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Dissertation by

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The formation, fate and transformation of nitromethane in potable reuse

Abstract

As water resources become increasingly scarce, potable reuse of wastewater is considered to be a potential solution. There are increasingly number of treatment processes currently in used in full- and pilot- scale water reclamation plants involves ozonation. Ozone is considered to be a highly effective oxidant and disinfectant. However, previous research has demonstrated that ozonation of wastewater overall drastically increases chloropicrin formation potential during subsequent chlorination. Chloropicrin is synthesized by chlorinating nitromethane, suggesting that nitromethane may be the immediate precursor of chloropicrin, although nitromethane is unlikely to occur naturally in wastewater.

In this work we demonstrated that wastewater ozonation forms nitromethane, which would be the key intermediate toward HNMs. Ozonation of wastewater effluent was shown to form abundant nitromethane. The formation pathway was studied, a category of stimulant drugs, such as ephedrine and methamphetamine, and certain antidepressants all feature N-methylamine functional groups. Ozonation of N-methylamine drugs ubiquitously formed nitromethane, typically at >50% yield.

The fate of nitromethane through water reuse treatment trains was characterized by analyzing samples from five reuse operations employing ozone. Nitromethane was poorly rejected by RO, not removed by, and in some cases, increased by ultraviolet/advanced oxidation processes (UV/AOP). In contrast, biological activated carbon removed most nitromethane.

The transformation of nitromethane to other products through secondary disinfection was investigated. When free chlorine was added to the system, chloropicrin formation was consistently observed. When chloramine was added to the system, other products such as nitrate, monochloronitromethane and dichloronitromethane were found, and the reaction mechanism was studied.

These results indicate that nitromethane presents a unique hazard to direct potable reuse systems, due to its ubiquitous formation during wastewater ozonation, poor removal by RO and UV/AOP, and facile conversion into genotoxic halonitromethanes upon secondary disinfection.