2-MIB removal of algal organic matter derived from the bloom-forming cyanobacterium *Microcystis Aeruginosa* in UV/H_2O_2 process

Sook-Hyun Nam[a], Jae-wuk Koo[a], Eunju Kim[a], Minhwan Kwon[b], Tae-Mun Hwang[a,*]

[1]Korea Institute of Civil Engineering and Building Technology, 283 Goyangdar-Ro, Ilsan-Gu, Goyang-Si, Gyeonggi-Do 411-712, Republic of Korea
[2]Department of Environmental Engineering, Yonsei University, Yonseidae-gil 1, Wonju-si, Gangwon-do, Republic of Korea
Keywords: NOM, Fluorescence spectroscopy, EEM, PARAFAC, AOP
Presenting author email: taemun@kict.re.kr

Introduction

Cyanobacterial blooms have been one of the critical concerns for drinking water treatment processes as they have contributed to the clogging of filters or impacted the water quality due to the release of taste and odor matters, as well as algal toxins such as microcystins and anatoxin. Geosmin and 2-methylisoborneol (2-MIB), the representative taste and odor-causing compounds (T&O), in surface water have been identified as being produced by cyanobacteria or different algae species. Advanced oxidation processes such as O_3/H_2O_2 and UV/H_2O_2 have been reported to be effective for removing algal toxins and T&O matter. To predict the removal efficiencies of target compounds, the determination of ozone, UV dose, and the H_2O_2 and OH radicals in the reactor is needed. However, the direct determination of OH radicals is difficult due to its very short lifetime in reactions. To solve this problem, indirect determination of OH radicals was proposed using an OH radical probe compound. In our recent study, we proposed the rapid spectrophotometric method using Rhodamine B in the UV/H_2O_2 AOP process. This method measures the OH radical scavenging factor using Rhodamine B as a means of predicting the removal efficiency of the target compound. The OH radical scavenging factor was observed to be seasonally variable. In particular, when the AOM (algal organic matter) characteristics changed during algae bloom, the OH radical scavenging factor was sharply increased. The AOM could be changed by the effect of the allogenic organic matter generated either extracellularly via metabolic excretion or intracellularly through cell autolysis. The objective of this study was to assess the effect of AOM characteristics on the scavenging factor.

Material and Methods

In this study, an algae solution was collected in P Lake. The number of *Microcystis aeruginosa* in P lake was 7.8×10^7 cell/L. Algal organic matter on the bloom-forming cyanobacterium *Microcystis aeruginosa* was experimentally separated into intracellular algal organic matter (IOM), extracellular algal organic matter (EOM), and dissolved algal organic matter (DOM). The 2-MIB and DOC concentrations of the separated organic matters were measured. The OH radical scavenging factor by Rhodamine B was measured by injecting the separated matter into the specimens. By using this procedure, the UV/H_2O_2 process dose was calculated to confirm the removal efficiency.

Results and Discussion

The DOC concentrations of DOM, EOM, and IOM were 62, 48, and 20 mg/L, respectively. The 2-MIB concentrations of DOM, EOM, and IOM were 2.8, 4.8, and 0.1 μg/L, respectively, and the EOM extract solution showed the highest value. 2-MIB was generated at high concentrations, and Geosmin was rarely generated at low concentrations. The results of obtaining the OH radical scavenging factors by adjusting the DOC concentration to 0.7 mg/L by injecting IOM, EOM, and DOM into the distilled water are shown in Fig. 1. The measurements of OH radical scavenging factors were high in the order of DOM, EOM, and IOM. The EEM fluorescence spectra were measured at different excitation wavelengths (ex) in the range from 200 nm to 550 nm in 5 nm step. DOM are characterized into humic-like peak (λ_{ex}=250–580 nm and λ_{em}=300–450 nm) and tryptophan is characterized as protein-like peak (λ_{ex}=270–280 nm and λ_{em}=320–350 nm). EOM are characterized into humic-like peak (λ_{ex}=330–350 nm and λ_{em}=420–480 nm) and fulvic-like peak (λ_{ex}=250-260 nm and λ_{em}=380-480 nm), and tryptophan is characterized into protein-like peak (λ_{ex}=270–280 nm and λ_{em}=320–350 nm). IOM are characterized into tryptophan protein-like peak (λ_{ex}=270–280 nm and λ_{em}=320–350 nm). The result of the LC-OCD analysis showed that biopolymers accounted for over 80 % in the case of IOM.

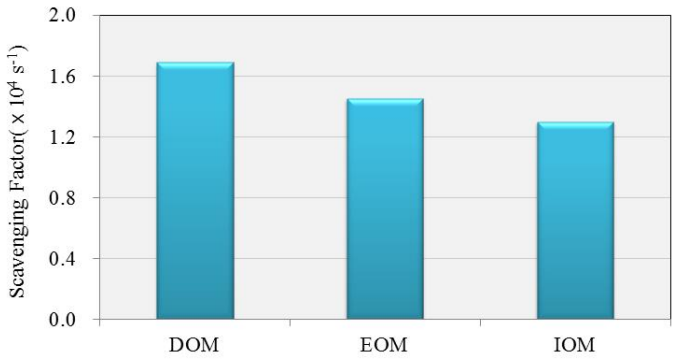

Fig. 1. Variation of OH radical scavenging factors DOM, EOM, and IOM

The DOC of the sample prepared by injecting 2 mL of DOM into the DOC 2 mg/L sample was 5.5 mg/L, and the OH radical scavenging factor was 101,770 s^{-1}. The 2-MIB removal efficiency according to the dose change is shown in Fig. 2. As a result of the experiment, the OH radical scavenging factor was obtained and more than 90% of the 2-MIB was removed from the estimated optimal dose of UV 1200 mJ/cm^2 and H_2O_2 dose of 10 mg/L.

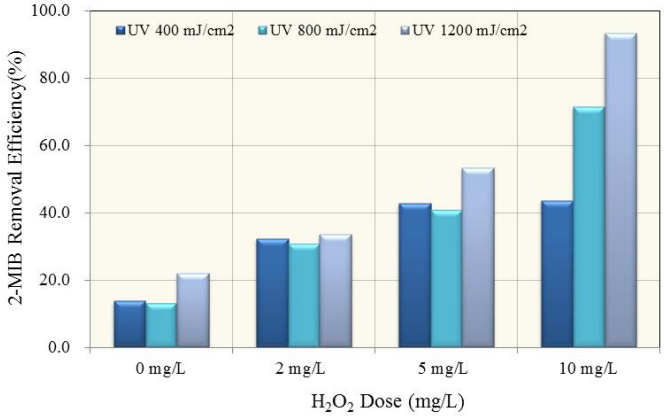

Fig. 2. 2-MIB removal of sample by UV/H_2O_2

Conclusions

As a result, it was shown that OH radicals were influenced by organic characteristics extracted from *Microcystis aeruginosa*. In addition, the measurement of OH radical scavenging factors can yield the optimal dose in the UV / H_2O_2 process.

References

[1] Leenheer, J. A. and Croue´J. P. (2003) Peer reviewed: Characterizing aquatic dissolved organic matter, Environ. Sci. Technol., 37, 18A–26A.

[2] Kavurmaci, S, S., Birben, N. C., Tomruk, A. and Bekbolet, M. (2016) Characterization of organic matter in natural waters by EEM fluorescence properties, Desalination and Water Treatment, 57, 2428–2436.

[3] Kwon, M. H., Kim, S. B., Yoon, Y. J., Jung, Y. M., Hwang, T. M. and Kang, J. W. (2014) Prediction of the removal efficiency of pharmaceuticals by a rapid spectrophotometric method using Rhodamine B in the UV/H_2O_2 process, Chemical Engineering Journal, 236, 438–447.

Acknowledgements

This subject was supported by “Field evaluation of best available technique for algae control in river” (code 18AWMP-B098632-04) funded by by Korea Environmental Industry & Technology Institute.