Integrated process for anaerobic digestion of dairy manure combined with ammonia recovery and biogas purification

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In this study, screened dairy manure, pressure-sterilized animal by-products, and cheese whey were co-digested in a mesophilic Plug Flow Reactor (PFR) over a period of 150 days. Dairy manure was obtained from a local animal farm and was screened at 1 mm. Pressure-sterilized animal by-products were provided from a rendering industry (Eftaxias et al., 2018) and cheese whey was collected from a local cheese factory. The mixture was characterized by TCOD = 70±8 g/L, SCOD = 26±6 g/L, NH_4-N = 1.5±0.3 g/L, TSS = 20±5 g/L, VSS = 18±6 g/L, TS = 33±5 g/L, VS = 26±2 g/L.

The PFR was constructed from plexiglass (20 L working volume) and the operational temperature was maintained at 36±1^{o}C. The PFR process was stable even under a hydraulic retention time of 3 days, corresponding to an organic loading rate (OLR) of 22 g/Ld. Effluent COD remained low (5.6±1.4 g/L) while VFA concentrations were negligible (< 0.5 g/L as COD). However, particulate COD removal was affected by the applied OLR and it decreased from 80% to 65% and 45% with OLR increasing from 7 to 15 and 22 g/Ld, respectively. The biogas production rate from the PFR ranged from 2.6 up to 7.3 L/Ld.

The anaerobic digestate was characterized by high ammonia content (1.7±0.5 g/L), which constitutes an environmental problem of great concern. Therefore, air-stripping was chosen for the effective removal of ammonia (Georgiou et al., 2019). Meanwhile, several types of quick and hydrated lime were investigated for the implementation of the necessary pretreatment step for pH-raising and the reduction of residual particulates. Hydrated lime as a slurry was finally preferred due to its fast reaction and low cost, while effective clarification of the anaerobic digestate was obtained at an elevated pH (≥11.5). A temperature of ≥45 °C was necessary for efficient ammonia removal. The final effluent was neutralized by CO_2 absorption through biogas injection in a scrubber. Concurrently, the biogas was upgraded since its methane content increased substantially, while H_2S was completely removed.

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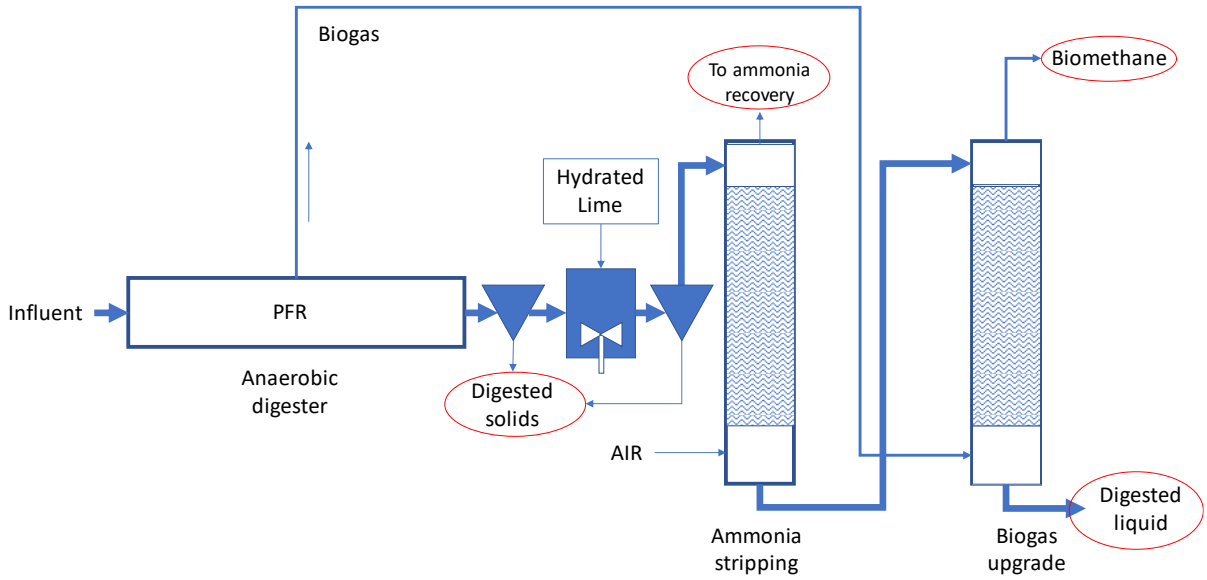

Figure 1. Schematic representation of the laboratory-scale anaerobic digestion facility combined with ammonia stripping and biogas upgrade.