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Incorporating hydrothermal liquefaction into a wastewater treatment plant: Impacts on the wastewater treatment processes and management of hydrochar

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Municipal sludge from wastewater treatment plants (WWTP) requires sustainable alternatives for management due to its significant volume and hazardous contents (e.g., pathogens and micropollutants). Hydrothermal liquefaction (HTL) is the latest ground-breaking technology that can simultaneously maximize energy recovery, decompose organic pollutants, and minimize waste for disposal. It converts sludge biomass into biocrude, which can be refined into low-carbon fuels to mitigate energy crises. In the near future, this technology may replace anaerobic digesters as the ultimate solution for sludge treatment. However, properly handling its waste streams, i.e., HTL aqueous and solid residue (hydrochar), is identified as the bottleneck for implementing HTL in WWTPs. Hydrochar typically accumulates large amounts of heavy metals that raise a concern for its disposal. HTL aqueous is known to have high concentrations of chemical oxygen demand (up to 115 g/L), ammonia (up to 5.7 g/L), and other organic contaminants, which require further treatment before discharge. One of the ideas for treating HTL aqueous is to return it to the headworks of the wastewater treatment plant (WWTP). In this study, we investigated the disposal methods for hydrochar and the effects of HTL aqueous on wastewater treatment processes if returned to the WWTP headworks. Through HTL treatment of mixed (primary + secondary) sludge (20% total solids by weight) at 350°C/170 bar for 15 min, this study found that most C (58%) and energy (64%) were recovered in biocrude from mixed sludge. Nitrogen (N) was mainly distributed to biocrude (40%) and HTL aqueous (49%), while >95% of phosphorus (P) accumulated in hydrochar. Recovering P from hydrochar is encouraged although it can be landfilled as non-hazardous waste but not directly land applied. The impacts of HTL aqueous on the aerobic biological process, secondary settling, and UV disinfection were investigated in the first time. Returning HTL aqueous to the headworks could significantly increase dissolved oxygen consumption and associated operational costs, although no acute inhibition on aerobic heterotrophic cultures was observed. It also decreased downstream settling and UV disinfection performances. Consequently, alternative options, such as utilizing volatile fatty acids in HTL aqueous for methane production by anaerobic digestion before returning to headworks, are currently under examination. The findings of this study would guide the exploration for sustainable management of HTL aqueous and hydrochar and enable the incorporation of HTL into WWTPs.