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Removal of 1,4-Dioxane via Synergism between Non-Thermal Plasma and Aerobic Biodegradation

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Background/Objectives. 1,4-Dioxane (dioxane) is an emerging groundwater contaminant that has attracted considerable attention in recent years. Several states in the US have established drinking water and groundwater guidelines for dioxane at 0.3-1 µg/L. Advanced oxidation processes (AOP) and biological processes have been widely tested to treat dioxane-contaminated groundwater, but their application is very limited due to the high cost of AOP and slow reaction kinetics (i.e., long treatment time) of the biological processes. To minimize the disadvantage of AOP and biological processes, we tested a novel approach that combined an advanced oxidation process (i.e., a non-thermal plasma reactor [NTPR]) followed by an aerobic biological reactor.

Approach/Activities. A synthetic groundwater containing dioxane at 30 mg C/L was pretreated in an NTPR in six scenarios, which differed at the hydraulic retention time (HRT = 0, 0.1, 0.2, 0.4, 0.8, 7.2 seconds). The pretreated water (except the one with HRT = 7.2 seconds) was stored in a post-plasma reactor for two days to allow further reaction between H_2O_2 and dioxane, and then transferred to a biological batch reactor that contained activated sludge. Dissolved organic carbon (DOC, measurement of intermediates) and dioxane concentrations in the biological reactor were monitored during the five-month experiment.

Results/Lessons Learned. To remove dioxane to below 1 mg C/L and intermediates (i.e., DOC) to below 4 mg C/L, the sole non-thermal plasma process needed 7.2 seconds (i.e., HRT in NTPR = 7.2 s), the combined process needed a non-thermal plasma treatment time of 0.8 second (HRT in NTRP = 0.8 s) and a biological treatment time of 25 days (i.e., one of the four combined scenarios), and the sole biological process (i.e., HRT in NTPR = 0 s) needed more than 150 days. Therefore, the combined processes saved significant electric energy compared to the sole non-thermal plasma process and significant treatment time compared to the sole biological process.