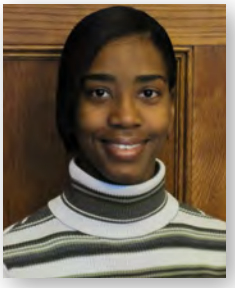
Influence of Effluent Organic Matter on the Hydroxyl Scavenging Capacity of Wastewater Effluents



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In wastewater, effluent organic matter (EfOM) is the principal scavenger of hydroxyl radicals (OH•) generated in advanced oxidation processes (AOPs) (Dong et al., 2010). This radical scavenging affects the AOP efficiency because of reduced •OH radical concentrations, and can increase the UV dose required for effectively treating wastewater effluents for contaminants of concern, such as micropollutants. EfOM, as the primary scavenger, is comprised of natural organic matter and soluble microbial products (SMPs). Of these, SMP is the major EfOM constituent and its characteristics may vary from one wastewater to the next. Hence, variability in EfOM components and effluent characteristics may lead to variations in the scavenging capabilities of effluent streams from different treatment processes.

Considering the effluents from two common wastewater treatment systems – conventional activated sludge (CAS) and membrane bioreactor systems (MBR) – the objective of this study was to compare the background scavenging capacity of these matrices. It was hypothesized that the EfOM from a CAS system may consistently have different •OH scavenging properties compared to the EfOM produced from MBRs, such that the effluent from one form of treatment may generally be more easily and cost-effectively treated using advanced oxidation. This evaluation would determine the extent to which scavenging capacity varies between the two systems and which effluent may be more amenable to treatment using AOPs because of lower UV dose and energy requirements. UV/H2O2 was used as the applied AOP for the study.

The scavenging capacities of the effluents from three CAS and three MBR plants were determined using a Rayox® UV collimated beam apparatus equipped with a 1kW medium-pressure UV lamp and the ROH,UV concept reported by Rosenfeldt et al., (2007) which was modified to account for a polychromatic light source. All effluents were collected from nitrifying plants prior to disinfection. Comprehensive characterization of the bulk EfOM was performed using specific UV absorbance (SUVA), resin fractionation, fluorescence excitation emission matrix (FEEM) analyses, and liquid chromatography-organic carbon detection (LC-OCD) analyses. Effluent samples were also analyzed for EfOM concentration (measured as TOC), UV254nm absorbance and the concentration of anions (chloride, nitrate, nitrite, sulfate, and phosphate).

For the six effluents used in this study, the average scavenging capacity of the CAS effluents exceeded that of the MBR by a factor of 1.6 (a difference that was significant at the 85 percent confidence level). Both effluent types had a similar distribution of EfOM components based on FEEM, LC-OCD and resin fractionation analyses. Both effluents were composed mainly of high molecular weight constituents (humic substances and biopolymers). The study also found a strong correlation between the high molecular weight components and the scavenging capacity of EfOM.

Our findings are consistent with the hypothesis that MBR effluents may be more amenable to AOP treatment and may require lower UV dose and energy requirements, but it is recognized that this is a limited case study. Our results also indicate that the cost of AOP treatment may be lowered by reducing the concentration of high molecular weight components, such as by use of enhanced coagulation that targets this EfOM fraction.

Dong, M., Mezyk, S.P., Rosario-Ortiz, F.L. 2010. “Reactivity of effluent organic matter (EfOM) with hydroxyl radical as a function of molecular weight”, Environmental Science & Technology 44: 5714 – 5720.

Rosenfeldt, E.J., Linden,K.G. 2007. “The ROH,UV concept to characterize and model UV/H2O2 process in natural waters”, Environmental Science & Technology 41(7): 2548 – 2553

Sucralose as a Hydroxyl Radical Probe

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The study by Keen and Linden "Re-engineering the artificial sweetener: sucralose transformation by hydroxyl radicals and its suitability as a probe" discusses the fate of a popular artificial sweetener sucralose in UV/H_2O_2 AOP. The molecule is not susceptible to photolysis at wavelengths of ≥ 200 nm, but it reacts with hydroxyl radicals. Its reaction rate constant is somewhat lower than the reaction rate constants for most other common trace organic contaminants found in drinking water or wastewater. The study also determined that the reaction with hydroxyl radicals replaces chlorine atoms on the sucralose molecule with hydroxyl groups. The process almost reverts the molecule back to sugar – the starting compound used to produce sucralose. The end product is a molecule consisting of fructose and sugar alcohol moieties and is likely to be as biodegradable and as benign as sugar.

Based on the findings above, the authors proposed sucralose as a hydroxyl radical probe suitable even for full-scale AOP. The compound is already found in environmental samples at levels higher than most other trace organic contaminants. The parent compound is benign enough to be added to the reactor to test its performance. The procedure would not require a photolysis control. And due to the slower reaction rate between hydroxyl radicals and sucralose, compared to many other trace contaminants, sucralose level of attenuation in the process would be a conservative estimate of the efficiency of the process for transforming the majority of other contaminants that may be present in the sample.