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Alternative Solutions to Solving the Problem of Accumulating Municipal Solid Waste and Sewage Sludge

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The world generated 2.01x109 tons of municipal solid waste (MSW) in 2018 and as the global population is increasing, it is expected that that MSW generation will increase by approximately 43x106 tons per year. About 44% of the generated MSW in the world consists of organic and green waste. Current solid waste management strategies include composting (5.5 %), incineration (11.1 %), sanitary landfill with gas collection (7.7%) and recycling (13.5 %). In total 33 % of generated solid waste is disposed of by dumping and 25.2 % is disposed of on uncontrolled open landfill sites. Despite mitigating strategies such as biogas capture at landfill sites, emissions from MSW is responsible for almost 5% of the world's annual greenhouse gas (GHG) emissions. Many countries struggle to keep pace with treating the ever-increasing volume of MSW and increasing volumes of sewage that is generated in concentrated areas due to global urbanization. A new strategy is thus necessary to alleviate pressure on inadequate and outdated treatment facilities by lowering the volumes of both MSW and primary sewage sludge. We propose one such strategy that will not only reduce the volume of MSW and sewage sludge but will also contribute towards the UN sustainable development goals of sustainable cities, clean water and clean, affordable energy. In our work, we have developed an MSW-based biorefinery, using hydrothermal liquefaction (HTL) as the main waste treatment step. HTL is a thermochemical process that converts organic material into bio-based liquid and solid fuels using the unique properties of water under subcritical conditions. It is ideal to treat MSW using primary sewage sludge as a solvent, thus reducing the volume of both of these waste types.

In this paper, HTL is used to produce bio-crude oil, hydrochar, process gas and an aqueous product. All reported product yields and quality is based on real-time experimental data. Considering the volume of organic waste generated, it is estimated from our research that about 1.1x1011 L of biodiesel (2% of global consumption), 2.8x108of GreenCoal (3.3 % of global consumption), 7.751x1010 m3 of pure CO2 gas (66.2% of global demand), 3.6 TWh of biogas electricity, 1.1x107 ton of platform chemicals, 1.8x107 ton of biodegradable polyurethane foam and 975 GL of clean water can be produced from the HTL products. Some of the hydrochar product (0.004 mass %) was used as an adsorbent for recovery of the alkali and alkali earth metals and phenolic platform chemicals present in the aqueous product. The carbon and nitrogen mass balance recovery of the HTL unit was 91.2 % and 76.9 %respectively. Furthermore, with an energy consumption rate of 0.142, the HTL unit will require 212 GWh to produce the products with a total average bulk market value of $365 billion. The methane in the processed biogas thus provides enough energy for the HTL unit to be run independently from the electricity grid. Furthermore, since excess electricity is generated, the biorefinery can be a stable source of electricity supply to an electricity grid.

Keywords: solid waste, sewage, bio-refinery, hydrothermal liquefaction, bio-based products