CLEANAQ

Newsletter

Issue 3, December 2019

1. About the BONUS CLEANAQ project

The BONUS CLEANAQ project investigates novel water treatment technologies to further reduce the environmental impact from fish farming in recirculating aquaculture systems (RAS) in the Baltic area.

The project aims at making advances within cost-efficient nitrogen removal techniques such as single-sludge denitrification, woodchip denitrification as well as in non-microbial nutrient removal methods (N & P). Focus is on treatment of fish farm effluents at the different salinities prevailing in the Baltic Sea area.

2. Work performed during the last half year of the project

RAS typically produce two different waste streams; the collected sludge from the mechanical filters, which is rich in organic matter and phosphorus and the clear overflow water from the production unit, which is rich in nitrogen, mainly as nitrate. Investigations by the University of Jyväskylä and the Natural Resources Institute Finland (LUKE), Jyväskylä, aimed at combing N & P removal, using starch-based organic flocculants for efficient P removal from sludge followed by N removal in woodchip bioreactors. It was hypothesized that the extra organic carbon from the flocculant would aid the denitrification process in the woodchip reactor, thereby avoiding the use of synthetic flocculants and external carbon sources for the denitrification process. Treatment efficiencies were studied at two salinities relevant for the northern Baltic Sea environment of the Finnish coastal aquaculture.

Two trials were conducted on the waste streams from a freshwater and a brackish (7ppt) water laboratory RAS at Laukaa Fish Farm, Finland. In the first series of trials, potato starch-based flocculants were screened by jar tests and in the second trial, the most promising flocculant treatment was combined with a woodchip reactor for combined P and N removal.

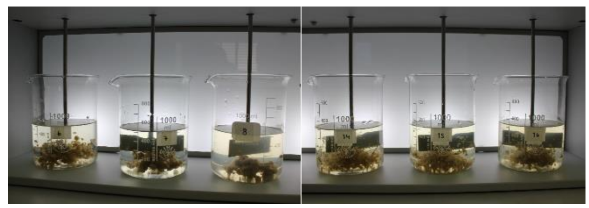

FIGURE 1. SCREENING OF FLOCCULENT CHEMICALS WITH JAR TESTS. COURTESY: JOUNI VIELMA

During the screening, phosphate removal efficiency with polyaluminum chloride (PAC) and most flocculants was 70-80 %, solids sedimented well in 20 min and supernatant turbidity was low at appr. 2-5 FTU in the most efficient treatments. Combination of two organic flocculants (PrimeBOND A0415 and PrimePHASE 3545) provided the best flocs and reasonably good phosphate removal of 73-84% and 75-84% in fresh- and brackish water, respectively.

The flocculant addition increased the carbon load to the woodchip reactors from 32.5 to 90.4 and from 43.1 to 143.1 mg/l sCOD in the freshwater and brackish water systems, respectively, which resulted in increases in nitrate removal rates in the woodchip reactors from 5.1 to 6.5 and from 6.6 to 16.5 $gN/m^3/d$, respectively. However, the use of flocculants also increased the levels of total ammonia nitrogen in the woodchip bioreactors likely as result of dissimilatory nitrate reduction to ammonia (DNRA) due to the increased carbon load. It was concluded that removal of phosphorus through flocculation followed by denitrification in woodchip bioreactors is a simple strategy for removing both N&P. Further optimization of the process parameters is needed, though.

Another study in the BONUS CLEANAQ project was finished which aimed to evaluate the single-sludge process at a marine land-based RAS with a production capacity of 2500 tons of yellow tail amberjack (*Seriola lalandi*).

FIGURE 2. PILOT-SCALE ACTIVATED SLUDGE SET-UP AT A COMMERCIAL MARINE RAS. COURTESY: CARLOS OCTAVIO LETELIER

The single-sludge denitrification reactor received 455±48 m^3/d of backwash water with varying salinity, and was operated at a volume of 50 m^3, resulting in a hydraulic retention time (HRT) of 2.6 h. Under this condition, the reactor was able to remove 8% of the incoming nitrate, corresponding to 3.5 kg NO_3--N per day or 69.4 g NO_3--N/m^3 of reactor per day. Standardizing the mesh size of the drum filters and avoiding the use of freshwater for the backwash resulted in a more stable flow of 460±5.0 m^3/d. This resulted in an increased nitrate removal of 27%, corresponding to 11.4 kg NO_3--N per day or 227.6 g NO_3--N/m^3 of reactor per day. Increasing the HRT from 2.6 h up to 4.9 h resulted in an increased nitrate removal of 46%, corresponding to 19 kg NO_3--N per day or 190.3 g NO_3--N/m^3 per m^3 reactor per day. The amount of N removed corresponds to 52% of the N required to be reduced for complying with the local environmental regulation. Based on the results obtained in this study, design and operational guidelines were suggested.

Furthermore, investigations were finalized regarding phosphorous removal from the production water (excluding the solid waste stream) with three reactive filter media calcium-silicate-hydrate (Sorbulite), calcium-silicate (Polonite), Polonite in combination with Vermiculite or Sorbulite with Vermiculite. Out of the tested reactive filter media Polonite showed the best P removal performance being able to remove PO_4-P from 1.g mg/l down to below 0.01 mg/l within 24h in batch tests with 1 and 2g of o Polonite in 50ml of RAS effluent. The performance of Polonite was followed by Sorbulite and Vermiculite, which showed a lower removal efficiency for phosphorous. It was, furthermore, suggested that once the Polonite is saturated with phosphorous, it could be directly applied as a valuable fertilizer on land, where it slowly releases phosphorous to the fields.

Work within the BONUS CLEANAQ project also focused on electrochemical oxidant formation in freshwater and brackish water and the potential antimicrobial effect on microbial activity in RAS water using an electrolysis unit (Doctor Chihiro® algae sterilizer) or a minute electrochemical unit (Micro flow cell, ElectroCell®).

Results of these benchtop investigations support previous studies, showing that current density, exposure time and salinity affects formation of TRO. As the formation of reactive oxidative species is much more pronounced in brackish water than in freshwater, certain disinfection applications are identified.

The antimicrobial effect was documented by new assays to evaluate microbial activity and inhibition hereof. However, currently the toxicity of the oxidants formed is unknown, and therefore safe application could include terminal disinfection of RAS (without holding fish) or electrochemical treatment of discharge. In conclusion, the benchtop studies showed promising results and future studies are required to evaluate cost and treatment efficiency in larger scale.

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Dissemination

Results from the BONUS CLEANAQ project were presented to 300 scientist and experts form the aquaculture industry working within recirculation technology at the renowned Nordic RAS conference, which was held from the 7th to 8th October in Berlin.

Carlos Octavio Letelier, DTU Aqua, presented about the potential for toxic H_2S formation in marine RAS and its relation to the presence of organic matter. Mathis von Ahnen, DTU Aqua, presented new insights on RAS effluent treatment using woodchip bioreactors. Sanni Aalto, JYU Finland, shined light on the diversity of microbial processes in full-scale woodchip bioreactors operated at commercial RAS.

Furthermore, results from the BONUS CLEANAQ project were disseminated at the Aquaculture Europe 2019 Conference, which was held from the 8th until the 10th of October in Berlin. Three presentations, originating from the BONUS CLEANAQ project, were given within the Baltic Aquaculture Session of the AE2019 Conference:

Xiaoyu Huang, DTU, presented results from a laboratory experiment, supervised by Carlos Octavio Letelier within the BONUS CLEANAQ project, where step fed batch reactors (SFBR) were operated with external and internal carbon sources to remove nitrogen from RAS water. Acetate showed the highest nitrate removal rates (57.64±6.55mg N/h/g bacteria) in SFBR followed by propionate and ethanol.

Gunno Renman, KTH Sweden, investigated reactive filter media in the BONUS CLEANAQ project and demonstrated their effectiveness at removing P from RAS effluents.

Sanni Aalto, JYU Finland, investigated the microbiology of denitrifying woodchip bioreactors in freshwater and seawater, with or without additions of bicarbonate. She concluded that efficient nitrate removal in woodchip bioreactors treating saltwater requires favorable conditions for autotrophic denitrifiers, e.g. through inorganic electron donors or using H_2S produced in the sulfate-rich saltwater RAS.

In addition, a popular publication on electrochemical water treatment of RAS water was prepared for the Global Aquaculture Alliance Magazine.

Main results achieved during the reporting period:

- Screening of starch-based flocculants for P removal combined with subsequent N removal in woodchip bioreactors.
- Evaluation of a single-sludge denitrification system at a marine RAS including design and operation guidelines for end-users.
- Effective P removal from RAS water was documented using several novel reactive filter media types.
- Evaluation of electrochemical disinfection and removal of organic matter in fresh- and brackish RAS wate.

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