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OZONATION OF RECIRCULATING AQUACULTURE SYSTEM BASED ON SYSTEM'S DEMAND

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Introduction

The water quality in intense recirculating aquaculture systems (RASs) is characterised by an accumulation of pollutants, potentially allowing fish pathogens to grow. Ozone has been implemented as a secondary water treatment technology (Langlais et al., 1991; Liltved et al., 2006) improving water quality. It oxidizes dissolved and particulate organic compounds, decolourises the water (Krumins et al., 2001) and reduces bacteria and fish pathogens (Bullock et al., 1997; Summerfelt et al., 2009). Excess of ozone (overdosing), is unwanted due to detrimental effects on the fish, and therefore, it is crucial to define the ozone demand of a specific RAS. Thus, this study aimed to develop a method to predict the ozone demand and to pursue a more direct approach to control the delivered ozone dosage in RASs. The required ozone dosage was predicted solely based on RAS water quality parameters analysed in the laboratory. RAS water samples were initially collected from a pilot-scale RAS, operated as an intensive commercial RAS subsequently subjected to ozonation.

Material and Methods

Several ozone dosages ranging from 0 to 10 mg O_3/L, were spiked repeatedly upon depletion, into an aliquot of 50 mL RAS water to investigate ozone reactivity and its sensitivity to optimal ozone dosage using the indigo colorimetric assay to quantify ozone concentration profiles over time. All samples including the non-ozonated control sample were measured with a fluorimeter to define the ozone effect on natural fluorescence degradation (Spiliotopoulou et al., 2017). The predicted optimal ozone dosages were applied in side-stream to pilot-RAS systems in which trouts were farmed (40 kg/m^3) to compare if the prediction of the effect of continues ozone dosage complied with a RAS with constant daily feed and water exchange.

Results and Discussion

Ozone decay and demand in RAS water was tested over a period of 70 days (Fig. 1a and b). The higher degree of pollution the faster the ozone degraded, correlated to the organic matter (OM) content to be oxidised. Based on the kinetics in Fig. 1, the ozone demand for the 1-week RAS water ranges from 16 to 20 mg O_3/L and the ozone demand at day 70 was between 30 to 40 mg O_3/L. Based on the results the ozone demand was 2.6 mg/l. Since the total volume of the system is 1700 L, 182 mg O_3/h was needed to purify the water. However, since this dosage was high, 130 mg O_3/h was suggested as the optimal dosage for water treatment in this case study.

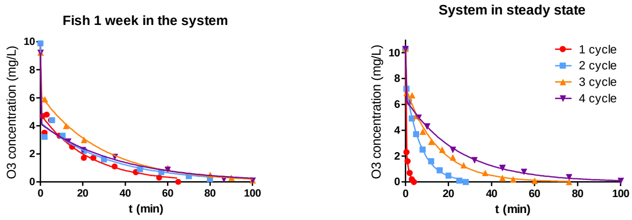

Figure 1. System's ozone demand based on kinetics in bench experiments; pollution build-up over time: a) sampling after a week and b) sampling on day 70.

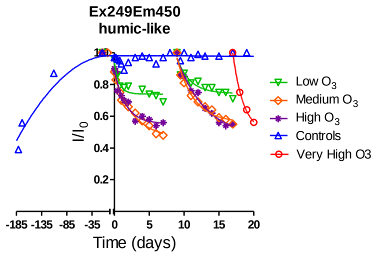

Figure 2. Fluorescence degradation upon 5 different dosages in pilot-scale; control, low, medium, high and very high ozone dosages.

Four ozone dosages, including a control (non-ozonated), were selected to be tested in pilot-RAS (Fig. 2). The ozonation trials consisted of 2 replicated campaigns utilising one RAS per dosage (low, medium, high) per time, each lasting seven days. The duplicate test levels ranged from 52-130 mg O_3/h, equivalent to 10-25 g O_3/kg feed, as used in previous studies (Summerfelt et al., 2009). An additional high dosage of 260 mg O_3/h equivalent to 50 g O_3/kg feed (exceeding the recommended ozonation level found in literature) was tested at the end of the trial 2. The fluorescence, indicative of organic matter (OM) content, was analysed over a period of 200 days. The highest the concentration of injected ozone into the systems the highest the fluorescence degradation (Spiliotopoulou et al., 2017). The very high ozone trial lasted 3-days (Fig. 2). Residual ozone was not detected in any trial, not even after the ozone reaction chamber. According to literature, lethal dosages have occurred above 30 g O_3/kg feed (Summerfelt et al., 2009). Our findings did not reveal any change in fish physiology or behaviour and no mortality were observed. The tested RAS systems had a prolonged retention time (~3 weeks) and were provided with OM input from the fish being fed on a daily basis. This may explain why the applied ozone dosages did not manage to completely decolourise the RAS water, nor had any detrimental effect on the fish when added at an elevated nominal concentration over 3 days.

Conclusions

The method applied to predict the optimal ozone dosage of pilot-RAS based on laboratory studies was efficient and fluorescence is a good indicator of organic matter removal with the potential to be the basis of a robust and low cost ozone dosage control.

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