B−53 Inactivation of Coliphage Qβ in secondary effluent from sewage treatment plant with ozone, UV and Ozone/UV

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1. INTRODUCTION

Even though ozone is considered an expensive option and concerns about the formation of potentially harmful by-product, it has been regarded as an alternative disinfection method due to its strong oxidative power and poses efficient disinfection to bacteriocidal and virucidal. However, the knowledge about a toxicity of ozone to pathogens is still not sufficient. UV irradiation became a favorite process for drinking water and wastewater disinfection thanks to its effective destruction of the DNA or RNA of microorganisms and no adverse effect to the receiving environment. The efficacy of this process strongly depends on UV transmittance of the effluent. On the other hand, advance oxidation processes (AOPs) such as ozone/UV are the alternative technologies that can potentially minimize the formation of by-product by generating hydroxyl radical with the combination of catalytic oxidants.

In this present study, the performance of ozone and UV processes for the inactivation of human enteric virus modeled by coliphage Qβ was evaluated with batch experiments using secondary effluent from wastewater treatment plant as a tested water. In addition, the effect of the combination of ozone with UV on the improvement of disinfection effectiveness by the single process of ozone or UV.

2. METHOD AND MATERIALS

In this study, three processes were evaluated including ozone, UV and ozone/UV processes. Biologically treated water from a municipal wastewater treatment plant was used as tested water. The characteristics of test water are as follows: TOC, 4-5 mg/L; UV_{254}, 0.060-0.070 /cm; coliphage Qß, 15 PFU/mL; pH, 6.2-6.5; Turbidity, <2NTU. Tested water temperature was controlled at 20°C with a thermo cycler during all the experiments.

Semi-batch experiment was conducted for ozone process and batch experiment for UV process with a batch reactor with the effective volume of 1.7 L. UV lamp applied for each experiment was a low pressure mercury lamp (UV wavelength: 254 nm, UV intensity: 0.640 mW/cm^2). Ozone gas concentration of 1.0 mg/L, 2.1 mg/L and 4.1 mg/L were continuously supplied during the ozone process with ozone feed rates of 0.3 mg/L/min, 0.6 mg/L/min and 1.2 mg/L/min respectively. Residual ozone concentrations in the samples were measured using Indigo method[1].

FRNA (NBRC20012) is a single strain-stranded RNA with no envelope and E.coli K12F+ (A/λ) (NBRC13965) as a host cell was obtained from NITE Biological Resource Center (NBRC). Coliphage Qß culture was produced by adding the coliphage stock solution into exponentially growing E.coli K12F+ (A/λ) (NBRC13965) pure culture growing in the DifcoTM LB Broth Lennox at 37°C. Suspended viruses were harvested by centrifugation (10,000 rpm, 20 min, 4°C) and filtration through 0.45μm membrane (Milipore).

The stock solution was diluted with phosphate buffer solution and spiked into the tested water to the final concentration 106 PFU/mL in tested water. Coliphage Qß was concentrated using USEPA method[2] with small modification. The concentrated viruses were diluted with DifcoTM LB Broth Lennox and assayed in double agar layer with DifcoTM Agar in duplicate petri dishes.

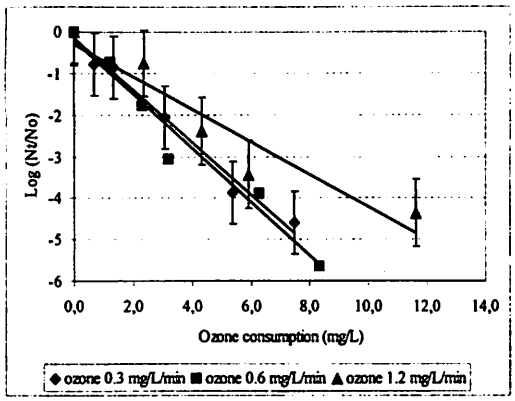

Fig. 1 Inactivation of coliphage Qß with varies ozone feed rate.

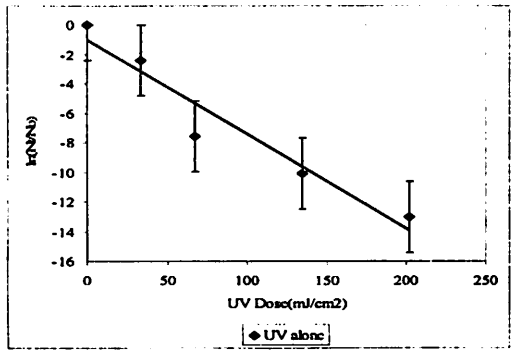

Fig.2 Inactivation of coliphage Qß with UV alone

3. RESULTS AND DISCUSSION

A degree of coliphage Qβ inactivation was evaluated regarding the exposure to three different processes namely ozone, UV and combination of ozone and UV. Short contact time from 0 to 10 mins was selected. In order to determine an efficient ozone consumption for the inactivation of coliphage Qβ, a different injected ozone were used with different ozone feed rate. In this study, 1.02, 2.01 and 4.0 mg/L ozone was injected with ozone feed rate 0.3, 0.6 and 1.2 mg/L/min respectively (**Fig. 1**).

The result shows that ozone consumption will increase with the increase of ozone feed rate. However, ozone feed rate 0.3 and 0.6 mg/L/min yielded a similar inactivation. The increasing of ozone feed rate to 1.2 mg/L/min did not enhance the inactivation of coliphage Qß. Therefore, for further analysis ozone feed rate 0.6 mg/L/min was used.

Based on UV process , log inactivation for 3-5 logs were achieved with UV dose 92-160 mJ/cm^2 (**Fig.2**). One study showed showed that MS2-phages needed 5-139 mJ/cm^2 for 4.9 log inactivation from wastewater[3].

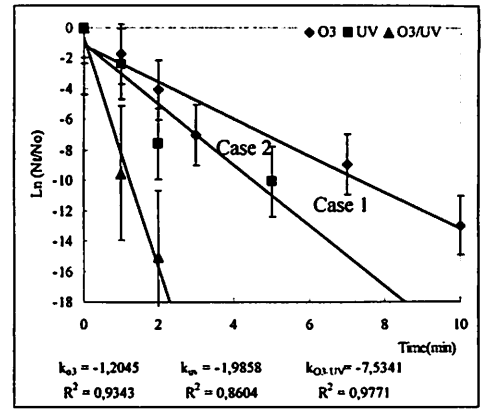

Fig.3 Degree of inactivation for coliphage Qß exposed to ozone, uv and ozone;uv processes.

In this study, to achieve the coliphage Qß inactivation at 3-logs (99.9%) with ozone feed rate 0.6 mg/L/min, the ozone consumption of 4.30 mg/L were needed. Furthermore, 5-logs (99.999%) inactivation could be achieved with 7.30 mg/L ozone consumptions. In other studies, ozone concentration of 0.4-2 mg/L was required to achieve 4.2-6 logs for HAV[4] and 3.9-4.9 logs for MS2 coliphage[5]. More than 3 logs inactivation of poliovirus type 3 could be achieved with 1.63 mg/L ozone consumption[4]. Coliphages Qß inactivation were observed more rapid when combination of ozone and UV were used. Combination of ozone and UV contributed to higher degree of inactivation compared to single process of ozone and UV(**Fig.3**) probably due to an exisent of hydroxyl radical in advance oxidation process. However, the mechanisms of hydroxyl radical reaction to viruses inactivation are still need to be investigated. In the combination process lower UV doses were neded to achieve he same inactivation rate compared with single process.

4. CONCLUSIONS

In conclusion, based on the condition in this study approximately 3 to 5 logs (99.9% - 99.999%) inactivation could be achieved with ozone and UV process with less then 10 mins contact time.

- Inactivation of coliphage Qß during ozone process was dependent with ozone consumption instead of contact time.
- UV inactivation was more efficient than ozone under the same condition in secondary effluent.To achieve 3-5 logs inactivation UV dose range from 92-160 mJ/cm^2 was needed.
-To achieve the coliphage Qß inactivation at 3- 5logs

(99.9%) with ozone feed rate 0.6 mg/L/min, the ozone consumption of 4.30 mg/L to 7.30 mg/L were needed.

- The inactivation of coliphage Qß was more rapid by the combination of ozone and UV process compared to single process.This suggested the existence of hydroxyl radical helped to accelerate the inactivation process.

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