MP UV/H_2O_2 treatment for organic contaminant control and byproduct mitigation

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SUMMARY (12-POINT ARIAL BOLD CAPITAL LETTERS)

This work illustrates the technological aspects to the application of MP UV/H_2O_2 treatment as a non-selective barrier for organic micropollutants in advanced drinking water production from eutrophic and polluted surface water. Furthermore, the mechanism and the preliminary risk of MP UV nitrate photolysis induced byproduct formation was studied, although the identity of the formed reaction products could not be established. The TEF concept, a widely accepted approach for risk assessment of mixtures of compounds with a similar mode of action, was used in this study to perform a MOE based preliminary risk assessment of the mixture of unknown compounds with genotoxic mode of action, causing the positive Ames test response in MP UV treated water. The preliminary risk assessment based on the MOE approach, using the developed 4-NQO based TEF, exceeded the level of no concern. However, MP UV/H_2O_2 treatment as part of an integrated multibarrier water treatment scheme provides a robust barrier for organic micropollutants and allows mitigation of formed byproducts.

KEYWORDS

Ames test, medium pressure UV, genotoxicity, margin of exposure, 4-NQO, nitrate photolysis, nitration

ABSTRACT

The widespread use of a large variety of chemicals in the community is a continuous threat to contaminate drinking water sources. Climate changes influencing algae blooms or affecting the discharge of rivers may also cause contaminants to emerge. The first groups of emerging contaminants were pesticides and algae toxins. In a later phase endocrine disrupting compounds and pharmaceuticals and currently perfluorated compounds and nanoparticles became emerging. These developments require a water treatment strategy based on multiple barriers, able to deal with a wide range of chemical contaminants with different degradation and removal properties.

Challenge test on pilot scale and incidents and spillage of micropollutants in the raw water source shows that, although the composition of emerging contaminants is changing continuously, the

combination of photolysis and OH radical oxidation by MP UV/H_2O_2 treatment followed by GAC providing adsorption and biodegradadation of the reaction products provides this robust treatment approach for organic contaminant control. Recently, it was learned that genotoxic nitro-organic byproducts are formed in water treatment when medium pressure ultraviolet technology is applied on nitrate containing water types. The genotoxicity was measured via the Ames test bioassay and converted into 4-nitroquinoline equivalents, using the Toxic Equivalency Factor methodology, for preliminary risk assessment purposes, based on the Margin of Exposure approach, indicating the necessity for further identification of the genotoxic compounds. Using labelled N15-NO_3 in bench scale experiments in reconstituted water with IHSS Pony Lake natural organic matter, allowed detection with LC-HR-MS of approximately hundred nitro-organic compounds in the 10-100 ng/L concentration. Analysis of full scale water treatment samples confirmed the bench scale experiments. Despite the byproduct formation, it can be concluded that MP UV/H_2O_2 treatment as part of an integrated multibarrier water treatment scheme provides a robust barrier for organic micropollutants, forming nitrated organic byproducts to levels exceeding the level of no risk in nitrate containing water types, a risk that can be mitigated by post treatment.