Anaerobic co-digestion of liquid pig manure with coffee residues for enhanced biogas production

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Agricultural residues have been successfully converted to methanerich biogas in anaerobic digestion (AD) which have presents a double advantage of producing biogas and simultaneously treating the residues, reducing their disposal in sanitary landfills (Wang et al., 2012; Li et al., 2011; Jacqueline et al., 2016).

Pig manure are well-studied co-substrates for its high buffering capacity and high nitrogen content which could enhance the digestion of lignocelluloses, and rich in micronutrients necessary for optimum bacterial growth (Callaghan et al., 2002). Many studies was about the co-digestion of manure and other residues (Panichnumsin et al., 2010; Li et al., 2013a,b; Ye et al., 2013). The use of liquid pig manure and coffee residues as a co-substrate may reduce the environmental impact while simultaneously enhancing energy production for their complementary properties.

With an average annual production of 5.9 Mtons, coffee is one of the most commonly marketed beverages in the world. Also, global coffee consumption has increased at an average annual growth rate of 2.4% since 2011 to reach approximately 9 million tons in 2014. Furthermore, coffee is the second largest traded commodity in the world and generates large amounts of by-products and residues during processing and consuming.

Co-digestion is the simultaneous digestion of a homogenous mixture of two or more substrates. Traditionally, anaerobic digestion was a single substrate, single purpose treatment. Recently, it has been realized that anaerobic digestion as such becomes more stable when the variety of substrates applied at the same time is increased. The most common situation is when a large amount of a main basic substrate (e.g. manure or sewage sludge) is mixed and digested together with minor amounts of a single, or a variety of additional substrates (Braun, 2002). The use of co-substrates usually improves the biogas yields from anaerobic digesters due to positive synergisms established in the digestion medium and the supply of missing nutrients by the co-substrates (Mata-Alvarez et al., 2014). Braun (2002) presents several possible ecological, technological and economic advantages of co-digestion, such as improved nutrient balance for optimal digestion and good fertilizer quality, and increased, steady biogas production throughout the seasons.

Optimization of biogas production from liquid pig manure (LPM) was attempted by co-digesting with coffee residues (CR). The continuous experiments were carried out in 220 L digester with 180L working volume. Initially, the reactor was inoculated with anaerobic sludge originating from anaerobic digester (fed with the same sewage sludge used in this experiment) of MSTP of the city of Heraklion, and contained 13. ± 4.1 g/L TS, 8.9 ± 3.7 g/L VS and 15.3 ± 2.5 g/L COD. Feedstock was added once daily, with a total feeding volume of 7.5 L daily and a hydraulic retention time (HRT) of 24 days, at a constant temperature of 37±2 ^{o}C. The initial feed was liquid pig manure and the bioreactor was operated using this feed for 60 days. The coffee residues were then added to the feed so that the reactor was fed continuously with a mixture of liquid pig manure and coffee residues with approximately 7 % of Total Solids (TS). The bioreactor was operated using this feed for 65 days.
The reactor treating the LPM produced approximately 22 $L_{biogas}/L_{reactor}$/d before the addition of CR and 240 $L_{biogas}/L_{reactor}$/d (7% TS of the mixture). The average removal of total chemical oxygen demand (T-COD) was 26 % for LPM & CR mixture and 19% reduction in the volatile solids.

The concept of co-digestion could be a promising perspective at anaerobic digestion units as it increases methane production significantly. Results show a great ascendancy of mixtures with LPM and CR (7% TS), as they improve significantly the biogas production rate.

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