Evaluation of cotreatment of bituminous coal mine drainage in the primary clarifier of municipal wastewater treatment facilities

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Abstract: Mine drainage (MD) is a persistent source of pollution throughout the world. While effective at raising the pH and removing dissolved metals from solution via oxidation, sorption, and/or precipitation, both passive and active MD treatment entail significant economic and environmental costs. Another option for MD treatment is utilizing existing municipal wastewater (MWW) treatment facilities to process MD. This approach provides potential benefits for the treatment of both waste streams: 1) the alkalinity present in MWW can raise the pH of MD, allowing dissolved metals to precipitate; and 2) the metals present in MD will react with PO_4 in wastewater by forming metal-PO_4 minerals or by adsorption of PO_4 to metal-hydroxides. However, there are concerns that adding MD to a MWW treatment system could impact the microbial metabolic rates in the aeration basins responsible for removing organics and nutrients from MWW.

In this study, MD from three sites with varying Fe and Al concentrations were mixed with raw MWW in 10% and 40% MD ratios and allowed to settle for two hours (simulating primary clarification in MWW treatment facilities), after which samples were taken from the supernatant and analyzed for pH, metals, PO_4, and BOD consumption. Control reactors using 10% and 40% distilled water were also evaluated. The pH after mixing and settling for two hours remained circumneutral for both 10% and 40% MD solutions. Fe and Al removal was substantial in both 10% and 40% AMD reactors, with dissolved Fe < 5 mg/L and dissolved Al < 1 mg/L in all reactors after mixing and settling for two hours. PO_4 removal from MWW was controlled by the molar ratio of ([Fe]+ [Al])/[PO_4-P] in the initial mixed solution, where PO_4-P removal increased with increasing [Fe] + [Al], and ≥95% PO_4 removal was consistently observed at ([Fe]+[Al])/[PO_4-P] > 2.0. The first-order kinetic rate of BOD removal was not significantly different between the raw MWW, MD reactors, and distilled water reactors used to observe dilution effects, indicating that the addition of bituminous coal MD to MWW treatment facilities will have little-to-no impact on BOD removal rates, given that the pH of the resulting solution remains circumneutral. Additionally, sweep floc coagulation was observed in the 40% Fe+Al MD reactor, which resulted in a ~30% decrease in the ultimate BOD (UBOD) in comparison to the 40% DI reactor. The decreased aeration requirements from removing oxygen demand in the primary clarifier could have substantial impacts on the operational costs of wastewater treatment facilities, where aeration typically accounts for over 50% of the total energy requirements in conventional activated sludge systems. Incorporating AMD treatment in existing WWTP could be an economically viable way to treat AMD while decreasing PO_4 loading in WWTP effluent. However, the alkalinity of MWW and acidity of AMD must be considered to determine appropriate mixing ratios that do impact the microbial metabolisms responsible for MWW treatment.