH\textsubscript{4}\textsuperscript{+} (ammonium) (LO\textsubscript{2}/LNH\textsubscript{4}) were close to 1.73 at this optimum. Real-time quantitative PCR based on 16S rRNA gene confirmed that sequential aeration, even at elevated average O\textsubscript{2} loads, stimulated the abundance of AnAOB and AOB and prevented the increase in NOB. Nitrous oxide (N\textsubscript{2}O) emissions were 100-fold lower compared to other anaerobic ammonium oxidation (Anammox)-nitritation systems. Hence, by applying periodic aeration to MABRs, one-stage autotrophic N removal biofilm reactors can be easily obtained, displaying very competitive removal rates, and negligible N\textsubscript{2}O emissions.
Sequential Aeration of Membrane-Aerated Biofilm Reactors (MABRs) Yields for High-Rate Autotrophic Nitrogen Removal: Experimental Demonstration
Shifts between Nitrospira- and Nitrobacter-like nitrite oxidizers underlie the response of soil potential nitrite oxidation to changes in tillage practices

General information
State: Published
Organisations: Urban Water Engineering, Department of Environmental Engineering, Environmental Chemistry
Pages: 315-326
Publication date: 2010
Peer-reviewed: Yes
Publication information
Journal: Environmental Microbiology
Volume: 12
Issue number: 2
ISSN (Print): 1462-2912
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 4.83 SJR 2.209 SNIP 1.31
Web of Science (2017): Impact factor 4.974
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 5.02 SJR 2.377 SNIP 1.383
Web of Science (2016): Impact factor 5.395
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 5.61 SJR 3.02 SNIP 1.571
Web of Science (2015): Impact factor 5.932
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 5.6 SJR 2.862 SNIP 1.599
Web of Science (2014): Impact factor 6.201
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 6.37 SJR 3.273 SNIP 1.823
Web of Science (2013): Impact factor 6.24
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 5.94 SJR 3.165 SNIP 1.639
Web of Science (2012): Impact factor 5.756
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
Surface roughness and limited hydration constrain motility-driven surface colonization by pseudomonads

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering
Contributors: Dechesne, A., Smets, B. F.
Publication date: 2010

Host publication information
Title of host publication: Proceedings of the 13th International Symposium on Microbial Ecology
Volume: CT37.001
Publisher: International Society for Microbiology
Source: orbit
Source-ID: 267675
Research output: Research - peer-review » Conference abstract in proceedings – Annual report year: 2010

The Pressurized Porous Surface Model: An improved tool to study bacterial behavior under a wide range of environmentally relevant matric potentials

General information
State: Published
TOL plasmid carriage enhances biofilm formation and increases extracellular DNA content in Pseudomonas Putida KT2440

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Smets, B. F., D'Alvise, P., Yankelovich, T., Sjøholm, O., Jin, Y., noWuertz, S.
Publication date: 2010

Host publication information
Title of host publication: Proceedings of the 13th International Symposium on Microbial Ecology
Volume: CT26.007
Publisher: International Society for Microbiology
Source: orbit
Source-ID: 267677
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2010

TOL plasmid carriage enhances biofilm formation and increases extracellular DNA content in Pseudomonas putida KT2440
Adherent growth of Pseudomonas putida KT2440 with and without the TOL plasmid (pWWO) at the solid-liquid and air-liquid interface was examined. We compared biofilm formation on glass in flow cells, and assayed pellicle (air-liquid interface biofilm) formation in stagnant liquid cultures by confocal laser scanning microscopy. The TOL-carrying strains formed pellicles and thick biofilms, whereas the same strains without the plasmid displayed little adherent growth. Microscopy using fluorescent nucleic acid-specific stains revealed differences in the production of extracellular polymeric substances: TOL carriage leads to more extracellular DNA (eDNA) in pellicles and biofilms. Pellicles were dissolved by DNase I treatment. Enhanced cell lysis due to plasmid carriage was ruled out as the mechanism for eDNA release. We report, for the first time, that carriage of a conjugative plasmid leads to increased biofilm formation by production of eDNA.

General information
State: Published
Organisations: National Food Institute, Division of Industrial Food Research, Department of Environmental Engineering
Contributors: D'Alvise, P., Sjoholm, O., Yankelevich, T., Jin, Y., Wuertz, S., Smets, B. F.
Pages: 84-92
Publication date: 2010
Peer-reviewed: Yes

Publication Information
Journal: F E M S Microbiology Letters
Volume: 312
TOL Plasmid Carriage Enhances Biofilm Formation and Increases Extracellular DNA Content in Pseudomonas Putida KT2440

Adherent growth of Pseudomonas putida KT2440 with and without the TOL plasmid (pWWO) at the solid-liquid and air-liquid interface was examined. We compared biofilm formation on glass in flow cells, and assayed pellicle (air-liquid interface biofilm) formation in stagnant liquid cultures by confocal laser scanning microscopy. The TOL-carrying strains formed pellicles and thick biofilms, whereas the same strains without the plasmid displayed little adherent growth. Microscopy using fluorescent nucleic acid-specific stains (cytox orange, propidium iodide) revealed differences in production of extracellular polymeric substances: TOL carriage leads to more extracellular DNA (eDNA) in pellicles and biofilms. Pellicles were dissolved by DNAse I treatment. eDNA was observed as ominous fibrous structures. Quantitative analysis of live and dead cells in static cultures was performed by flow cytometry combined with specific cytostains; release of cytoplasmic material was assayed by a β-glucosidase assay. Enhanced cell lysis due to plasmid carriage was ruled out as the mechanism for eDNA release. We report, for the first time, that carriage of a conjugative plasmid leads to increased biofilm formation by production of eDNA.

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering, Division of Industrial Food Research, National Food Institute, Technical University of Denmark, University of California at Davis, University of Copenhagen
Contributors: Smets, B. F., D’Alvise, P., Yankelovich, T., Sjøholm, O., Jin, Y., Wuertz, S.
Publication date: 2010
Peer-reviewed: Yes
DOI: 10.1111/j.1574-6968.2010.02105.x
Source: orbit
Source-ID: 312400
Research output: Research - peer-review › Conference abstract for conference – Annual report year: 2010

TOL plasmid invasion is contingent on cell growth and temporary conjugation depression

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Seoane, J. M., Yankelovich, T., Dechesne, A., Merkey, B., Smets, B. F.
Publication date: 2010

Host publication information
Title of host publication: ISME 13 - 13th International Symposium on Microbial Ecology, August 22-27, 2010, Seattle, WA, USA
Volume: USB Key
Place of publication: International Society for Microbiology
Source: orbit
Source-ID: 267676
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2010
Towards successful bioaugmentation with entrapped cells as a soil remediation technology: Effects of the water content and cell dispersal.

Soil remediation technologies are proposed that rely on inoculation with degrading microorganisms entrapped in protective carriers. A mathematical model developed to model entrapped cell bioaugmentation describes the 3-D diffusion-driven mass transfer of benzoate, and its mineralization by Pseudomonas putida KT2440 entrapped in alginate beads spatially distributed in a sandy matrix. The model is validated against experimental data where one, three, and nine degradation hotspots are spatially distributed in sandy microcosms. The lowest mineralization rates are observed in dry conditions (water saturation 7%) and agree satisfactory well with model predictions. In contrast, much larger mineralization rates are measured for wet conditions (water saturation of 68%). This discrepancy originates from extensive cell dispersal, not accounted for in the model, which occurs in wet conditions but is restricted in dry conditions, as confirmed by performing cell counts. This highlights the potential of entrapped cells when they act as seeds for soil colonization.
Abundance and diversity of microbial communities in long-term aporated anammox biofilm reactors initiated with different inocula

General information
State: Published
Organisations: Urban Water Engineering, Department of Environmental Engineering
Contributors: Terada, A., Lackner, S., Smets, B. F.
Pages: 138-141
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: Abstract Book
Place of publication: Aalborg
Source: orbit
Source-ID: 244484
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2009

An Individual-based model to describe horizontal gene transfer in biofilms

General information
State: Published
Organisations: Department of Environmental Engineering
Pages: 71-77
Publication date: 2009

Host publication information
Title of host publication: International Conference Biofilms 2009. Processes in Biofilms: Fundamentals to applications, September 13-16, 2009, Davis, CA, USA
Volume: Conference Proceedings. CD-ROM
Place of publication: Davis, CA, USA
Publisher: University of California
Source: orbit
Source-ID: 250256
Research output: Research - peer-review › Article in proceedings – Annual report year: 2009

Enhancing the formation and shear resistance of nitrifying biofilms on membranes by surface modification
Polypropylene (PP) membranes and polyethylene (PE) surfaces were modified to enhance formation and shear resistance of nitrifying biofilms for wastewater treatment applications. A combination of plasma polymerization and wet chemistry was employed to ultimately introduce poly(ethyleneglycol) (PEG) chains with two different functional groups (-PEG-NH2 and -PEG-CH3). Biofilm growth experiments using a mixed nitrifying bacterial culture revealed that the specific combination of PEG chains with amino groups resulted in most biofilm formation on both PP and PE samples. Detachment experiments showed similar trends: biofilms on -PEG-NH2 modified surfaces were much stronger compared to the other modifications and the unmodified reference surfaces. Electrostatic interactions between the protonated amino group and negatively charged bacteria as well as PEG chain density which can affect the surface structure might be possible explanations of the superiority of the -PEG-NH2 modification. The success of the-PEG-NH2 modification was independent of the original surface and might, therefore, be used in wastewater treatment bioreactors to improve reactor performance by making biofilm formation more stable and predictable.

General information
State: Published
Organisations: Department of Environmental Engineering, Polymer Microsystems for Electrophysiology Group, Polymer Micro and Nano Engineering Section, Department of Micro- and Nanotechnology
Contributors: Lackner, S., Holmberg, M., Terada, A., Kingshott, P., Smets, B. F.
Pages: 3469-3478
Publication date: 2009
Peer-reviewed: Yes

Publication information
Journal: Water Research
Volume: 43
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

Scopus rating (2005): SJR 2.113 SNIP 2.334
Web of Science (2005): Indexed yes

Scopus rating (2004): SJR 2.209 SNIP 2.108
Individual- and population-scale swimming motility on unsaturated surfaces: Experimental quantification and biophysical modeling

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering
Contributors: Dechesne, A., Wang, G., Or, D., Gulez, G., Smets, B. F.
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: 247053
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2009

Initial population of ammonia- and nitrite-oxidizing bacteria compromises successful nitrification in a counter-diffusion biofilm geometry

General information
State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry
Contributors: Terada, A., Lackner, S., Kristensen, K., Smets, B. F.
Publication date: 2009
Peer-reviewed: Yes
Event: Poster session presented at 5th IWA Activated Sludge Population Dynamics Specialist Conference, Aalborg, Denmark.
Source: orbit
Source-ID: 244488
Research output: Research - peer-review › Poster – Annual report year: 2009

Mass Action Models Describing Extant Horizontal Transfer of Plasmids: Inferences and Parameter Sensitivities
Predicting the fate of horizontally transmissible elements in extant microbial communities might be facilitated by the availability of suitable mathematical models. Since the mid-1970s, mass action models have been introduced to describe the transfer of conjugal and mobilizable genetic elements. This chapter will summarize and explain the assumptions behind spatially homogenous models, and show the predictions by these models under typical scenarios, such as evaluating existence conditions of conjugal plasmids under chemostat or seasonal growth conditions. Special attention is given to the sensitivity of the outcomes to the various plasmid dynamic parameters. For our analysis, we developed a set of user-friendly MatLab® routines, which are deposited in the public domain. We hope that the availability of these routines will encourage the computationally untrained microbiologist to make use of these mathematical models. Finally, further permutations, as well as limitations of these mass action models in view of the structured complexity of most
microbial systems are addressed.

**General information**
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering, National Institute for Agronomic Research
Contributors: Smets, B. F., Lardon, L.
Pages: 289-305
Publication date: 2009

**Host publication information**
Title of host publication: Horizontal Gene Transfer : Genomes in Flux
Volume: 17
Publisher: Springer
Editors: Gogarten, M. B., Gogarten, J. P., Olendzenski, L.
ISBN (Print): 978-1-60327-852-2
(Methods in Molecular Biology; No. 532).
Source: orbit
Source-ID: 318468
Research output: Research - peer-review › Book chapter – Annual report year: 2009

Midrobial community analysis in an autotrophic hollow-fiber membrane-aerated biofilm reactor (HFMBR) treating a high-strength nitrogen wastewater

**General information**
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering
Pages: 146-148
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: Abstract Book
Place of publication: Aalborg
Source: orbit
Source-ID: 244485
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2009

Modelling of consortial linuron mineralization in unsaturated porous media

**General information**
State: Published
Organisations: Department of Environmental Engineering
Contributors: Owssianiak, M., Dechesne, A., Binning, P. J., Smets, B. F.
Pages: 24-25
Publication date: 2009

**Host publication information**
Title of host publication: CREAM and RECETO Symposium "Microbial Degradation of Soil Pollutants - Processes and Impact", KU-LIFE, Copenhagen, 3-4 November 2009
Place of publication: Copenhagen
Publisher: Copenhagen University
Source: orbit
Source-ID: 257365
Research output: Research › Conference abstract in proceedings – Annual report year: 2009

Nitritation performance and biofilm development of co- and counter-diffusion biofilm reactors: Modeling and experimental comparison
A comparative study was conducted on the start-up performance and biofilm development in two different biofilm reactors with aim of obtaining partial nitritation. The reactors were both operated under oxygen limited conditions, but differed in geometry. While substrates (O-2, NH3) co-diffused in one geometry, they counter-diffused in the other. Mathematical simulations of these two geometries were implemented in two 1-D multispecies biofilm models using the AQUASIM software. Sensitivity analysis results showed that the oxygen mass transfer coefficient (K-i) and maximum specific growth
rate of ammonia-oxidizing (AOB) and nitrite-oxidizing bacteria (NOB) were the determinant parameters in nitrogen conversion simulations. The modeling simulations demonstrated that Ki had stronger effects on nitrogen conversion at lower (0-10 m d(-1)) than at the higher values (> 10 m d(-1)). The experimental results showed that the counter-diffusion biofilms developed faster and attained a larger maximum biofilm thickness than the co-diffusion biofilms. Under oxygen limited condition (DO <0.1 mg L-1) and high pH (8.0-8.3), nitrite accumulation was triggered more significantly in co-diffusion than counter-diffusion biofilms by increasing the applied ammonia loading from 0.21 to 0.78 g NH4+-N L-1 d(-1). The co- and counter-diffusion biofilms displayed very different spatial structures and population distributions after 120 days of operation. AOB were dominant throughout the biofilm depth in co-diffusion biofilms, while the counter-diffusion biofilms presented a stratified structure with an abundance of AOB and NOB at the base and putative heterotrophs at the surface of the biofilm, respectively.

**General information**
- State: Published
- Organisations: Department of Environmental Engineering, Urban Water Engineering, Environmental Chemistry
- Pages: 2699-2709
- Publication date: 2009
- Peer-reviewed: Yes

**Publication information**
- Journal: Water Research
- Volume: 43
- Issue number: 10
- 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
Nitrogen Removal from Digested Black Water by One-stage Partial Nitritation and Anammox

This study assessed the technical feasibility to treat digested black water from vacuum toilets (> 1000 mg NH4+-N L-1) in a lab-scale oxygen-limited autotrophic nitrification/denitrification (OLAND) rotating biological contactor. After an adaptation period of 2.5 months, a stable nitrogen removal rate of ca. 700 mg N L-1 d(-1) was reached over the subsequent 5 months. Suppression of the nitrite oxidizing bacteria at free ammonia levels above 3 mg N L-1 resulted in a nitrogen removal efficiency of 76%. The favorable ratios of both organic and inorganic carbon to nitrogen guaranteed endured anammox activity and sufficient buffering capacity, respectively. Quantitative FISH showed that aerobic and anoxic ammonium-oxidizing bacteria (AerAOB and AnAOB) made up 43 and 8% of the biofilm, respectively. Since a part of the AerAOB was probably present in anoxic biofilm zones, their specific ammonium conversion was very low, in contrast to the high specific AnAOB activity. DGGE analysis showed that the dominant AerAOB and AnAOB species were resistant to the transition from synthetic medium to digested black water. This study demonstrates high-rate nitrogen removal from digested black water by one-stage partial nitritation and anammox, which will allow a significant decrease in operational costs compared to conventional nitrification/denitrification.

General information
State: Published
Organisations: Urban Water Engineering, Department of Environmental Engineering, Residual Resource Engineering
Contributors: Vlaeminck, S., Terada, A., Smets, B. F., van der Linden, D., Boon, N., Verstraete, W., Carballa, M.
Pages: 5035-5041
Publication date: 2009
Peer-reviewed: Yes
A mechanistic oxygen transfer model was developed and applied to a flow-through hollow-fiber membrane-aerated biofilm reactor. Model results are compared to conventional clean water test results as well as performance data obtained when an actively nitrifying biofilm was present on the fibers. With the biofilm present, oxygen transfer efficiencies between 30 and 55% were calculated from the measured data including the outlet gas oxygen concentration, ammonia consumption stoichiometry, and oxidized nitrogen production stoichiometry, all of which were in reasonable agreement. The mechanistic model overpredicted the oxygen transfer by a factor of 1.3 relative to the result calculated from the outlet gas oxygen concentration, which was considered the most accurate of the measured benchmarks. A mass transfer coefficient derived from the clean water testing with oxygen sensors at the membrane-liquid interface was the most accurate of the predictive models (overpredicted by a factor of 1.1) while a coefficient determined by measuring bulk liquid dissolved oxygen underpredicted the oxygen transfer by a factor of 3. The mechanistic model was found to be an adequate tool for design because it used the published diffusion and partition coefficients rather than requiring small-scale testing to determine the system-specific mass transfer coefficients.
Plasmid invasion and plasmid persistence in pseudomonas putida biofilm

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering
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
Start-up strategies of membrane-aerated biofilm reactor (MABR) for completely autotrophic nitrogen removal

Completely autotrophic nitrogen removal, coupling aerobic and anaerobic ammonium oxidation, can be achieved via redox stratified biofilms growing on gas-permeable membranes. These sequential reactions are mediated by aerobic and anaerobic ammonium oxidizing bacteria (AOB and AnAOB). The major downside of this process stems from a long start-up period due to the slow growth rate of AnAOB. Therefore, two different start-up strategies, i.e., continuous inoculation of AnAOB and sequential batch inoculation of AOB and AnAOB, were tested in two laboratory scale membrane-aerated biofilm reactor (MABRs). Results indicate that the continuous inoculation strategy was more rapid and effective to achieve nitrogen removal than the sequential inoculation approach. Nitrogen loss in the reactor continuously inoculated with AnAOB was observed after 120 day operation, with an average NH4+-N and TN removal rate of 3.41 and 1.95 g-N/m²-membrane/day, respectively. On the other hand, nitrogen loss was hardly observed in the MABR with the sequential inoculation strategy.

The effect of hydroxylamine on the activity and aggregate structure of autotrophic nitrifying bioreactor cultures

Addition of hydroxylamine (NH2OH) to autotrophic biomass in nitrifying bioreactors affected the activity, physical structure, and microbial ecology of nitrifying aggregates. When NH2OH is added to nitrifying cultures in 6-h batch experiments, the initial NH3-N uptake rates were physiologically accelerated by a factor of 1.4-13. NH2OH addition caused a 20-40% decrease in the median aggregate size, broadened the shape of the aggregate size distribution by up to 230%, and caused some of the microcolonies to appear slightly more dispersed. Longer term NH2OH addition in fed batch bioreactors decreased the median aggregate size, broadened the aggregate size distribution, and decreased NH3-N removal from >90% to values ranging between 75% and 17%. This altered performance is explained by quantitative fluorescence in situ hybridization (FISH) results that show inhibition of nitrifying populations, and by qPCR results showing that the copy numbers of amoA and nxrA genes gradually decreased by LIP to an order-of-magnitude. Longer term NH2OH addition damaged the active biomass. This research clarifies the effect of NH2OH on nitrification and demonstrates the need to incorporate NH2OH-related dynamics of the nitrifying biomass into mathematical models, accounting for both ecophysiological and structural responses.
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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
Original language: English
Keywords: hydroxylamine, aggregate size, nitrification, ammonia oxidizers, microcolony, nitrite oxidizers
DOI:
10.1002/bit.22121
Source: orbit
Source-ID: 235460
Research output: Research - peer-review › Journal article – Annual report year: 2009

TOL PWW0 transfer dynamics in Pseudomonas putida KT2440

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering
Publication date: 2009
Peer-reviewed: Yes
Event: Poster session presented at 3rd Congress of European Microbiologists, Goteborg, Sweden.
Source: orbit
Source-ID: 247054
Research output: Research - peer-review › Poster – Annual report year: 2009

Treatment trains for the remediation of aquifers polluted with MTBE and other xenobiotic compounds

General information
State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry
Contributors: Tsitonaki, A., Bjerg, P. L., Smets, B. F., Mosbæk, H.
Number of pages: 71
Publication date: Sep 2008

Publication information
Original language: English
Electronic versions:
WWW version
URLs:

Bibliographical note
+ appendix
Source: orbit
Source-ID: 221900
Research output: Research › Ph.D. thesis – Annual report year: 2008

A critical comparison of extant batch respirometric and substrate depletion assays for estimation of nitrification biokinetics

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering
Contributors: Chandran, K., Hu, Z., Smets, B. F.
Pages: 62-72
Publication date: 2008
Peer-reviewed: Yes

Publication information
Journal: Biotechnology and Bioengineering (Print)
Volume: 101
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
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
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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
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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
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BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.551 SNIP 1.354
Web of Science (2010): Impact factor 3.7
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BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.498 SNIP 1.358
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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
Ammonium removal performance and spatial distribution of nitrifying bacterial populations in autotrophic co- and counter-diffusion biofilms under oxygen limited conditions

General information
State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry, Urban Water Engineering
Publication date: 2008

Host publication information
Title of host publication: IWA World Water Congress and Exhibition, 7-12 September 2008, Vienna
Volume: Proceedings. CD-ROM
Place of publication: London, UK
Publisher: IWA Publishing
Source: orbit
Source-ID: 223528
Research output: Research - peer-review › Article in proceedings – Annual report year: 2008

Analysis of an individual-based model describing plasmid transfer in biofilms

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering, Environmental Chemistry
Pages: N-039
Publication date: 2008

Host publication information
Title of host publication: ASM 108th General Meeting, Boston June 1-5, 2008
Volume: CD-ROM
Place of publication: Washington, DC
Publisher: American Society for Microbiology
Source: orbit
Source-ID: 236830
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2008

An improved cell recovery method for iron oxidizing bacterial (IOB) enrichments
Two cell recovery methods for IOB enrichments were evaluated for DNA extraction and further PCR-based 16S rRNA gene clone library creation. One was a published method consisting of heating plus oxalic acid treatment and the other one was a new method based on enzymatic agarose digestion (using β-agarase I). The results indicated that the enzymatic method was much gentler on IOB cells and yielded an approximately 5000-fold higher DNA mass than the published method. The 16S rRNA gene clone library developed from the β-agarase I treated IOB enrichments indicated a high IOB community diversity with sequences in greek small letter alpha-, β-, γ-, δ-, ε-Proteobacteria, unclassified Proteobacteria, unclassified Bacteroidetes and unclassified Bacteria. In contrast, the published method resulted in mainly γ-Proteobacterial clone sequences. In addition, only the cells recovered by agarase treatment were amenable to direct
fluorescence in situ hybridization (FISH). Therefore, we propose that the agarase method is a better IOB cell recovery method, because it is simpler, faster, and retains more genetic diversity.

**General information**

State: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering, University of Connecticut
Contributors: Yu, R., Graf, J., Smets, B. F.
Pages: 235-240
Publication date: 2008
Peer-reviewed: Yes

**Publication information**

Journal: Journal of Microbiological Methods
Volume: 72
Issue number: 3
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
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Web of Science (2014): Impact factor 2.026
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Scopus rating (2013): CiteScore 2.5 SJR 0.924 SNIP 1.015
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ISI indexed (2013): ISI indexed yes
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ISI indexed (2012): ISI indexed yes
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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
Antecedent growth conditions alter retention of environmental Escherichia coli isolates in transiently wetted porous media

The physical transport of Escherichia coli in terrestrial environments may require control to prevent its dissemination from potential high-density sources, such as confined animal feedlot operations. Biobarriers, wherein convective flows carrying pathogens pass through a porous matrix with high retentive capacity, may present one such approach. Eight environmental E. coli isolates were selected to conduct operational retention tests (ORT) with potential biobarrier materials Pyrax or dolomite, or silica glass as control. The conditions in the ORT were chosen to simulate conditioning by manure solutes, a pulse application of a bacterial load followed by rainfall infiltration, and natural drainage. Removal was limited, and likely caused by the relatively high velocities during drainage, and the conditioning of otherwise favorable adhesion sites. Flagella-mediated motility showed the strongest correlation to biobarrier retention. Significant variability was observed across the E. coli isolates, but consistently higher retention was observed for cells with external versus intestinal pregrowth histories. E. coli 0157: H7 was retained the least with all examined matrices, while E. coli K-12 displayed moderate retention and may not serve as representative model strain. Pyrax is a good candidate biobarrier material given its superior removal ability across the tested E. coli strains.

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering
Contributors: Yang, H., Morrow, J. B., Grasso, D., Vinopal, R. T., Dechesne, A., Smets, B. F.
Pages: 9310-9316
Publication date: 2008
Peer-reviewed: Yes

Publication information
Journal: Environmental Science & Technology (Washington)
Volume: 42
Issue number: 24
ISSN (Print): 0013-936X
Ratings:
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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
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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
Scopus rating (2009): SJR 2.86 SNIP 1.809
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 2.96 SNIP 1.935
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 2.774 SNIP 1.914
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 2.55 SNIP 1.893
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 2.608 SNIP 1.999
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 2.86 SNIP 2.046
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 2.54 SNIP 2.065
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 2.392 SNIP 1.949
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 2.387 SNIP 1.968
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 3.03 SNIP 2.315
Assessing the permissivity of soil microbial communities towards receipt of exogenous mobile elements

General information
State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry
Contributors: Musovic, S., Sørensen, J., Smets, B. F.
Pages: N-238
Publication date: 2008

Host publication information
Title of host publication: ASM 108th General Meeting, Boston June 1-5, 2008
Volume: CD-ROM
Place of publication: Washington, DC
Publisher: American Society for Microbiology
Source-ID: 236829
Research output: Research - peer-review » Conference abstract in proceedings – Annual report year: 2008

Biokinetic characterization of the acceleration phase in autotrophic ammonia oxidation

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering
Contributors: Chandran, K., Smets, B. F.
Pages: 732-739
Publication date: 2008
Peer-reviewed: Yes

Publication information
Journal: Water Environment Research
Volume: 80
ISSN (Print): 1061-4303
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 0.84 SJR 0.283 SNIP 0.312
Web of Science (2017): Impact factor 0.825
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.89 SJR 0.324 SNIP 0.443
Web of Science (2016): Impact factor 0.91
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 0.8 SJR 0.344 SNIP 0.493
Web of Science (2015): Impact factor 0.659
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 0.75 SJR 0.4 SNIP 0.537
Web of Science (2014): Impact factor 0.865
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 1.04 SJR 0.408 SNIP 0.601
Web of Science (2013): Impact factor 1
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 0.99 SJR 0.501 SNIP 0.697
Web of Science (2012): Impact factor 1.134
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 0.9 SJR 0.459 SNIP 0.483
Web of Science (2011): Impact factor 0.883
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.428 SNIP 0.384
Web of Science (2010): Impact factor 0.89
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.469 SNIP 0.523
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.479 SNIP 0.64
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.431 SNIP 0.417
Scopus rating (2006): SJR 0.539 SNIP 0.711
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.516 SNIP 0.658
Scopus rating (2004): SJR 0.742 SNIP 0.945
Scopus rating (2003): SJR 1.045 SNIP 1.052
Scopus rating (2002): SJR 0.614 SNIP 0.807
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.685 SNIP 0.864
Scopus rating (2000): SJR 0.747 SNIP 0.874
Scopus rating (1999): SJR 0.756 SNIP 0.848
Original language: English
DOIs:
10.2175/106143008X296442
Source: orbit
Source-ID: 236827
Research output: Research - peer-review › Journal article – Annual report year: 2008

Do different initial microbial communities converge in identically operated anammox biofilm reactors?

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Terada, A., Lackner, S., Smets, B. F.
Number of pages: 35
Publication date: 2008

Host publication information
Title of host publication: Proceedings of Biofilm III Conference, München 6-8 October 2008
Place of publication: München
Publisher: Gesellschaft zur Förderung des Lehrstuhls für Wassergüte- und Abfallwirtschaft der Technischen Universität München
Source: orbit
Source-ID: 227946
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2008

Dynamics of spatial distribution and microbial activity of nitrifying populations in redox-stratified biofilms: Modeling and experimental investigations
Ecological role of flagellar motility under unsaturated conditions

Ecological value of swimming motility on variably-saturated surfaces

Effect of membrane surface functionalization on formation and shear resistance of nitrifying biofilms
Effects of heat-activated persulfate oxidation on soil microorganisms

The effects of heat-activated persulfate on indigenous microorganisms and microcosms augmented with Pseudomonas putida KT2440 were studied in laboratory batch reactors with aquifer material. Microscopic enumeration was used to measure the changes in cell density, and acetate consumption was used to evaluate metabolic activity after exposure to activated persulfate. The cell enumerations showed that persulfate concentrations up to 10 g/L did not affect the indigenous microorganisms but were detrimental to P. putida survival. Acetate consumption was inhibited at the highest persulfate dose (10 g/L). The results emphasize the necessity of using multiple toxicity assays and indigenous cultures in order to realistically assess the potential effects of in situ chemical oxidation on soil microorganisms. A comparison to other studies suggests that the effects of activated persulfate on soil microorganisms are less damaging than those of Fenton's reagent and hydrogen peroxide.

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Tsitonaki, A., Smets, B. F., Bjerg, P. L.
Pages: 1013-1022
Publication date: 2008
Peer-reviewed: Yes

Publication information
Journal: Water Research
Volume: 42
Issue number: 4-5
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
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
Heterotrophic activity compromises autotrophic nitrogen removal in membrane-aerated biofilms: Results of a modeling study

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering, Residual Resource Engineering
Contributors: Lackner, S., Terada, A., Smets, B. F.
Pages: 1102-1112
Publication date: 2008
Peer-reviewed: Yes

Publication information
Journal: Water Research
Volume: 42
Issue number: 4-5
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
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
Impact of plasmid harboring on biofilm formation and invasion

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering, Environmental Chemistry
Contributors: El Azhari, N., Lardon, L., Smets, B. F.
Pages: N-038
Publication date: 2008

Host publication information
Title of host publication: ASM 108th General Meeting, Boston June 1-5, 2008
Volume: CD-ROM
Place of publication: Washington,DC
Publisher: Amerian Society for Microbiology
Source-ID: 236831
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2008

In situ chemical oxidation as the first part of a sequential remediation for groundwater contamination

General information
State: Published
Organisations: Department of Environmental Engineering, Environmental Chemistry
Contributors: Tsitonaki, A., Smets, B. F., Bjerg, P. L.
Pages: 155-164
Publication date: 2008

Host publication information
Title of host publication: Vintermøde om jord- og grundvandsforurening, Vingstedcentret 4.-5. marts 2008
Volume: Bind 1
Place of publication: Kgs. Lyngby
Publisher: ATV Jord og Grundvand
Source-ID: 211648
Research output: Research › Article in proceedings – Annual report year: 2008

Limited diffusive fluxes of substrate facilitate coexistence of two competing bacterial strains
Soils are known to support a great bacterial diversity down to the millimeter scale, but the mechanisms by which such a large diversity is sustained are largely unknown. A feature of unsaturated soils is that water usually forms thin, poorly-connected films, which limit solute diffusive fluxes. It has been proposed, but never unambiguously experimentally tested, that a low substrate diffusive flux would impact bacterial diversity, by promoting the coexistence between slow-growing bacteria and their potentially faster-growing competitors. We used a simple experimental system, based on a Petri dish and a perforated Teflon(R) membrane to control diffusive fluxes of substrate (benzoate) whilst permitting direct observation of bacterial colonies. The system was inoculated with prescribed strains of Pseudomonas, whose growth was quantified by microscopic monitoring of the fluorescent proteins they produced. We observed that substrate diffusion limitation reduced the growth rate of the otherwise fast-growing Pseudomonas putida KT2440 strain. This strain out-competed Pseudomonas fluorescens F113 in liquid culture, but its competitive advantage was less marked on solid media, and even disappeared under conditions of low substrate diffusion. Low diffusive fluxes of substrate, characteristic of many unsaturated media (e.g. soils, food products), can thus promote bacterial coexistence in a competitive situation between two strains. This mechanism might therefore contribute to maintaining the noncompetitive diversity pattern observed in unsaturated soils.
Microbial population dynamics in redox-stratified biofilms during start-up of autotrophic nitrogen removal reactors

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering, Urban Water Engineering
Publication date: 2008

Host publication information
Title of host publication: 12th International Symposium on Microbial Ecology (ISME-12) - Microbial Diversity - Sustaining the Blue Planet, August 17-22, 2008, Cairns, Australia
Volume: Abstracts. CD-ROM
Publisher: International Society for Microbiology
Source: orbit
Source-ID: 236833
Research output: Research › Conference abstract in proceedings – Annual report year: 2008

Parameter estimation procedures for an individual-based model describing horizontal gene transfer in biofilms

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering, Environmental Chemistry
Number of pages: 45
Publication date: 2008

Host publication information
Title of host publication: Biofilms III, 3rd International Conference, München 6-8 October 2008
Volume: Abstracts
Place of publication: München
Publisher: Gesellschaft zur Förderung des Lehrstuhls für Wassergüte- und Abfallwirtschaft der Technischen Universität München
Source: orbit
Source-ID: 236834
Research output: Research › Conference abstract in proceedings – Annual report year: 2008

Redox stratification controlled biofilm reactors for completely autotrophic nitrogen removal

General information
State: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering, Urban Water Engineering
Contributors: Smets, B. F., Terada, A., Lackner, S.
Publication date: 2008

Host publication information
Title of host publication: IWA North American membrane research conference, Amherst, Massachusetts, August 10-13, 2008
Volume: Proceedings on CD
Publisher: International Water Association
Source: orbit
Redox Stratified Controlled Biofilm Reactor for Completely Autotrophic Nitrogen Removal

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering, Residual Resource Engineering
Contributors: Pellicer i Nàcher, C., Lackner, S., Terada, A., Lardon, L., Smets, B. F.
Publication date: 2008
Peer-reviewed: Yes
Event: Poster session presented at IWA Leading-Edge conference on Water and Wastewater Technologies, Zürich, .
Electronic versions:
Poster.LET_final.pdf
Source: orbit
Source-ID: 262397
Research output: Research - peer-review › Poster – Annual report year: 2008

Start-up strategies for stable autotrophic nitrogen removal in redox-stratification controlled biofilm reactor (ReSCoBiR)

General information
State: Published
Organisations: Department of Environmental Engineering, Urban Water Engineering, Residual Resource Engineering
Pages: 491-492
Publication date: 2008

Host publication information
Title of host publication: IWA Biofilm Technologies Conference, 8 - 10 January 2008, Singapore : Abstract Handbook
Volume: CD-ROM
Publisher: IWA Publishing
Source: orbit
Source-ID: 220343
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2008

The porous surface model, a novel experimental system for online quantitative observation of microbial processes under unsaturated conditions

Water is arguably the most important constituent of microbial microhabitats due to its control of physical and physiological processes critical to microbial activity. In natural environments, bacteria often live on unsaturated surfaces, in thin (micrometric) liquid films. Nevertheless, no experimental systems are available that allow real-time observation of bacterial processes in liquid films of controlled thickness. We propose a novel, inexpensive, easily operated experimental platform, termed the porous surface model (PSM) that enables quantitative real-time microscopic observations of bacterial growth and activity under controlled unsaturated conditions. Bacteria are inoculated on a porous ceramic plate, wetted by a liquid medium. The thickness of the liquid film at the surface of the plate is set by imposing suction, corresponding to soil matric potential, to the liquid medium. The utility of the PSM was demonstrated using Pseudomonas putida KT2440 tagged with gfp as a model bacterium. Single cells were inoculated at the surface of the PSM, and the rate at which colonies expanded laterally was measured for three matric potentials (−0.5, −1.2, and −3.6 kPa). The matric potential exerted significant influence on colony expansion rates, with a faster rate of spreading at −0.5 than at −1.2 or −3.6 kPa (diameter increase rate, ca. 1,000, 200, and 17 µm h−1, respectively). These differences can be attributed to cell motility, strongly limited under the most negative matric potential. The PSM constitutes a tool uniquely adapted to study the influence of liquid film geometry on microbial processes. It should therefore contribute to uncovering mechanisms of microbial adaptation to unsaturated environments.

General information
State: Published
Organisations: Environmental Chemistry, Department of Environmental Engineering
Contributors: Dechesne, A., Or, D., Gulez, G., Smets, B. F.
Pages: 5195-5200
Publication date: 2008
Peer-reviewed: Yes

Publication information
Journal: Applied and Environmental Microbiology
Volume: 74
Issue number: 16
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
The potential for bioremediation after in situ chemical oxidation for the remediation of contaminated soil and groundwater

**General information**

State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Contributors: Tsitonaki, A., Smets, B. F., Bjerg, P. L.
Publication date: 2008

**Host publication information**

Title of host publication: 4th European BioRemediation Conference, 3-6 September 2008, Chania, Crete, Greece : E-proceedings
Volume: CD-ROM
Publisher: Department of Environmental Engineering, Technical University of Crete
Source: orbit
Source-ID: 223816
Research output: Research - Conference abstract in proceedings – Annual report year: 2008

Horizontal gene transfer in pseudomonas putida biofilms

**General information**

State: Published
Organisations: Department of Environmental Engineering
Contributors: Bazire, A., Lauritzen, B., Lardon, L., Smets, B. F.
Publication date: 2007
Peer-reviewed: No
Event: Poster session presented at 4th ASM Conferences Biofilms 2007, Quebec City, Canada.
Source: orbit
Source-ID: 209934
Research output: Research - Poster – Annual report year: 2007

Idynomics: A software platform for modeling microbial communities

**General information**

State: Published
Organisations: Department of Environmental Engineering
Contributors: Lardon, L., Doetsch, A., Xaier, J., Kreft, J., Picloreanu, C., Smets, B. F.
Publication date: 2007
Peer-reviewed: No
Event: Poster session presented at 4th ASM Conferences Biofilms 2007, Quebec City, Canada.
Source: orbit
Source-ID: 209935
Research output: Research - Poster – Annual report year: 2007
Proteinaceous surface appendage contribution to Pseudomonas aeruginosa PAO1 surface properties and adhesive ability: Abstract 00193

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Morrow, J., Smets, B. F., Grasso, D.
Publication date: 2007
Peer-reviewed: No

Publication information
Journal: Geophysical Research Abstracts
Volume: 9
Ratings:
Web of Science (2014): Indexed yes
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
ISI indexed (2011): ISI indexed no
Web of Science (2011): Indexed yes
BFI (2009): BFI-level 1
Original language: English
Source: orbit
Source-ID: 198820
Research output: Research - peer-review › Journal article – Annual report year: 2007

Redox-stratification controlled biofilm (ReSCoBi) for completely autotrophic nitrogen removal: The effect of co-versus-diffusion on reactor performance

General information
State: Published
Organisations: Urban Water Engineering, Department of Environmental Engineering
Contributors: Terada, A., Lackner, S., Tsuneda, S., Smets, B. F.
Pages: 40-51
Publication date: 2007
Peer-reviewed: Yes

Publication information
Journal: Biotechnology and Bioengineering
Volume: 97
**Issue number:** 1  
**ISSN (Print):** 0006-3592  
**Ratings:**

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| Scopus rating (2004): SJR 1.105 SNIP 1.245 |
TNT biotransformation: When chemistry confronts mineralization

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Smets, B. F., Yin, H., Esteve-Nunez, A.
Pages: 267-277
Publication date: 2007
Peer-reviewed: Yes

Publication information
Journal: Applied Microbiology and Biotechnology
Volume: 76
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
Cultivation-dependent and independent examination of conjugative plasmid transfer kinetics

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Musovic, S., Smets, B. F.
Publication date: 2006
Peer-reviewed: Yes
Event: Abstract from 11th International Symposium on Microbial Ecology, Vienna, Austria.
Source: orbit
Source-ID: 191261
Research output: Research - peer-review » Conference abstract for conference – Annual report year: 2006
Flow cytometric determination of biomass fractions in activated sludge: nitrification case study

General information
State: Published
Organisations: Center for Biomedical Microbiology, Department of Systems Biology, Department of Environmental Engineering
Contributors: Jubany, I., Baeza, J. A., Carrera, J., Casas, C., Sternberg, C., Smets, B. F.
Number of pages: 32
Publication date: 2006

Host publication information
Place of publication: Leipzig
Publisher: F&U confirm
Source: orbit
Source-ID: 190445
Research output: Research - peer-review › Conference abstract in proceedings – Annual report year: 2006

Intestinal versus external growth conditions change the surficial properties in a collection of environmental Escherichia coli isolates

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Yang, H., Morrow, J., Grasso, D., Vinopal, R., Smets, B. F.
Pages: 6976-6982
Publication date: 2006
Peer-reviewed: Yes

Publication information
Journal: Environmental Science & Technology (Washington)
Volume: 40
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
Mathematical modeling of start-up scenarios for nitrogen removal via a nitritation: anaerobic ammonium oxidation-coupled biofilm in a hollow fiber membrane bioreactor

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Capuno, J., Love, N., Smets, B. F.
Publication date: 2006
Peer-reviewed: Yes
Source: orbit
Source-ID: 195515
Research output: Research - peer-review › Poster – Annual report year: 2006
Observation and mathematical description of the acceleration phenomenon in batch respirograms associated with ammonium oxidation

Two-step nitrification models are generally calibrated using short-term respirometric batch experiments. Important discrepancies appear between model predictions and experimental observations just after the pulse addition since a fast transient in the OUR profile is experimentally observed. Acceleration of the OUR appears ongoing between the substrate addition and attainment of the maximum OUR value. Among the several phenomena that could contribute to this observation, the most probable cause is the limitation of reducing equivalents required for maximal ammonia monooxygenase activity at the time of substrate addition. Ignoring acceleration would result in large parameter estimation errors from respirometric batch experiments. This work proposes a simple methodology to successfully describe (not to explain) the acceleration phenomenon estimating only two parameters. This methodology consists of introducing a Gaussian-like expression in the model.

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Guisasola, A., Chandran, K., Smets, B. F., Baeza, J., Carrera, J., Lafuente, J.
Pages: 181-188
Publication date: 2006
Peer-reviewed: Yes

Publication Information
Journal: Water Science and Technology
Volume: 54
Issue number: 8
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
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  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
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  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
Oxidation of aminonitrotoluenes by 2,4-DNT dioxygenase of Burkholderia sp. strain DNT

General information
State: Published
Organisations: Residual Resource Engineering, Department of Environmental Engineering
Pages: 231-237
Publication date: 2006
Peer-reviewed: Yes

Publication information
Journal: Biotechnology and Bioengineering
Volume: 93
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
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Redox-stratification controlled biofilm for completely autotrophic nitrogen removal: Modeling the effect of substrate co- versus counter-diffusion on performance

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Terada, A., Lackner, S., Tsuneda, S., Smets, B. F.
Pages: 407-416
Publication date: 2006

Host publication information
Title of host publication: Proceedings of International Conference Biofilm Systems VI, September 24-27, 2006, Amsterdam, The Netherlands
Publisher: IWA
Source: orbit
Source-ID: 194981
Research output: Research - peer-review › Article in proceedings – Annual report year: 2006

Sampling Methods to Determine the Spatial Gradients and Flux of Arsenic at a Groundwater Seepage Zone
Abstract—Sampling techniques with centimeter-scale spatial resolution were applied to investigate biogeochemical processes controlling groundwater arsenic fate across the groundwater–surface water interface at a site characterized by fine sediments (40% sand, 46% silt, 14% clay). Freeze-core sediment collection gave more detailed and depth-accurate arsenic and iron contaminant and microbial distributions than could be obtained with the use of a hand auger. Selective chemical extractions indicated that greater than 90% of the arsenic was strongly sorbed to very amorphous iron oxyhydroxides. These solids accounted for more than 80% of the total iron in the sediments. Microbial enrichments indicated that iron-oxidizing bacteria (IOB) were up to 1% of the total bacterial abundance, whereas iron-reducing bacteria (IRB) were about two orders of magnitude less abundant than IOB. The abundance of IRB mirrored the IOB depth profile. Push-point pore-water sampling captured large amounts of sediment fines, even with controlled (20 ml/min) water withdrawal, thereby necessitating filtration before water quality analysis. Bead columns containing glass media enabled short-term (29 d) characterization of pore water–to–sediment transfer of arsenic and iron. Bead columns indicated quantitative capture of groundwater arsenic and iron during 2003, suggesting that freeze-core inventories corresponded to 2 to 20 years of accumulation, depending on location.
Keyword: Sediment pore water, Arsenic, Hyporheos, Landfill, Groundwater

General information
State: Published
Organisations: University of Connecticut
Contributors: Gan, P., Yu, R., Smets, B. F., MacKay, A. A.
Pages: 1487-1495
Publication date: 2006
Peer-reviewed: Yes

Publication information
Journal: Environmental Toxicology and Chemistry
Volume: 25
Issue number: 6
ISSN (Print): 0730-7268
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 2.87 SJR 1.178 SNIP 1.018
Web of Science (2017): Impact factor 3.179
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.74 SJR 1.231 SNIP 1.021
Web of Science (2016): Impact factor 2.951
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 3 SJR 1.433 SNIP 1.056
Web of Science (2015): Impact factor 2.763
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 2.69 SJR 1.501 SNIP 1.12
Web of Science (2014): Impact factor 3.225
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 2.88 SJR 1.656 SNIP 1.086
Web of Science (2013): Impact factor 2.826
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 2.81 SJR 1.639 SNIP 1.108
Web of Science (2012): Impact factor 2.618
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 3.05 SJR 1.947 SNIP 1.168
Web of Science (2011): Impact factor 2.809
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.715 SNIP 0.992
Web of Science (2010): Impact factor 3.026
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BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.616 SNIP 1.053
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 2
Scopus rating (2008): SJR 1.487 SNIP 1.036
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.694 SNIP 1.127
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.609 SNIP 1.142
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Scopus rating (2005): SJR 1.534 SNIP 1.184
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 2.107 SNIP 1.397
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.747 SNIP 1.323
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.815 SNIP 1.385
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.75 SNIP 1.365
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 2.124 SNIP 1.526
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 2.292 SNIP 1.571
Slow substrate diffusion attenuates bacterial competition and allows bacterial coexistence

Antecedent growth conditions cause large changes in adhesion and transport in periodically wetted porous media within a collection of environmental Escherichia coli isolates

Attenuation of As transport by iron oxides at the groundwater surface water interface and possible microbial contribution
Biomass characteristics in three sequencing batch reactors treating a wastewater containing synthetic organic chemicals

The physical and biochemical characteristics of the biomass in three lab-scale sequencing batch reactors (SBR) treating a synthetic wastewater at a 20-day target solids retention time (SRT) were investigated. The synthetic wastewater feed contained biogenic compounds and 22 organic priming compounds, chosen to represent a wide variety of chemical structures with different N, P and S functional groups. At a two-day hydraulic retention time (HRT), the oxidation-reduction potential (ORP) cycled between -100 (anoxic) and 100mV (aerobic) in the anoxic/aerobic SBR, while it remained in a range of 126 +/- 18 and 249 +/- 18 mV in the aerobic sequencing batch biofilm reactor (SBBR) and the aerobic SBR reactor, respectively. A granular activated sludge with excellent settleability (SVI = 98 +/- 31 L mg(-1)) developed only in the anoxic/aerobic SBR, compared to a bulky sludge with poor settling characteristics in the aerobic SBR and SBBR. While all reactors had very good COD removal (> 90%) and displayed nitrification, substantial nitrogen removal (74%) was only achieved in the anoxic/aerobic SBR. During the entire operational period, benzoate, theophylline and 4-chlorophenol were completely removed in all reactors. In contrast, effluent 3-nitrobenzoate was recorded when its influent concentration was increased to 5 mg L-1 and dropped only to below 1 mg L-1 after 300 days of operation. The measured competent biomass fractions for 3-nitrobenzoate degradation were significantly lower than the influent COD fractions of these compounds. Correspondent to the highest competent biomass fraction for benzoate degradation among the test SOCs, benzoate oxidation could be quantified with an extant respirometric technique, with the highest specific oxygen uptake rate (SOURbenzoate, 0.026g O(2)h(-1) g(-1) XCOD) in the anoxic/aerobic SBR. These combined results suggest that operating SBRs with alternative anoxic/aerobic cycles might facilitate the formation of granular sludge with good settleability, and retain comparable removal of nitrogen and synthetic organic compounds. Hence, the practice of anoxic/aerobic cycling should be considered in wastewater treatment systems whenever possible.

General information
State: Published
Organisations: Department of Environmental Engineering
Pages: 710-720
Publication date: 2005
Peer-reviewed: Yes

Publication information
Journal: Water Research
Volume: 39
Issue number: 4
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
Conjugal TOL transfer from *Pseudomonas putida* to *Pseudomonas aeruginosa*: Effects of restriction proficiency, toxicant exposure, cell density ratios, and conjugation detection method on observed transfer efficiencies

**General information**
State: Published
Organisations: Department of Environmental Engineering
Contributors: Pinedo, C., Smets, B. F.
Pages: 51-57
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
Effect of long-term exposure, biogenic substrate presence, and electron acceptor conditions on the biodegradation of multiple substituted benzoates and phenolates

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Hu, Z., Ferraina, R., Ericson, J., Smets, B. F.
Pages: 3501-3510
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
Horizontal gene flow in microbial communities: The dynamic microbial gene pool compensates for microbial species clonality, presenting us with both threats and promises

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Barkay, T., Smets, B. F.
Pages: 412-419
Publication date: 2005
Peer-reviewed: Yes

Publication information
Journal: ASM news (Washington)
Volume: 71
Issue number: 9
ISSN (Print): 0044-7897
Ratings:
BFI (2008): BFI-level 1
Web of Science (2005): Indexed yes
Web of Science (2004): Indexed yes
Web of Science (2003): Indexed yes
Original language: English
Source: orbit
Source-ID: 182065
Research output: Research - peer-review › Journal article – Annual report year: 2005

Horizontal gene transfer: Perspectives at a crossroads of scientific disciplines

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Smets, B. F., Barkay, T.
Pages: 675-678
Publication date: 2005
Peer-reviewed: Yes

Publication information
Journal: Nature Reviews. Microbiology
Volume: 3
ISSN (Print): 1740-1526
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 13.39 SJR 17.634 SNIP 7.075
Web of Science (2017): Impact factor 31.851
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 11.56 SJR 15.351 SNIP 6.289
Web of Science (2016): Impact factor 26.819
BFI (2015): BFI-level 2
Macro- and nanoscale observations of adhesive behavior for several E. coli strains (O157:H7 and environmental isolates) on mineral surfaces

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Morrow, J., Stratton, R., Yang, H., Smets, B. F., Grasso, D.
Pages: 6395-6404
Publication date: 2005
Peer-reviewed: Yes

Publication information
Journal: Environmental Science and Technology
Volume: 39
ISSN (Print): 1382-3124
Ratings:
Web of Science (2018): Indexed yes
Web of Science (2017): Indexed yes
ISI indexed (2013): ISI indexed no
ISI indexed (2012): ISI indexed no
Optimizing experimental design to estimate ammonia and nitrite oxidation biokinetic parameters from batch respirograms

General information
State: Published
Organisations: Department of Environmental Engineering
Contributors: Chandran, K., Smets, B. F.
Pages: 4969-4978
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
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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
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BFI (2011): BFI-level 2
Protein engineering of the archetypal nitroarene dioxygenase of Ralstonia sp strain U2 for activity on aminonitrotoluenes and dinitrotoluenes through alpha-subunit residues leucine 225, phenylalanine 350, and glycine 407

Naphthalene dioxygenase (NDO) from Ralstonia sp. strain U2 has not been reported to oxidize nitroaromatic compounds. Here, saturation mutagenesis of NDO at position F350 of the alpha-subunit (NagAc) created variant F350T that produced 3-methyl-4-nitrocatechol from 2,6-dinitrotoluene (26DNT), that released nitrite from 23DNT sixfold faster than wild-type NDO, and that produced 3-amino-4-methyl-5-nitrocatechol and 2-amino4,6-dinitrobenzyl alcohol from 2-amino-4,6-dinitrotoluene (2A46DNT) (wild-type NDO has no detectable activity on 26DNT and 2A46DNT). DNA shuffling identified the beneficial NagAc mutation G407S, which when combined with the F350T substitution, increased the rate of NDO oxidation of 26DNT, 23DNT, and 2A46DNT threefold relative to variant F350T. DNA shuffling of NDO nagAcAd also generated the NagAc variant G50S/L225R/A269T with an increased rate of 4-amino-2-nitrotoluene (4A2NT; reduction product of 2,4-dinitrotoluene) oxidation; from 4A2NT, this variant produced both the previously uncharacterized oxidation product 4-amino-2-nitrocresol (enhanced 11-fold relative to wild-type NDO) as well as 4-amino-2-nitrobenzyl alcohol (4A2NBA; wild-type NDO does not generate this product). G50S/L225R/A269T also had increased nitrite release from 23DNT (14-fold relative to wild-type NDO) and generated 2,3-dinitrobenzyl alcohol (23DNBA) fourfold relative to wild-type NDO. The importance of position L225 for catalysis was confirmed through saturation mutagenesis; relative to wild-type NDO, NDO variant L225R had 12-fold faster generation of 4-amino-2-nitrocresol and production of 4A2NBA from 4A2NT as well as 24-fold faster generation of nitrite and 15-fold faster generation of 23DNBA from 23DNT. Hence, random mutagenesis discovered two new residues, G407 and L225, that influence the regiospecificity of Rieske non-heme-iron dioxygenases.
Reductive transformation of TNT by Escherichia coli: pathway description

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Organisations: Department of Environmental Engineering
Contributors: Yin, H., Wood, T., Smets, B. F.
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Reductive transformation of TNT by Escherichia coli resting cells: kinetic analysis

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Saturation mutagenesis of 2,4-DNT dioxygenase of Burkholderia sp. strain DNT for enhanced dinotrotoluene degradation

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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
Substrate diffusion heterogeneity controls bacterial competition and coexistence

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Contributors: Dechesne, A., Or, D., Smets, B. F.
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Scopus rating (2010): SJR 1.389 SNIP 1.233
Web of Science (2010): Impact factor 3.28
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.363 SNIP 1.068
Web of Science (2009): Indexed yes
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
Scopus rating (2005): SJR 1.131 SNIP 1.2
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 1.181 SNIP 1.168
Web of Science (2004): Indexed yes
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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