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Grease Trap Waste Valorization Through Hydrothermal Liquefaction and Anaerobic Digestion: A Circular Approach to Dairy Wastewater Treatment

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Abstract

The presence of fats, oils, and greases (FOG) in dairy wastewater can cause sludge flotation in biological treatments, and result in biomass washout and thus process inefficiencies. A common approach is to separate the FOG prior to wastewater treatment using grease traps at the source site. This grease trap waste (GTW) is a complex sludge primarily composed of fatty acids, suspended solids, and water. In this study, hydrothermal liquefaction (HTL) was used to convert GTW into biocrude while the generated wastewater (AP) was subjected to anaerobic digestion (AD) to recover additional energy in the form of biomethane. To maximize the conversion of organic carbon into biocrude and minimize the use of freshwater, we evaluated the feasibility of re-using/-circulating a fraction of the AP as a reaction medium in subsequent HTL reactions (AP-R), contrasting the conventional approach of using freshwater (AP-0) in each HTL reaction. Specifically, the impacts of AP-R *vs.* AP-0 on the performance of the HTL and AD processes were evaluated in terms of the yields and properties of the biocrude produced from the GTW, and the methanogenic biodegradability, biomethane yields, and treatment efficiency of the different APs. Results show that, although marginally, the AP-R approach can increase biocrude yields in comparison to the AP-0 approach (*i.e.,* 77.7 *vs.* 73.4%). Moreover, both biocrudes showed similar HHVs, which were also comparable to that of fossil-based crude oil (*i.e., ca.* 38 *vs.* 41.9 MJ/kg); however, the biocrude produced under the AP-R approach was characterized with a lower fraction of gasoline, kerosene, diesel oil and other lighter hydrocarbons (boiling points <290°C), according to TGA analyses. Batch AD assays using the biochemical methane potential (BMP) showed a methanogenic biodegradability of 64% for the AP-0.

Compounds, such as amino phenols, pyrrolidinones, and pyridine derivatives, which are known to be inhibitory to the anaerobic microbiota, were identified in all APs *via* GC-MS analyses, likely hindering methane production. Likewise, a myriad of complex, refractory, and potentially inhibitory compounds were found in increasing relative areas with each recirculation cycle. Indeed, by the 5th recirculation cycle, the biodegradability of the AP had decreased to 47%. Finally, continuous AD using an EGSB reactor operated at a constant OLR of 3 g COD L^{-1} d^{-1}, showed that biomethane yields and treatment efficiency decreased with increasing fractions of AP-0 fed to the reactor. When the AP-0 constituted 100% of the influent COD, biomethane yields reached 210 mL g-COD^{-1} fed (at STP), whereas 68% of the influent COD was removed and 60% methanogenic biodegradability was achieved. Moreover, when 100% of the influent COD was composed of AP-R, only 45% biodegradability was achieved. Despite of the AP used, the COD of the final effluent was in the range of 630 and 950 g L^{-1}, while the overall energy recovered was 85-87% of that contained in the GTW. Our results demonstrate that the integration of HTL and AD processes allows for recovering a large fraction of the GTW energy while producing a more stabilized wastewater, diverting GTW from landfills, and mitigating GHG emissions.

Keywords: grease trap waste, anaerobic digestion, hydrothermal liquefaction, energy recovery

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