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Sensitivity Analysis of a Proposed Model for Removal Efficiency of Trihalomethanes (THMs) Using Spray Aeration

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Abstract

Trihalomethanes (THMs) form in drinking water treatment systems as a byproduct of chlorination and are problematic from a public health perspective due to their carcinogenic potential and their potential for additional formation throughout distribution systems. Recently, regulations have tightened on THMs in an attempt to reduce the risk of exposure for consumers at the far ends of distribution systems. Due to widespread use of chlorine and the reluctance of drinking water providers to overhaul current treatment systems, research has been undertaken to investigate post-treatment removal of THMs. One such method is spray aeration, whereby water is recycled in water storage tanks by spraying it through showerheads. Using a spray aeration model and a simple sensitivity analysis, the following study evaluates the influence of various parameters on the model's output. It was determined that the configuration and magnitude of the recycle flow were the most influential parameters, while spray angle and the distribution of THM species (speciation) were the least influential. These results are important for practitioners as they can help them to determine the most important design parameters for spray aeration systems. Additionally, the following study elucidates the advantages of spray aeration in the removal of brominated THM species.

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Glossary of Terms and Acronyms

air-to-water ratio	The physical parameter based on the ratio of either the volume or the volumetric flow rate of air versus that of water.
biota	Organisms in the environment.
brominated	Species of trihalomethanes that are partly comprised of bromine.
$CHCl_3$	Chloroform; a species of THMs.
$CHBrCl_2$	Bromodichloromethane; a species of THMs.
$CHBr_2Cl$	Dibromochloromethane; a species of THMs.
$CHBr_3$	Bromoform; a species of THMs.
chloramination	The use of chlorine in the combined form with ammonia, chloramines, for disinfection.
CSTR	Completely-stirred tank reactor.
DBPs	Disinfection by-products; chemicals formed due to interactions between disinfectants and naturally occurring organic matter.
DOC	Dissolved organic carbon.
d_{smd}	Sauter mean diameter; the diameter of a droplet that has the same volume to surface area as the total spray coming out of a nozzle.
EPA	The United States Environmental Protection Agency
Fick's First Law	A physical law that controls the rate at which dissolved masses diffuse across a concentration gradient.
fulvic acids	A type of organic acid that forms due to the breakdown of organic matter in natural waters.
Henry's Law	Physical chemistry principle that controls the extent to which a dissolved volatile substance will evacuate from the solvent it is dissolved in (typ. water).
humic acids	A type of organic acid that forms from the breakdown of organic matter waters.
IARC	International Agency for Research on Cancer
lignin	A natural byproduct of the breakdown of wood plants. Precursor to humic and fulvic acids.
NDMA	*N*-nitrosodimethylamine; a DBP and carcinogen that may be caused by chloramination.
NOM	Naturally occurring organic matter; carbon based substrates that are present in drinking water source waters.
pathogens	Disease causing microorganisms.
speciation	The relative amounts of various trihalomethane species that are present in waters being treated.
THMs	Trihalomethanes; a type of DBP formed by chlorination.
THMFP	Trihalomethane formation potential; the upper concentration limit for the amount of THMs that can be formed in a water based on its water quality.
TTHM	Total trihalomethane concentrations.
$TTHM_{formed}$	Mass of trihalomethanes formed based on the THMFP.
VOCs	Volatile organic carbon substances.
µg/L	Micrograms per liter.
µm	Micrometers.

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