PROCESS REQUIREMENTS FOR ACHIEVING FULL-FLOW DISINFECTION USING OZONATION AND UV IRRADIATION

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Without an internal disinfection process, obligate and opportunistic fish pathogens can accumulate in aquaculture systems that treat and reuse water (RAS), especially in the event of a disease outbreak when the pathogen is propagating and shedding from its host. To proactively prevent the accumulation of fish pathogens, ozonation and ultraviolet (UV) irradiation processes have been used separately or in combination to treat water in RAS before it returns to the fish culture tanks. In freshwater RAS, previous research has also indicated that ozonation can improve water quality by improving microscreen filter performance, breaking refractory compounds and thereby eliminating the accumulation of water color, and oxidizing nitrite to nitrate. Previous research indicates that achieving these water quality control benefits required the addition of only 15-25 g of ozone (O_3) for every kilogram of feed fed to the recirculating system. This level of ozonation has also been found to improve fish health (i.e., preventing recurring episodes of bacterial gill disease in rainbow trout without use of chemotherapeutic treatment) without providing even a 1 log10 reduction in heterotrophic bacteria counts in the water column. To achieve an O_3 residual concentration sufficient to produce significant bacteria reduction, however, the O_3 demand of the nitrite and organic carbon found in the RAS waters must be overcome. This O_3 dose was unknown prior to the present study.

The objective of the present study was to determine the process requirements necessary to disinfect the full RAS flow, using ozonation followed by UV irradiation, just before the flow was returned to the fish culture tank(s). We found that a proportional-integral-derivative (PID) feed-back control loop was able to automatically adjust the concentration of O_3 generated in the oxygen feed gas (and thus added in the low head oxygenator) in order to maintain the dissolved O_3 residual or ORP at a pre-selected set-point. We determined that it was easier and just as effective to continuously monitor and automatically control O_3 dose using an ORP probe (in comparison to a dissolved ozone probe) that was located at the outlet of the O_3 contact chamber and immediately before water entered the UV irradiation unit. PID control at an ORP set-point of 450 mv and 525 mv and a dissolved O_3 set-point of 20 ppb provided practically complete full-flow inactivation of heterotrophic bacteria plate counts (i.e., producing < 1 cfu/ml) and improved water quality (especially color and % UVT) in a full-scale recirculating system. Achieving this level of treatment required adding a mean dose of approximately 29 ± 3 mg O_3 per kg feed. However, because water is treated and reused over and over in a water reuse system, the mean daily O_3 demand required to maintain an ORP of 375 to 525 mv (or at 20 ppb) was just 0.34-0.39 mg/L, which is nearly 10 times lower than what is typically required to disinfect surface water in a single pass treatment. These findings can be used to improve biosecurity and product quality planning by providing a means for continuous water disinfection in controlled intensive RAS.