POTENTIAL ZERO WATER EXCHANGE SYSTEM FOR RECIRCULATING AQUARIUM USING OZONE-DHS-USB SYSTEM

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1. INTRODUCTION

Generally, conventional methods such as water exchange about 10-20% of water from tank capacity and sand filter were used to reduce NH_3 concentration in the water. Due to water becoming scarce, it is crucial to reduce large amount of water usage for maintaining the aquarium (Asano et al., 2003). Our research group has developed a biological nitrogen removal system consisted of down-flow hanging sponge (DHS) and up-flow sludge blanket (USB) system for maintaining nitrogenous compounds concentration in the water at low level to eliminate the water exchange necessity. Adlin et al., 2017 showed that nitrogenous components were successfully maintained by DHS-USB system at NH_3-N: 0.1, NO_2^--N: 0.1, and NO_3^--N: 10 [mg L^{-1}]) in an on-site recirculating freshwater aquarium for an overall period of 192 days. However, water exchange was still performed despite low NH_3^--N concentration in the water. The purpose of performing water exchange was to reduced color build up in the aquarium which was resulted from the accumulation of yellow substances in the water over time. In this study, ozone (O_3) was introduced to reduce the color build up. The objective of this study is to demonstrate O_3 capability in maintaining color and turbidity as much as performing 50% water exchange and the suitability of O_3-DHS-USB system as a potential zero water exchange system for on-site aquarium.

2. METHODS & MATERIALS

The study was conducted in four phases. A 600 L breeding tank and 100 L bottom tank was used in the study. Three carps (*Cyprinus carpio var. Koi*) were bred in the breeding tank. Ozone generator was installed at the bottom tank at phase 2. Short-term ozonation over a period of 8 h at constant O_3 concentration of 70 mg-O_3 h^{-1} was operated at Phase 2 and 4. DHS-USB reactor and ozone were installed at the bottom tank. DHS reactor has a volume of 12 L sponge and HRT of 0.01 h. The USB reactor has a volume of 8 L but were only half -filled with sludge. It has a HRT of 2.7 h. Nitrogenous components in aquaria water was monitored by routine analysis of samples taken from aquaria tank. The presence of yellow substance that contributed to color build up was monitored using Drainage Analyzer for Coloration and Contaminated Color (NDR 2000, Nippon Denshoku Industries Co., Ltd) with 20 mm cell. In addition, sponge and sludge sample were collected for microbial analysis.

3. RESULTS AND DISCUSSIONS

Changes in color and turbidity of the water were observed from ending of phase 2 to phase 4 **(Fig.1).** The average color obtained from aquarium water at phase 2 was 7.3 ± 0.5 NTU. When O_3 was stopped at phase 3, a slight increase in color was observed. However, the aquarium water turned clear again after O_3 was reintroduced at phase 4. The average color level measured at phase 3 and 4 was 9.3 ± 2.18 and 5.5 ± 0.6 NTU respectively

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Although O_3 had reduced yellow substances in the water, it is critical to maintain a low O_3 concentration in aquarium. This is because O_3 is highly toxic to aquatic organisms and also harmful to humans. It was reported that O_3 concentration as low as 0.01 mg- O_3 L^{-1} can be lethal to fish (Summerfelt & Hochheimer, 1997). In this study, about 560 mg-O_3 day^{-1} was assumed to been released in the water, but only 0.03 mg L^{-1} O_3 concentration was detected in the aquarium. As the actual lethal O_3 concentration may varies depending on species and life stages, it is suggested that carps have higher tolerance to O_3 toxicity. In addition, no abnormal behavior and health effect on carps were observed during the study. NH_3-N, NO_2^--N and NO_3^--N concentrations remained below attainment level throughout 550 days of total operational period **(Fig.2).** NH_3-N concentration was maintained at 0.10 ± 0.12 mg-N L^{-1}. NO_2^--N concentration was maintained at 0.03 ± 0.13 mg-N L^{-1} and NO_3^--N at 6.40 ± 7.46 mg-N L^{-1} throughout the study. The results showed that DHS-USB system was capable to operate at long term. The presence of microbial community in the reactor was also analyzed. *Crenarcheota* was observed in DHS reactor and *Proteobacteria* was observed in USB reactor.

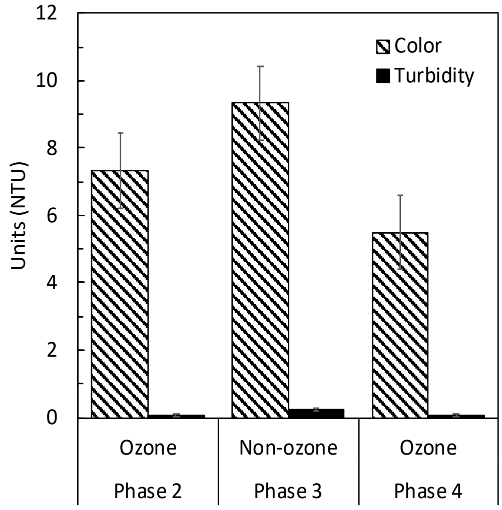

Fig.1 Average color and turbidity during ozone phase and non-ozone phase

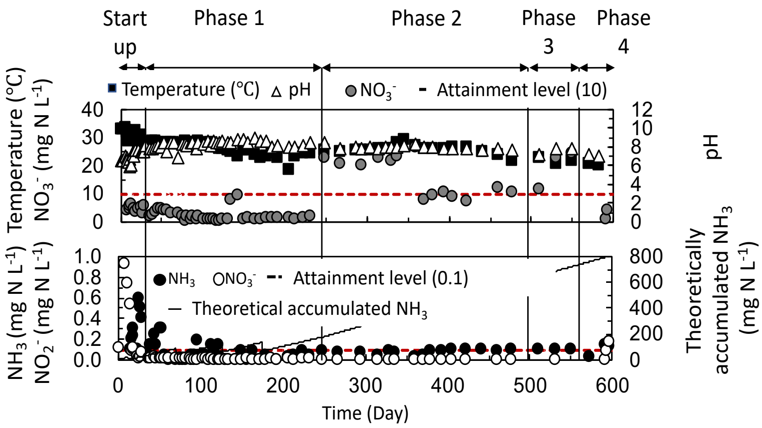

Fig.2 Nitrogenous compounds concentration against time

4. CONCLUSIONS

After the introduction of O_3, the necessity for water exchange was eliminated. Continuous O_3 exposure for 560 mg-O_3 day^{-1} was sufficient to maintain clear water in aquaria at average color density of 5.5 ± 0.6 NTU. Fish survived despite no water exchange performed for 425 days. Ozone-DHS-USB system has high potential as zero water exchange system for on-site aquarium. maintenance-free system for aquaria.

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