## Anaerobic Co-digestion of the Halophyte Salicornia Ramosissima and Pig Manure in Lab-Scale Batch and Semi-continuous Stirred Tank Reactors: Biomethane Production and Reactor Performance

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Abstract : Optimization of the anaerobic digestion (AD) process of halophytic plants is essential as the biomass contains a high salt content that can inhibit the AD process. Anaerobic co-digestion, together with manure, can resolve the inhibitory effects of saline biomass in order to dilute the salt concentration and establish favorable conditions for the microbial consortia of the AD process. The present laboratory study investigated the co-digestion of S. ramosissima (Sram), and pig manure (PM) in batch and semi-continuous stirred tank reactors (CSTR) under mesophilic (38oC) conditions. The 0.5L batch reactor experiments were in mono- and co-digestion of Sram: PM using different percent volatile solid (VS) based ratios (0:100, 15:85, 25:75, 35:65, 50:50, 100:0) with an inoculum to substate (I/R) ratio of 2. Two 5L CSTR systems (R1 and R2) were operated for 133 days with a feed of PM in a control reactor (R1) and with a co-digestion feed in an increasing Sram VS ratio of Sram: PM of 15:85, 25:75, 35:65 in reactor R2 at an organic loading rate (OLR) of 2 gVS/L/d and hydraulic retention time (HRT) of 20 days. After a startup phase of 8 weeks for both reactors R1 and R2 with PM feed alone, the halophyte biomass Sram was added to the feed of R2 in an increasing ratio of 15 - 35 %VS Sram over an 11-week period. The process performance was monitored by pH, total solid (TS), VS, total nitrogen (TN), ammonium-nitrogen (NH4 - N), volatile fatty acids (VFA), and biomethane production. In the batch experiments, biomethane yields of 423, 418, 392, 365, 315, and 214 mL-CH4/gVS were achieved for mixtures of 0:100, 15:85, 25:75, 35:65, 50:50, 100:0 %VS Sram: PM, respectively. In the semi-continuous reactor processes, the average biomethane yields were 235, 387, and 365 mL-CH4/gVS for the phase of a co-digestion feed ratio in R2 of 15:85, 25:75, and 35:65 %VS Sram: PM, respectively. The methane yield of PM alone in R1 was in the corresponding phases on average 260, 388, and 446 mL-CH4/qVS. Accordingly, in the continuous AD process, the methane yield of the halophyte Sram was highest at 386 mL-CH4/gVS in the co-digestion ratio of 25:75%VS Sram: PM and significantly lower at 15:85 %VS Sram: PM (100 mL-CH4/gVS) and at 35:65 %VS Sram (214 mL-CH4/gVS). The co-digestion process showed no signs of inhibition at 2 - 4 g/L NH4 - N, 3.5 - 4.5 g/L TN, and total VFA of 0.45 - 2.6 g/L (based on Acetic, Propionic, Butyric and Valeric acid). This study demonstrates that a stable co-digestion process of S. ramosissima and pig manure can be achieved with a feed of 25%VS Sram at HRT of 20 d and OLR of 2 gVS/L/d.

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