Carlos Octavio Letelier-Gordo - DTU Orbit (16/07/2018)

Carlos Octavio Letelier-Gordo

Organisations

Postdoc, National Institute of Aquatic Resources
19/09/2011 → present
colg@aqua.dtu.dk
VIP

Section for Aquaculture
13/03/2013 → present
VIP

Publications:

Denitrification in saltwater recirculating aquaculture systems (RAS) using an up-flow sludge bed reactor (USB)

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Monitoring and Data, Section for Aquaculture
Authors: Herreros, M. M. (Intern), Letelier-Gordo, C. O. (Intern)
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Pages: 39
Publication date: 2017

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Title of host publication: 4th NordicRAS Workshop on Recirculating Aquaculture Systems. Aalborg, Denmark, 12-13 October 2017: Book of Abstracts
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"End-of-Pipe treatment" y "residual resource"

General information
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Authors: Letelier-Gordo, C. O. (Intern)
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Volume: 47
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Performance of a marine activated sludge system for N removal using external and internal carbon sources

General information
The composition of readily available carbon sources produced by fermentation of fish faeces is affected by dietary protein:energy ratios

Fish solid waste (faeces) produced in recirculated aquaculture systems (RAS) might be used for on-farm, single-sludge denitrification if transformed into soluble organic carbon substances. The current study investigated the effect of feeding diets with increasing protein to energy ratios (P:E_15, 17, 19, 21 and 23 g/MJ) to rainbow trout (Oncorhynchus mykiss) on the production of volatile fatty acids (VFAs) and ethanol during 7 days fermentation of the produced fish faeces. The total yields of VFAs and ethanol obtained (expressed as chemical oxygen demand (COD)) ranged between 0.21±0.04 and 0.24±0.04 gCOD/gTCOD, showing no differences between treatments. However, the type and quantities of individual VFAs and ethanol changed according to the dietary treatment. Lower P:E ratio diets resulted in higher production of butyric acid and ethanol, whereas higher P:E ratio diets resulted in an increased production of acetic and valeric acid. Changing the diet composition thus affects the composition of readily available carbon that can be derived from the faeces. This can be applied to enhance on-farm single sludge denitrification and reduce the need for adding external carbon sources such as e.g. methanol.
Transforming waste into new resources: optimizing sludge hydrolysis to improve nitrogen removal in aquaculture through denitrification

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Aquaculture
Authors: Letelier-Gordo, C. O. (Intern), Pedersen, P. B. (Intern), Dalsgaard, A. J. T. (Intern)
Number of pages: 119
Publication date: 2017

Publication information
Publisher: Technical University of Denmark. National Institute of Aquatic Resources
Original language: English
Main Research Area: Technical/natural sciences
Anaerobic digestion of solid waste in RAS: Effect of reactor type on the biochemical acidogenic potential (BAP) and assessment of the biochemical methane potential (BMP) by a batch assay

Anaerobic digestion is a way to utilize the potential energy contained in solid waste produced in recirculating aquaculture systems (RASs), either by providing acidogenic products for driving heterotrophic denitrification on site or by directly producing combustive methane. In this study the biochemical acidogenic potential of solid waste from juvenile rainbow trout was evaluated by measuring the yield of volatile fatty acids (VFA) during anaerobic digestion by batch or fed-batch reactor operation at hydrolysis time (HT) / hydraulic retention time (HRT) of 1, 5, or 10 days (and for batch additional 14 and 20 days) in continuously stirred tank reactors. Generally, the VFA yield increased with time and no effect of the reactor type used was found within the time frame of the experiment. At 10 days HT or 10 days HRT the VFA yield reached 222.3 ± 30.5 and 203.4 ± 11.2 mg VFA g-1 TVS0 (total volatile solids at day 0) in batch and fed-batch reactor, respectively. For the fed-batch reactor, increasing HRT from 5 to 10 days gained no significant additional VFA yield. Prolonging the batch reactor experiment to 20 days increased VFA production further (273.9 ± 1.6 mg VFA g-1 TVS0, n=2). After 10 days HT / HRT, 16.8 - 23.5 % of total Kjeldahl N was found as TAN and 44.3 - 53.0 % of total P was found as ortho-phosphate. A significant difference between reactor types was detected for the phosphorous dissolution at 5 days HT / HRT as a relatively steep increase (of a factor 2-3) in ortho-P content occurred in fed-batch reactors but similar steep increase was only notable after 10 days HT for batch reactors. No differences between reactor types at the other HT / HRT were recorded for P as well as (for all HT / HRT for) N. Based on this study a HRT of approximately 5 days would be recommended for the design of an acidogenic continuously stirred reactor tank in a RAS single-sludge denitrification set-up. The biochemical methane potential of the sludge was estimated to 318 ± 29 g CH4 g-1 TVS0 by a batch assay and represented a higher utility of the solid waste when comparing the methane yield with the VFA yield (in COD units). This points towards a technological challenge of ultimately increase the acidogenic output to match the methane yield as both products are formed from the same reference point.

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Aquaculture
Authors: Suhr, K. I. (Intern), Letelier-Gordo, C. O. (Intern), Lund, I. (Intern)
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Feed composition affects sludge as a resource for denitrification

General information
State: Published
Organisations: National Institute of Aquatic Resources, Section for Aquaculture
Authors: Letelier-Gordo, C. O. (Intern), Larsen, B. K. (Intern), Dalsgaard, A. J. T. (Intern), Pedersen, P. B. (Intern)
Pages: 21
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Reducing the dietary protein: Energy (P: E) ratio changes solubilization and fermentation of rainbow trout (Oncorhynchus mykiss) faeces

Nutrients discharged from aquaculture industries can detrimentally affect water recipients, and this problem must be addressed if the production is to be decoupled from the natural environment. Denitrification is a process by which nitrate is removed using soluble, readily biodegradable carbon compounds. Hydrolysis and concomitant fermentation of organic solids produces such soluble carbon compounds e.g. in the form of volatile fatty acids (VFAs). The current study examined the hydrolysis and the production of VFAs, the carbon:nitrogen ratio (C:N), and the release of nutrients (phosphorus and ammonium) from hydrolyzing and fermenting settable faecal solids (SFS) obtained from rainbow trout (Oncorhynchus mykiss). Triplicate tanks of fish were fed five isoenergetic experimental diets with different protein:energy (P:E) ratios: 15, 17, 19, 21, and 23. The SFS from four consecutive days were collected and pooled prior to incubation in 15 mL anoxic/anaerobic batch reactors maintained at 20±2°C and continuous magnetic stirring. Daily samples from the batch reactors were obtained for 7 successive days and analyzed for total ammonia nitrogen (TAN), phosphorus expressed as orthophosphate (PO43–P), VFA, and soluble COD (sCOD). The results showed that the two lowest P:E ratio diets (i.e. 15 and 17) produced SFS with a significantly higher degree of solubilization measured as sCOD:total chemical oxygen demand (TCOD), compared to the higher P:E ratio diet 21 (0.30-0.29 versus 0.24g sCOD/g TCOD). Inversely, SFS deriving from the lowest P:E ratio diet (i.e. 15) displayed the lowest degree of fermentation measured as VFAs/sCOD, compared to SFS deriving from the four higher P:E diets (0.36 versus 0.51-0.56g VFA/g sCOD). In the same way, the lowest P:E diet showed a significantly lower solubilization of nitrogen measured as TAN:total Kjeldahl Nitrogen (TKN) compared to the three highest P:E diets (i.e. 19-23; 0.14 versus 0.26-0.34g TAN/g TKN). The two lowest P:E diets (i.e. 15-17) showed on the contrary the highest solubilization of phosphorus expressed as PO43–P/total phosphorus (TP) (0.15 and 0.08g/g, respectively) probably due to the lower pH obtained. All SFS produced enough soluble carbon, measured as VFAs, to stoichiometrically denitrify the nitrogen (N) contained in the faeces and potentially additionally 86-100% of all N produced from the fish culture process.
Single-sludge denitrification in recirculating aquaculture systems: effects of pre-fermentation and pH

Single-sludge denitrification (DN) reactors in aquaculture use the carbonous solid fish waste produced in the system to reduce the discharged nitrate load. The solid waste is available for denitrifiers when present in soluble, readily biodegradable form, and the transformation is accomplished by bacterial hydrolysis and fermentation. The objective of this study was to quantify the effect of pre-fermentation of solid fish waste on single-sludge DN reactor efficiency. Pre-fermentation times tested were 0 d (no pre-fermentation), 1 d, 5 d, and 10 d, and the efficiency was quantified as the potential DN rate obtained in laboratory assays. Results showed that the highest DN rate was achieved with 1 d pre-fermentation. The volumetric DN rates measured in decreasing order were 23.4 +/- 0.00 mg NO3-N L-1 h(-1) (1 d), 20.5 +/- 0.35 mg NO3-N L-1 h(-1) (5 d), 17.0 +/- 0.47 mg NO3-N L-1 h(-1) (10 d), and 14.2 +/- 0.24 mg NO3-N L-1 h(-1) (0 d). It was suspected that the poor utilization of soluble COD (sCOD) in the 5 d and 10 d pre-fermentation treatments was due to the low starting pH (pH <7). Subsequently, the experiments were repeated in 0.1 M HEPES buffer (pH = 7.1) and showed a clear correlation between specific DN rate and sCOD content. Overall, the highest increase in potential specific DN rate was achieved by applying pre-fermentation; e.g., from 0 d to 1 d, the increase was 123% and 106% at unadjusted pH and pH 7.1, respectively. An additional 20% increase was achieved at pH 7.1 by prolonging the pre-fermentation time to 5 d.

General information

State: Published
Organisations: National Institute of Aquatic Resources, Section for Aquaculture, Department of Environmental Engineering
Authors: Suhr, K. I. (Intern), Letelier-Gordo, C. O. (Intern), Prat Busquets, P. (Intern)
Pages: 1825-1831
Publication date: 2015
Main Research Area: Technical/natural sciences

Publication information
Journal: American Society of Agricultural and Biological Engineers. Transactions
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Effective harvesting of the microalgae Chlorella protothecoides via bioflocculation with cationic starch.

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

General information
State: Published
Organisations: Department of Environmental Engineering, Residual Resource Engineering
Effects of dietary protein: energy ratios on hydrolysis and fermentation of faecal solids from rainbow trout (Oncorhynchus mykiss) for denitrification

Single-sludge denitrification in recirculating aquaculture systems: Effects of pre-fermentation and pH

High effective harvesting of microalgae Chlorella protothecoides via flocculation with cationic starch
Cost efficient solutions for reducing the waste discharged in land-based marine recirculating aquaculture systems (WASTE-TREAT) (39190)

Growth in aquaculture production demands a high degree of environmental engineering to minimize nutrient discharge thereby reducing the environmental impact. This industrial collaboration project aims at finding the cost-efficient treatment methods for reducing the waste discharged from large-scale land-based marine recirculating aquaculture systems. End-of-pipe solutions for minimizing the N, P, and organic matter waste discharge from seawater RAS are to be developed, demonstrated and evaluated.

The project is coordinated by AKVA Group Denmark A/S.

The project is funded by the Danish Ministry of Food, Agriculture and Fisheries through the Green Development and Demonstration Program (GUDP).

National Institute of Aquatic Resources
Section for Aquaculture

AKVA Group Denmark A/S

Danish Salmon A/S
Period: 15/08/2014 → 01/09/2017
Number of participants: 3
Research area: Aquaculture
Project participant:
Fernandes, Paulo (Intern)

Project Manager, academic:
Letelier-Gordo, Carlos Octavio (Intern)
Pedersen, Per Bovbjerg (Intern)

Environmentally effective nitrogen removal in fish farming using sludge hydrolysis (wiN-wiN) (39119)

Reducing nitrogen discharge is important to fish farms and their environmental performance. Removal of nitrogen can be done by applying denitrification filters end-of-pipe (i.e. before discharge) through an anaerobic de-nitrification process using organic carbon as energy source.

Using external carbon is costly and introduces additional organic matter into the system. In contrast, sludge produced by the farmed fish might provide the organic matter given that a hydrolysis process can be controlled and optimised according to the needs of the denitrification process.

The project strives to establish, optimize and demonstrate an integrated system in commercial scale able to hydrolyse generated sludge and subsequently use it as energy source for nitrogen removal in end-of-pipe denitrification filters.

This project is coordinated by HME, Denmark.

The project is funded by the Danish Ministry of Food, Agriculture and Fisheries through the Green Development and Demonstration Program (GUDP) and the partners involved.

National Institute of Aquatic Resources
Section for Aquaculture
Optimized sludge hydrolysis and improved nitrogen removal through denitrification

National Institute of Aquatic Resources
Period: 15/04/2013 → 15/03/2017
Number of participants: 7
Phd Student:
Letelier-Gordo, Carlos Octavio (Intern)
Supervisor:
Dalsgaard, Anne Johanne Tang (Intern)
Main Supervisor:
Pedersen, Per Bovbjerg (Intern)
Examiner:
Lund, Ivar (Intern)
Lund, Ivar (Intern)
von Rijn, Jaap (Ekstern)
von Rijn, Jaap (Ekstern)

Financing sources
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Name of research programme: 1/3 DTU-stip, 2/3 FUR/andet
Project: PhD

Development of sustainable technologies and modeling tools in aquaculture aiming at increasing overall production (UDTÆNK) (39030)
The project aimed at developing methods and modeling tools that may assist the aquaculture industry in expanding its production while minimizing the environmental impact.

To obtain this, the project included six work packages concerning:
- Increased production of rainbow trout by providing methods for reducing the discharge of nitrogen and organic matter.
- Increased production in net cages by providing academic guidance to social workers on concurrent production of trout and mussels.
- Improved sustainability of the industry by providing guidance on optimal system design with respect to reducing nutrient discharge.

The project was funded by the Danish Ministry of Food, Agriculture and Fisheries and the European Fisheries Fund (EFF).

National Institute of Aquatic Resources
Section for Aquaculture
Dansk Akvakultur
Period: 09/07/2012 → 31/05/2015
Number of participants: 6
Research area: Aquaculture
Project participant:
Pedersen, Per Bovbjerg (Intern)
Larsen, Bodil Katrine (Intern)
Marine model trout farms (38816)

Based on the success with the development and implementation of Danish model trout farms in freshwater, a somewhat similar concept was developed for sea water farming of large trout and potentially also salmon in land-based, recirculating systems. Design and technology for the recirculation unit as well as for end-of-pipe treatment were developed and tested in 3 consecutive seasons.

During the project, design and operation were optimized and documented. End-of-pipe treatment, especially related to nitrogen removal and sludge hydrolysis were also investigated.

Based on the concept and the results achieved in the major unit in commercial scale at DTU Aqua premises in Hirtshals, it can be concluded that there is potential for such open land-based sea water farming units and that they can be operated commercially sustainable. Major issues related to reducing/preventing (toxic) algal blooms and supersaturation in seawater needs to be addressed before commercial operations should be initiated, though.

The project was coordinated by North Sea Science Park, Denmark.

The project was funded by the Danish Ministry of Food, Agriculture and Fisheries through the Green Development and Demonstration Program (GUDP) and the partners involved.