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Study tests disinfectant alternatives to formalin

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Hydrogen peroxide, peroxyacetic acid noted for antimicrobial effects and rapid breakdown

A Danish farmer checks his fish and residual hydrogen peroxide concentrations during water treatment.

Relatively large amounts of formalin are used to control exoparasites in freshwater aquaculture systems. This practice takes place in traditional flow-through systems as well as semi-recirculation raceways and model farms that produce rainbow trout.

Formalin has a number of beneficial attributes, but due to work safety issues and potential negative effects on receiving water bodies, the Danish Aquaculture Organisation (DAO) has launched a strategy to cease the use of formalin by year 2014. Recent applied research by DTU Aqua and DAO with a handful of Danish commercial fish farmers investigated current water disinfection routines and methods to improve them.

Formalin

Formalin can be applied over a short period of time in flow-through systems and maintained at low concentrations in recirculating aquaculture systems. Under the latter circumstances, formaldehyde does not impair the nitrification processes.

The majority of the active concentrations of formaldehyde can be maintained over a prolonged period of time without affecting fish health. It is hence an efficient agent to eliminate free-living stages of the common ciliate parasite I. multifiliis, which causes white spot disease. For these reasons, formalin is often the first choice as a preventive or curative measure to control water quality.

Project goal

To replace formalin, new candidate disinfectants should comply with the same set of requirements. In the present study, hydrogen peroxide and peroxyacetic acid were chosen due to their reported antimicrobial effects and rapid breakdown. In theory, both disinfectants are potential environmentally friendly candidates to replace formalin, but hands-on experience at commercial fish farms is still limited.

A number of controlled batch and pilot-scale lab experiments have been carried out during the last couple of years to test mechanisms of breakdown in order to adapt treatment protocols for full-scale applications. Based on these preliminary investigations, hydrogen peroxide and peroxyacetic acid were applied at different types of fish farms.

Hydrogen peroxide protocols

Protocols for raceway systems without biofilters on how to continuously supply hydrogen peroxide and maintain a concentration of about 15 mg/L for a period of three to four hours were developed. These procedures were easily adopted, and the fish farmers quickly learned how to monitor safe and correct levels of hydrogen peroxide.

Protocols were also tested for recirculating aquaculture systems with biofilter sections, where different protocols were implemented. One method included backwashing of the biofilter with hydrogen peroxide to allow only transient inhibition of the nitrification processes and biofilm control. Another method included the option of maintaining low-dose peroxide in the rearing units for a period of three hours.

The treatments had a significant positive effect on biofilter flow hydraulics and particle flocculation, and increased the visibility of the production water accordingly. The treatments were accompanied by veterinarian inspections, which confirmed that prolonged low-dose hydrogen peroxide exposure was able to combat a number of parasites. However *Ichthyobodo necator* and *I. multifillis* were not sufficiently controlled by the treatment. Further research will focus on the effects of permanent or repeated low-dose exposure on fish health and parasites.

Peroxyacetic acid protocols

Peroxyacetic acid was found to rapidly degrade when applied to aquaculture systems, and protocols were accordingly developed on the optimized use of commercial peroxyacetic acid products. Tests were made with eggs, juveniles and growing fish.

Effective guidelines for application were difficult to obtain from system to system. Some fish farmers routinely use peroxyacetic acid and have prevented major disease outbreaks. Due to its rapid decay and relatively low dosage levels, environmental concerns are not expected to become an issue.

Easily degradable peroxyacetic acid residuals require immediate measurements, here with a simple mobile lab. The column set-up on the right is used to assess nitrification performance on biofilter elements exposed to disinfectant residuals.

Improved disinfection

Possibilities for improving management performance were identified in all types of aquaculture systems. In some cases, substitution for formalin seemed straightforward – but situations may arise when aquaculturists are forced to change practices with formalin use, as was the case with the previous use of malachite green.

The present study has resulted in an increased use of hydrogen peroxide and peroxyacetic acid, and a number of farmers now routinely apply both chemicals. However, more research is needed to fully implement the disinfectants and identify the full range of safe applications and antimicrobial effects.

Perspectives

The chemical fate of the two easily degraded peroxygen compounds varies from system to system. The authors recommend that precautionary step-by-step measures are taken when new chemicals are introduced. Experiences from the project indicated the following.

- Hydrogen peroxide levels can easily be monitored according to changes in water oxygen concentrations or by using semiquantitative sticks.
- Peroxyacetic acid disappears rapidly in recirculation systems, with a 95 percent reduction in 20 to 30 minutes.
- Variations in actual and expected peroxyacetic acid levels are primarily influenced by organic matter content.
- Active peroxyacetic acid content varies substantially among commercial products.
- Hydrogen peroxide and peroxyacetic acid can be used to improve system hygiene, including surface disinfection and biofilm/biofilter control.
- Disinfection demand for hydrogen peroxide depends on the microbial abundance of the water, whereas peracetic acid decay is merely related to chemical oxidation and organic matter content.

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