Fate of water borne therapeutic agents and associated effects on nitrifying biofilters in recirculating aquaculture systems

Recent discharge restrictions on antibiotics and chemotherapeutant residuals used in aquaculture have several implications to the aquaculture industry. Better management practices have to be adopted, and documentation and further knowledge of the chemical fate is required for proper administration and to support the ongoing development of a sustainable aquaculture industry. A focal point of this thesis concerns formaldehyde (FA), a commonly used chemical additive with versatile aquaculture applications. FA is safe for use with fish and has a high treatment efficiency against fungal and parasite infections; however, current treatment practices have proven difficult to comply with existing discharge regulations. Hydrogen peroxide (HP) and peracetic acid (PAA) are potential candidates to replace FA, as they have similar antimicrobial effects and are more easily degradable than FA, but empirical aquaculture experience is limited. The two main objectives of this Ph.D. project were to 1) investigate the fate of FA in nitrifying aquaculture biofilters, focusing on factors influencing degradation rates, and 2) investigate the fate of HP and PAA in nitrifying aquaculture biofilters and evaluate the effects of these agents on biofilter nitrification performance. All experiments were conducted through addition of chemical additives to closed pilot scale recirculating aquaculture systems (RAS) with fixed media submerged biofilters under controlled operating conditions with rainbow trout (Oncorhynchus mykiss) in a factorial design with true replicates. Biofilter nitrification performances were evaluated by changes in chemical processes, and nitrifying populations were identified by fluorescence in situ hybridisation (FISH) analysis. FA was degraded at a constant rate immediately after addition, and found to positively correlate to temperature, available biofilter surface-area, and the frequency of FA-exposure. Prolonged biofilter exposure to FA did not negatively affect nitrification, and could therefore be a method to optimize FA treatment in RAS and reduce FA discharge. HP degradation was rapid and could be described as a concentration-dependent exponential decay. HP was found to be enzymatically eliminated by microorganisms, with degradation rates correlated to organic matter content and microbial abundance. Nitrification performance was not affected by HP when applied in dosages less than 30 mg/L, whereas prolonged multiple HP dosages at 10 mg/L were found to inhibit nitrite oxidation in systems with low organic loading. PAA decay was found to be concentration-dependent. It had a considerable negative effect on nitrite oxidation over a prolonged period of time when applied at a dosage ≥2 mg/L. PAA and HP decay patterns were significantly affected by water quality parameters, i.e. at low organic matter content HP degradation was impeded due to microbial inhibition. FISH analysis on biofilm samples from two different types of RAS showed that Nitrosomonas oligotropha was the dominant ammonia oxidizing bacteria, whereas abundant nitrite oxidizing bacteria consisted of Nitrospira spp. In conclusion, measures to reduce FA have been documented, and investigations of HP and PAA have reflected a relatively narrow safety margin when applied to biofilters.