A Novel Method of Water Purification: Optimizing Foam Fractionation for Effective Broad-Spectrum Removal of DBP Precursors in Chlorinated Drinking Water

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Water treatment plants use disinfectants like chlorine to eliminate waterborne diseases such as cholera and typhoid. However, disinfection results in the formation of disinfection byproducts (DBPs), toxic compounds formed when disinfectants react with natural organic matter (NOM) in water. Studies have shown a significant association between DBP exposure and an increased risk of bladder cancer in males, along with detrimental reproductive outcomes in females. Approximately 70% of halogenated byproducts in conventional drinking water remain unidentified, making them impossible to remove. Current treatment methods for removing precursors and DBPs incur significant energy demands and operational expenses. Foam fractionation separates surfactant-containing foam from liquid solutions using bubbling columns to induce phase separation. Foam fractionation has never been used or optimized for DBP and DBP precursor removal in chlorinated water. A pilot-scale foam fractionator was developed and various amino acids were tested as DBP precursors. ANOVA testing confirmed statistically significant differences ($F = 7.20$, $p = 0.00748$). The tested DBPs were analyzed using gas-chromatography mass-spectrometry. Foam fractionation removed significant (>95% removal efficiency) amounts of DBPs, with optimal foaming conditions enhancing separation efficiency while minimizing water wastage (>70% water recovery rate). The unpaired t-test indicated a $p < 0.0001$ with a 95% CI for each DBP tested. Results demonstrate that foam fractionation is a scalable, economic, reproducible, and effective method for DBP and DBP precursor removal and water resource management, demonstrating feasibility for both global and industrial applications.

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