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Thermal Depolymerisation of Digestate for Biofuel and Biomaterial Production

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Extended Abstract

The global upsurge in the application of anaerobic digestion technologies to simultaneously manage agricultural waste and generate cheap bioenergy has resulted in the generation of large masses of the associated biogas digestate. This digestate must be processed and the liquid and solid fractions treated to eliminate zoonotic agents [1], recover useful water and recover cheap fertiliser respectively. Crucially however, existing digestate processing technologies are very costly and complex [2] with minimal value extractions achieved. To facilitate a cheaper and less complex digestate handling process, the present study has identified hydrothermal processing as a sufficiently green and sustainable digestate handling technological alternative. This is because the hydrothermal processing technology will facilitate the production of valuable products from high moisture containing digestate, circumventing the need for preliminary energy drying operations while also eliminating the need for additional digestate sterilisation steps, due to the conditions of high temperature and high pressure typically imposed. An investigation into the hydrothermal processing of digestate for optimal co-production of insoluble biochar product as a soil additive, which enhances soil physicochemical properties, and hydrophobic biocrude product, which has a higher heating value (30-38 MJ/kg [3]) comparable to petroleum crude[1] (~43 MJ/kg), has therefore been undertaken in the present study.

Experimental investigations established that optimal co-production masses of the desired product streams namely, energy dense biocrude and insoluble solid biochar of 205 g and 1,377 g respectively are feasible when 100 kg of high moisture digestate containing only 3.02 % wt. total solids is utilised as the feedstock. Other hydrothermal liquefaction products namely soluble solids in the post-HTL water phase and gaseous products are measured to be 559 g and 878 g, respectively. The poor optimal biocrude yield is expected since the mass of biocrude formed during the hydrothermal liquefaction process is largely dependent on the presence of lipid molecules in the feedstock [4]. This implies that since the original digestate sample contains only 1.6 wt. % lipids (on a dry digestate basis), a small mass of the biocrude product is anticipated. The measured high biochar yield is also expected, because the original digestate sample contains high concentrations of carbohydrates (41.4 wt. %) and ash (39.53 wt. %) on a dry digestate basis with previous studies establishing a strong correlation between the carbohydrate and ash contents of the feedstock and biochar yield [5].

We have also investigated the degree of carbonisation of digestate-sourced biocrude in order to amplify compositional similarities between the biocrude products and liquid fossil sourced fuels. For completeness an investigation into the chemical compound composition of the optimally produced biocrude has been undertaken as a basis for providing an improved understanding of its usefulness as a petroleum crude replacement. Some crucial agronomic properties of the optimally generated biochar product, namely, the thermal stability, pH value, electric conductivity, porosity and nutrient content have also been investigated as a precursor to an exploration of the sufficiency of biochar in the amelioration of agricultural soils.

Keywords: Hydrothermal Processing, Co-Production Optimisation, Biochar Production, Biocrude Co-Production, Agricultural Digestate Residue.

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