D5.1 Technical note

Promising water treatment practices with peracetic acid products

Lars-Flemming Pedersen[1*], Alfred Jokumsen[1],
Villy Juul Larsen[2] & Niels Henrik Henriksen[2].

[1] Technical University of Denmark, DTU Aqua, Section for Aquaculture,
The North Sea Research Centre, P.O. Box 101, DK-9850 Hirtshals, Denmark.
[2] Danish Aquaculture Organization, Vejlsoevej 51, 8600 Silkeborg, Denmark
* Corr. Author: Ph..: +45 35 88 32 15; E-mail: lfp@aqua.dtu.dk

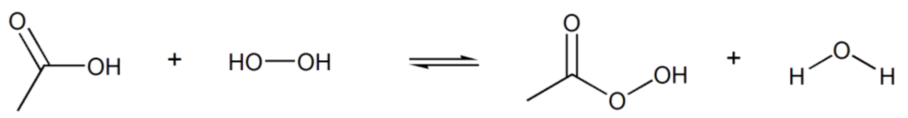
Summary

Peracetic acid products can be used as sanitizers to control water quality in aquaculture systems. Here we describe recent practical experiences of applying peracetic acid (PAA) as an alternative to formalin or sodium chloride. PAA has strong antimicrobial effect, it is easy degradable and relatively safe to use work-wise. Being a strong oxidant, PAA resembles ozone in its mode of action and the associated rapid decay. This can be a challenge towards optimizing treatment protocols, and continuous low dose applications seem to be a promising solution.

PAA is listed among the few disinfectants to be approved to be applied in organic aquaculture where formalin is prohibited (EU, 2014a). As of January 2016, organic trout production fully depends on organic reared ova and fry, which already are available for purchase from Danish hatcheries. DTU Aqua, The Danish Aquaculture Organisation in cooperation with DTU Vet, University of Copenhagen and University of Aalborg have recently launched research projects, which include addressing how to optimise PAA application in juvenile trout production in order to be prepared to meet new production conditions (ROBUSTFISH, 2014).

Background and mode of action

Various chemical agents are used to improve water quality. Water quality control is an important part of management practice and includes measures to reduce bacterial loads and control fungal and ectoparasitic infestations in fresh- and saltwater aquaculture systems. Some systems rely on continuously disinfection with UV/ozone, whereas others rely on periodically flushes or baths using biocides. Peracetic acid (CH_3CO_3H) is an example of the latter, having strong oxidizing potential and antimicrobial abilities similar to ozone. Peracetic acid (PAA) products are emerging in numbers, modes of applications and aquaculture related use has increased significantly over the last few years. Common for all trade products is that PAA is only available in acidified, stabilized solutions with hydrogen peroxide (H_2O_2) and acetic acid (CH_3CO_2H). The composition and strength of the products varies with active concentrations ranging from 5 to 40 % PAA/l.



Acetic acid	Hydrogen Peroxide	Peracetic acid (PAA)	Water
~ 40 %	≤ 35 %	5-10 %	15-20 %

This relative broad concentration interval of the active agent is the first thing to consider when planning water treatment. PAA products are used in most of the rearing phases, for egg-disinfection, water quality control in hatcheries, raceways, grow out tanks and delivery ponds. PAA can efficiently control parasites (e.g. *Ichthyophtirius multifiliis* (ICH) - white spot disease and costia), reduce dinoflagellates (heterotrophic microalgae) and suppress fungal infections related to the handling of broodstock/spawners.

Treatment efficacy of PAA

PAA has proven to be effective against ICH and saprolegnia on eggs. Prophylactic treatment of eggs is done by mixing 10-20 ml PAA with a 2 litres of water and adding this solution to the inlet of the tray. Treatment concentrations applied to juvenile, fingerlings and grow out sized fish are relatively low, often in the range of 2-10 ml/m^3. This corresponds to PAA concentrations in the order of 0.3-1.5 mg/l. Due to its highly reactive property PAA residual concentration will rapidly decline even faster in organic matter rich water. This is a second issue to take into account when using PAA: If the system contains large pools of organic matter higher PAA dosages are needed. Using a low dose PAA in organic matter rich water causes under-dosing, as PAA efficacy will be reduced due to unintended PAA consumption. In such a situation the degradation of the chemicals can be in the order of few minutes which have implications for the positions on where to add the chemicals. If added at the inlet to a long raceway, the residuals may be degraded before it reaches the end of the raceway; in such case multiple sites of application or repetitive dosing is recommended. System design, for example tank configuration, flow or presence of biofilters is the third thing to take into account.

Types of application with PAA

The correct dose depends on the water composition, fish size, temperature and system design. Treatment protocols can include pulse dosage application where the chemical is added once on a daily basis. It can also include repetitive addition or be added continuously at a very low dose over prolonged period of time.

In systems with low organic matter content, e.g. hatchery facilities and well-water ponds, continuous PAA could be a feasible solution to control water quality. The continuous addition relies on dosage pumps and adjustment of dose according to flow and makeup water. Recent experiences from some Danish fish farms, applying prolonged, continuous addition of PAA (in the daytime from April to August) have shown that the usual outbreaks of white spot disease more or less have been avoided.

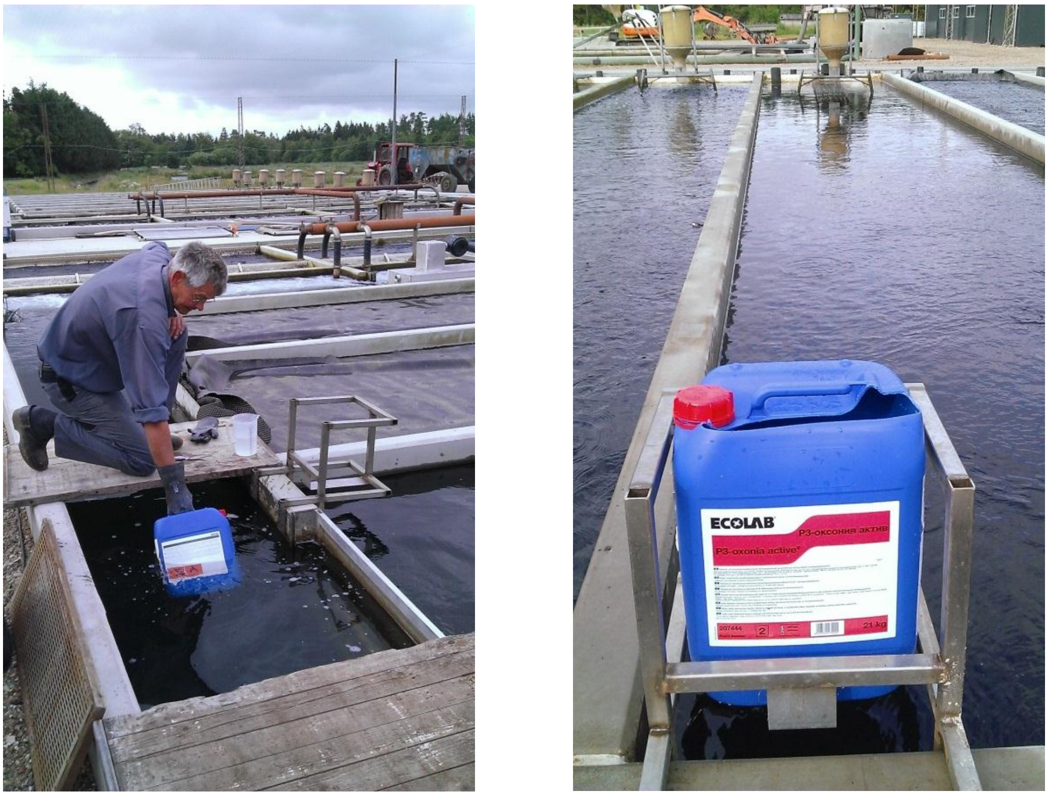


Fig. 1. A practical solution to add PAA over a prolonged period of time. An amount of PAA product diluted in water is added to the farm unit during 1-1½ hours. This ensures a fairly even addition and avoids severe local peak PAA concentrations and drop in pH.

Environmental impact of PAA

Due to the low dose applied and the rapid degradation of PAA, residual amount of PAA in the effluent is at very low levels if present at all. With half-lives in the order of few minutes, far the majority or all PAA is degraded within the pond, raceway or in the constructed wetland leaving no residues to enter the receiving water bodies. The degradation product of PAA is acetate and eventually H_2O_2, CO_2 and water and harmful disinfection by-products are not formed. For these reasons PAA is a benign disinfectant, as it – compared to chloramine-T, sodium chloride, formaldehyde - will degrade before entering the recipient. Hence, PAA is an ideal environmental neutral chemical due to the very limited volume applied and with the degradability of PAA in mind.

Worker safety using PAA

PAA products are all acid stabilized and hence corrosive. All types of handling require proper precautions such as safety goggles and acid resistant gloves. PAA products have a pungent smell and should be stored at a place with ventilation. PAA products have pressure snap caps and should not be decanted from large to smaller jars.

Compared to formalin which is a severe nasal/pharyngeal irritant and considered carcinogenetic, PAA is relative harmless.

Organically reared fry and the dependence on good water quality

Several Danish aquaculture producers have now been certified as organic aquaculturists, producing approximately 1000 MT of rainbow trout per year. According to EU, 2014, at least 50% of the ova/fry used should be reared organically by January 2015 and from January 2016 all organic fish production have to be based on organic certified fry. This has put even more focus on optimizing water treatment routines, in order to i) further improve water quality conditions, ii) find and implement legal disinfectants in an organic context to replace formalin. Low dose continuous PAA application has shown promising results for a couple of organic fry producers. The treatment procedure is so far effectively controlling white spot disease in the critical summer period (which normally would have been controlled be addition of formalin) and the application has not led to discharge of unwanted chemical residuals. Periodic outbreaks of latent diseases such as Rainbow Trout Fry Syndrome or furunculosis are expected to be less frequent if water quality is good and maintained stable. PAA application is expected to help improving the water quality and indirectly preventing out-breaks of bacterial diseases.

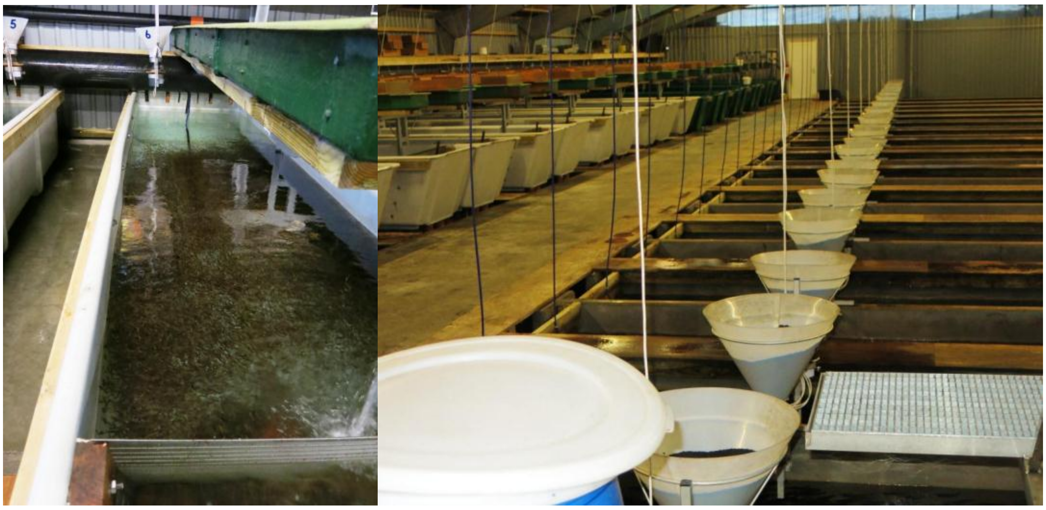


Fig. 2. The above egg trays, tanks and raceways are sanitized with PAA on a daily basis.

Challenges and scope for improvement with PAA

Optimal application of PAA is not easy. The recommended guidelines depend on the product applied and the system to be sanitized. As a rule of thumb 0.2-- 0.5 mg PAA/l is the concentration to aim for. This concentration is very low and the fact that no test kits/sticks are available, expected PAA concentration is often overestimated. In the case of controlling white spot disease, PAA application set other demands than for example baths of formalin or sodium chloride. The life cycle of the white spot disease causing parasite (ICH) includes a free-swimming stage – theronts – which can be eliminated by disinfectants. The theronts are liberated throughout the day hence necessitating continuous chemical application.

In oligotrophic aquaculture systems this can be achieved by dripping PAA into the distribution channel subsequently leading to the inlets of the ponds. This has proven to be effective in some cases; however when system water quality becomes richer in organic matter higher dosages are needed and more difficult to adjust. Continuous PAA application has also been applied to control unwanted pathogens in recirculating aquaculture systems. Preliminary observations and measurements show the potential of this and also highlight a potential need of base adjustment if water reuse is significant.

Fig. 3. Spectrophotometric analyses of peracetic acid concentration measured on location, here a commercial Danish hatchery.

Practical solutions are plentiful and still associated with scope for improvements. Examples of decanting PAA from one container to another have cased loss of strength thereby suboptimal treatment efficacy.
There are still troublesome parasites remaining, e.g. Costia, that cannot sufficiently be controlled by current practices of applying PAA. This incidence often correlates to insufficient solids removal and increased organic matter content complicating PAA dosing. It is expected that another approved chemical for organic aquaculture operation – hydrogen peroxide (H_2O_2) – alone or in combination with PAA can be a complementary chemical agent to ensure proper water quality.

Perspectives

PAA is relatively safe to handle and degrades rapidly, hence beneficial both from a worker safety and an environmental perspective. The reactiveness, mode of action and rapid decay, similar to that of ozone, is a challenge for aquaculturists and sets high requirements for the proper dosage. Recent developments within the industry have accelerated better water treatment practices now including daily pulse addition as well as continuous low dosage application. Proper water quality control is essential for all aquaculture systems. In organic aquaculture systems even more focus on rearing conditions and water quality are made. Here PAA is expected to have a pivotal role in the future development of organic certified aquaculture.

Conclusion

PAA products can become an important trump card to have for aquaculture operators. In particular, PAA is one of the few tools to be used as corresponding action in organic aquaculture. The mode of action and antimicrobial effects of PAA along with the benign environmental impact leaves PAA as a near complete substitute for formalin. Though guidelines are getting established more research are needed to fully exploit and optimize PAA use for all stages in fresh, brackish and saltwater aquaculture systems.

References/additional reading

EU, 2014: Commission implementing Regulation (EU) No 1364/2013 of 17 December 2013 amending Regulation (EC) No 889/2008 laying down detailed rules for the implementation of Council Regulation (EC) No 834/2007 as regards the use of non-organic aquaculture juveniles and non-organic seed of bivalve shellfish in organic aquaculture

EU, 2014a: Pending hearing of: Commission Implementing Regulation (EU) No. …/.. of XXX amending Regulation (EC) No 889/2008 laying down detailed rules for the implementation of Council Regulation (EC) No 834/2007 as regards the origin of organic aquaculture animals, aquaculture husbandry practices, feed for organic aquaculture animals and products and substances allowed for use in organic aquaculture.

ROBUSTFISH, 2014: New possibilities for growth and robustness in organic aquaculture (Research, Development and Demonstration project - 2014 – 2017). http://www.icrofs.org/Pages/Research/ORG_RDD2_Robustfish.html

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