Co-digestion of condensate produced from drying of Household Fermentable Waste and Landfill Leachate for Biogas production through Anaerobic Digestion

K. Filippou [1], P.M. Bourcha [1], A. Zarchaliou [1], K. Papadopoulou [1], G. Lyberatos [1, 2]

[1] School of Chemical Engineering, National Technical University of Athens, Zografou Campus, Athens, 15780, Greece

[2] Institute of Chemical Engineering Sciences, Stadiou Str, Platani, 26504, Patras, Greece

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Presenting author email: filippoukonstandina@gmail.com

According to the Food and Agriculture Organization, about 1.3 billion tons of food are lost or wasted each year worldwide. At the same time, the average amount of municipal solid waste (MSW) generated per capita in the European Union was accounted as 477 kg per year in 2015 (Malinauskaite et al., 2017). Moreover, households are one of the main sources of fermentable waste, in Europe. Conventional methods of food waste (FW) treatment include landfilling and incineration, with almost 95% of FW being landfilled. In Greece, FW is collected and managed the same way as recyclables (plastics, paper / cardboard, glass and metals) in green bins with direct disposal in landfills. The MSW disposed of in landfills can take decades or even hundreds of years for complete degradation, with some of the environmental impacts of its disposal in landfills being aquifer pollution from the produced leachate, emission of greenhouse gases (GHG) and odour generation (Capson-Tojo et al., 2016).

Leachate can be defined as a liquid that is produced from the degradation of the organic fraction of the wastes in the landfill, in combination with the percolating rain water (El-Gohary & Kamel, 2016). It extracts dissolved and suspended matter from the MSW and causes significant threat to surface water and groundwater (Raghab et al., 2013).

An innovative household fermentable waste (HFW) valorization approach was developed within the framework of the Horizon 2020 project Waste4think which included a drying/shredding process of the HFW resulting in a homogenized solid biomass product named FORBI (Food Residue Biomass). Almost 75-80% of the initial moisture of raw material was removed, in the form of water vapors that are collected by a condenser. The produced condensate is rich in organic carbon but poor in nitrogen which limits its biological treatment (Lytras et al., 2020).

Anaerobic digestion (AD) is considered as an environmentally friendly and cost- effective alternative for renewable energy production and treatment of organic matter (Xu et al., 2018). The two products of AD, biogas and nutrient rich digestate, can both be utilized. Biogas can be used for production of electricity, heat or fuel, and digestate serves as an organic matrix with agronomic properties (Logan & Visvanathan, 2019).

The aim of this work was the anaerobic co-digestion of condensate produced by the drying/shredding process of HFW and leachate from landfills. Production of biogas, COD reduction of the feedstock and the simulation of the anaerobic digester process based on the mathematical Anaerobic Digestion Model No. 1 (ADM1) in Aquasim 2.0 software was evaluated.

For the purpose of the experiments, a lab-scale (4L) CSTR was used, which operated under mesophilic conditions (35ºC) with hydraulic retention time (HRT) of 20 days in 3 different phases. In the 1st experimental phase, a glucose solution was used as feedstock, as a transitional stage for biomass acclimatization. The methane percentage in biogas, during that phase, was 39% and 91% removal of COD was achieved. During the 2nd and 3rd experimental phase, synthetic condensate with synthetic landfill leachate and real condensate with synthetic landfill leachate were used as substrate, respectively. The methane percentage in biogas was 53% and 40%, respectively. The ratio of condensate to leachate remained stable at 3:1 for the last 2 phases of the experiment. The C:N ratios examined were 50:1 for the first 2 phases and 30:1 for the last one. The organic loading rate (OLR) was the same during the whole experiment, at 0.32 g COD/L/d. Furthermore, the modeling of anaerobic digester process is satisfying as the experimental findings are similar to those of the model.

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