Preliminary investigation on Pyrolysis-Anaerobic Digestion Integration for the safe Exploitation of Digestate

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Keywords: Pyrolysis, Anaerobic Digestion, Digestate
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Digestate is the ultimate unavoidable waste of biorefining and, more in general, anaerobic digestion (AD). This material, which is a Mton resource, is not anymore suitable for biological conversion but still retains a significant amount of nutrients/carbon/energy content. Due to chemical proprieties of digestate, there is still no technical solution for small scale thermochemical conversion of digestate into a drop in energy carrier. Py-AD concept depolymerises digestate with pyrolysis, thus providing water-soluble pyrolysis products (WS) and pyrolysis gases to anaerobic digestion (performed in the presence of biochar co-product), to obtain additional biomethane. Digestate was subjected to slow pyrolysis (at 400°C and 550°C) followed by gasification in CO2/H2O atmosphere at 900°C. Pyrolysis/gasification products were quantified and characterized providing a detailed mass, energy, carbon and nitrogen balance of the process. WS was analysed in detail for the first time, characterizing a satisfactory (45%) amount of WS on a molecular basis. To address the challenges related to AD of WS and gases AD, a novel pyrolysis-anaerobic digestion (PyAD) concept was investigated. The developed system uses a continuously stirred tank reactor (CSTR, for WS) connected to a Char-Based Sparger reactor (CBSR, for gases). The CSTR receives char from the gasification stage and both WS and gases. In this reactor, to address the ammonia issue, a lab-tested approach, namely cyclic aeration of biochar (which partially nitrifies and/or strips ammonia) is used. This method exploits an important feature of AD-activated biochar, it acts as a weak acid exchange resin and concentrates a significant amount of ammonia on the solid. In practice, a portion of the biochar is withdrawn from the bottom of the CSTR, exposed to air and/or stripped and put back into the CSTR, with an extremely simple procedure that stabilizes the aqueous ammonia concentration below 3000 mgNH_3-N/L even when processing WS with 14 000 mgNH3-N/L and C/N lower than 10. The developed system allowed o process up to 5 gCOD/L d of WS and syngas, delivering biogas and an interesting nutrient enriched biochar. Overall digestate to biomethane conversion yield was 50% and AD-treated biochar showed interesting chemical features (pH<8.2, low PAHs content) that suggests a significant agronomic value.

Figure 1: Graphical description of PyAD concept for digestate valorisation