Ozonation control and effects of ozone on water quality in recirculating aquaculture systems

To address the undesired effect of chemotherapeutants in aquaculture, ozone has been suggested as an alternative to improve water quality. To ensure safe and robust treatment, it is vital to define the ozone demand and ozone kinetics of the specific water matrix to avoid ozone overdose. Different ozone dosages were applied to water in freshwater recirculating aquaculture systems (RAS). Experiments were performed to investigate ozone kinetics and demand, and to evaluate the effects on the water quality, particularly in relation to fluorescent organic matter. This study aimed at predicting a suitable ozone dosage for water treatment based on daily ozone demand via laboratory studies. These ozone dosages will be eventually applied and maintained at these levels in pilot-scale RAS to verify predictions. Selected water quality parameters were measured, including natural fluorescence and organic compound concentration changes during ozonation. Ozone reactions were described by first order kinetics. Organic matter, assessed as chemical oxygen demand and fluorescence, decreased by 25% (low O3), 30% (middle O3) and 53% (high O3), while water transmittance improved by 15% over an 8-day period. No fish mortality was observed. Overall, this study confirms that ozone can improve RAS water quality, provides a better understanding of the ozone decay mechanisms that can be used to define further safe ozone treatment margins, and that fluorescence could be used as a monitoring tool to control ozone. This study might be used as a tool to design ozone systems for full-scale RAS by analysing water sample from the specific RAS in the laboratory.

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Bacterial activity dynamics in the water phase during start-up of recirculating aquaculture systems

Microbial water quality in recirculating aquaculture systems (RAS) is important for successful RAS operation but difficult to assess and control. There is a need to identify factors affecting changes in the bacterial dynamics – in terms of abundance and activity – to get the information needed to manage microbial stability in RAS. This study aimed to quantify bacterial activity in the water phase in six identical, pilot scale freshwater RAS stocked with rainbow trout (Oncorhynchus mykiss) during a three months period from start-up. Bacterial activity and dynamics were investigated by the use of a patented method, BactiQuant®. The method relies on the hydrolysis of a fluorescent enzyme-substrate and is a rapid technique for quantifying bacterial enzyme activity in a water sample. The results showed a forty-fold increase in bacterial activity within the first 24 days from start-up. Total ammonia nitrogen, nitrite and nitrate levels were very similar in all six RAS and were neither related to nor affected by BQV. Chemical oxygen demand (COD) and biological oxygen demand (BOD5) were highly reproducible parameters between RAS with a stable...
equilibrium dynamic over time. This study showed that bacterial activity was not a straightforward predictable parameter in the waterphase as e.g. nitrate-N would be in identical RAS, and showed unexpected sudden changes/fluctuations within specific RAS. However, a bacterial activity stabilization phase was observed as systems matured and reached equilibrium, suggesting a successive transition from fragile to robust microbial community compositions.
Combined effects of chronic exposure to suspended solid load and increased unionized ammonia concentrations on the physiology and growth performance of rainbow trout (Oncorhynchus mykiss)

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Monitoring abrupt changes in bacteria within biological stable RAS water

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Prediction of required ozone dosage for pilot recirculating aquaculture systems based on laboratory studies

In recirculating aquaculture systems (RAS), the water quality changes continuously. Organic and inorganic compounds accumulate creating toxic conditions for the farmed organisms. Ozone improves water quality diminishing significantly both bacteria load and dissolved organic matter. However, in a non-meticulously designed system, residual ozone might reach the culture tanks causing significant harm to cultured species or excess costs. The aim of the study was to predict the suitable ozone dosage in pilot RAS, for water treatment purposes, based on laboratory studies. The ozone effect on water quality of freshwater RAS and system’s ozone demand was investigated. Bench-scale ozonation experiments revealed the ozone demand of the system to be 180 mg O3/h. Three different ozone dosages were applied to four replicated systems with fixed feed loading (1.56 kg feed/m3 make up water). Results suggested that the optimal ozone dosage was 15g O3/ kg feed. Selected water quality parameters were measured, assessing biofilters performance as well as nitrogen and carbon–based compound concentration change during ozonation. Overall, this study contributed to a better understanding of the challenges of an ozonated RAS leading to the optimal design of such systems.

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Microbial water quality dynamics in RAS during system start-up

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Organisations: National Institute of Aquatic Resources, Section for Aquaculture
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Projects:

Environmental neutral aquaculture water treatment (MIVANA) (39295)
Despite a transition from flow-through systems to more advanced open water reuse aquaculture systems (e.g. model trout farms), the need for water treatment still exists. In brackish and saltwater reuse systems, blooms of toxic microalgae in an example of a recently new challenge.

The purpose of this project is to further develop current aquaculture water treatment practice and reduce the total amount of disinfectants used.

The project includes 3 different work packages, investigating
- ecological consequences of continuous application of peroxyacetic acid.
- toxicological effects of easy degradable disinfectants.
- alternative biological methods to control / avoid blooms of toxic heterotrophic dinoflagellates.

Trials will include mesocosms experiments where disinfectants are added continuously or by daily pulses over a prolonged period of time where phyto- and zoo-plankton abundance and compositions will be investigated. Other trials will be made in batch experiments with pure algae cultures, as will prolonged continuous peroxyacid application experiments be made.

This project is coordinated by DTU Aqua.

The project is funded by the Environmental Protection Agency's Programme for Pesticide Research.
National Institute of Aquatic Resources
Section for Aquaculture
Period: 01/08/2015 → 31/12/2017
Number of participants: 9
Research areas: Aquaculture & Marine Populations and Ecosystem Dynamics
Project participant:
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Sproegel, Ulla (Intern)
Frandsen, Dorthe (Intern)
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Jensen, Rasmus Frydenlund (Intern)
Project Manager, organisational:
Pedersen, Lars-Flemming (Intern)
Phd Student:
Rojas-Tirado, Paula Andrea (Intern)
Project

Water treatment technology for microbial stabilization in landbased aquaculture systems (MicStaTech) (39277)

MicStaTech is a transnational research project (COFASP) between Norwegian, German and Danish research groups. The paradigm of this project is that a stable, elevated microbial abundance in the water phase of land based aquaculture systems can be beneficial for fish health and economically profitable. A common challenge in land based systems, and shown across species, is the loss of fish due to unfavourable conditions and disease outbreaks that may be linked to opportunistic bacteria. A popular approach to prevent this is to attempt to reduce the load of bacteria in the systems by the use of UV, ozone or chemical disinfection. This is however not possible or sufficient in the majority of systems, because disinfection has a non-lasting effect on the numbers and a destabilising effect on the composition of bacteria. In most systems, the water exchange rates and organic loading applied for biological reasons allow for microbial regrowth in the rearing tanks. Hence, alternative approaches to reduce the chances of disease outbreaks are needed. This project pursues the concept of establishing and maintaining stable microbial systems.

Water treatment technology for promoting K-selection, which is a selective pressure disfavouring the r-selected opportunists, has shown very promising results for several marine species in small scale experiments, but the up-scaling and optimization for flow through systems (FTS) and recirculating aquaculture systems (RAS) remains. The paradigm favouring a stable and elevated bacterial abundance is foreseen to reduce fish mortality and also reduce water treatment costs. This project will investigate fish health and microbial carrying capacity in experiments performed at three locations – NTNU, DTU Aqua and University of Applied Sciences, Saarlandes, Germany.

This project is coordinated by Norwegian University of Science and Technology, Norway.

The project is funded by EU, COFASP, ERA-NET.

National Institute of Aquatic Resources
Section for Aquaculture
Norwegian University of Science and Technology
Hochschule für Technik und Wirtschaft des Saarlandes University of Applied Sciences
Period: 01/03/2015 → 31/12/2017
Number of participants: 7
Research area: Aquaculture
Project participant:
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Rojas-Tirado, Paula Andrea (Intern)
Sproegel, Ulla (Intern)
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Møller, Brian (Intern)
Nielsen, Sara Møller (Intern)
Project Manager, academic:
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Microbial Water Quality within Aquaculture Recirculation Systems

National Institute of Aquatic Resources

Period: 01/12/2014 → 30/11/2017
Number of participants: 6

Phd Student: Rojas-Tirado, Paula Andrea (Intern)
Supervisor: Pedersen, Per Bovbjerg (Intern)
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Examiner: Dalsgaard, Anne Johanne Tang (Intern), Attramadal, Kari (Ekstern), Verdegem, Marc (Ekstern)

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Name of research programme: Samfinansieret - Andet
Project: PhD

Towards stable water quality in RAS by use of a new rapid microbial test (Biostable water) (39154)

Water quality control is central for successful management of recirculating aquaculture systems. Most common and important chemical parameters (i.e. pH, TAN, nitrite, alkalinity) are measurable, whereas microbial water quality (abundance and activity) is more complicated to measure. Microbial water quality measurements are important for several reasons: it can be used to ensure safe and stable conditions (baseline), to identify sudden changes (deviations from baseline) and potentially contribute to improve system performance by identifying suboptimal treatment component or practices.

The aim of this project is to test a rapid microbial methods developed by Mycometer; a test that quantifies the microbial activity in different types of water samples within 30 minutes from sampling to measurement. The Bactiquant® method is expected to provide new insight of microbial succession within RAS and will be used to monitor microbial water quality in commercial recirculating aquaculture systems.

The project includes controlled batch experiments where disinfection efficiency and regrowth potentials can be estimated. The new knowledge can be applied in RAS management, and the project also includes method verification under commercial RAS conditions. The equipment has been introduced and implemented on a large model trout 3 farm with mixed effect and valuable experiences. The method is also being introduced to a huge smolt RAS facility build by Billund Aqua; here daily monitoring as well as intensive campaigns including diurnal measurements will be performed.

The project is coordinated by DTU Aqua.

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
Mycometer A/S

Billund Aquaculture Service Aps
Period: 01/02/2014 → 01/07/2016
Number of participants: 9
Research area: Aquaculture
Project participant: Rojas-Tirado, Paula Andrea (Intern), Pedersen, Per Bovbjerg (Intern), Sproegel, Ulla (Intern), Møller, Brian (Intern), Nielsen, Sara Møller (Intern)