Anaerobic co-digestion of agricultural residues produced in Southern Greece during spring/summer season

V.P. Aravani[1], K. Tsigkou[2], M. Kornaros[2], V.G. Papadakis[1]

[1]Department of Environmental Engineering, University of Patras, Seferi 2, 30100, Agrinio, Greece
[2]Department of Chemical Engineering, University of Patras, Karatheodori 1, University Campus-Rio, 26504, Patras, Greece
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Presenting author email: vasiliki.arav@gmail.com

Greece exhibits high biomass potential due to its intense agricultural activity. The main categories of residual biomass in Greece are: (a) crop residues that are left in the fields, (b) animal manures and (c) secondary agricultural (liquid and solid) wastes from agricultural processing plants. Although most European countries use biomass as significant source of electricity and thermal energy, in Greece only a small percentage of biomass is valorised in order to cover electrical energy needs. The management practice still followed in many areas around Greece consists in burning the residual biomass in the field (Aravani et al., 2022).

Anaerobic digestion is one of the most environmentally friendly technologies, able to convert organic wastes to valuable energy sources (Moustakas et al., 2020; Vlyssides et al., 2015). In particular, anaerobic co-digestion offers a variety of advantages, among them the low-cost and the mitigation of inhibition due to toxic substances (i.e., ammonia, etc.) contained in single waste streams (Cortesi et al., 2018; Kashi et al., 2017). Although this process has been investigated for many years, in Greece there is still lack of experimental knowledge on the valorisation of locally available substrates.

In Southern Greece, the most abundant residues suitable for anaerobic digestion during the spring/summer season are corn silage, tomato processing residues, unsuitable for human consumption watermelons, and cattle manure. The aim of this study was the assessment of biochemical methane potential (BMP) of the representative biomass feedstocks of Southern Greece, which are available during the spring/summer season in order to define their potential for biogas production and subsequently follow the evaluation of their anaerobic-co-digestion in a continuous one-stage system.

Design of Experiments (DOE) by Minitab, 19 was used for the various substrate mixtures prior to the BMP assays, while the procedure protocol was based on Angelidaki et al. (2009). The biogas composition analysis was determined by a gas chromatographer (Agilent Technologies 7890A) with a thermal conductivity detector (TCD), while the physicochemical parameters were measured according to the "*Standard Methods for the Examination of Water and Wastewater*" (APHA AWWA WEF, 2012).

Concerning the results of the BMP assays, the highest methane yield was exhibited by watermelon as mono-substrate (421 ml CH_4/g VS_{added}) (Figure 1). After the evaluation of the mixtures and mono-substrates results, one of the most promising mixtures for wet anaerobic digestion seemed to be the case of 10% corn silage-14% cattle manure-66% watermelon-10% tomato processing residues (w/w), in terms of methane yield maximization, while its moisture content is maintained higher or equal to 80%.

The selected agro-waste mixture was subsequently tested as feedstock in a mesophilic single-stage continuous anaerobic digestion system with working volume of 0.75 L. The digester was operated at a hydraulic retention time (HRT) of 20 days and an initial organic loading rate (OLR) of 2 g COD/($L_{Reactor}$·d). In order to assess the system's performance and operation limits, the OLR was further increased after the system reached steady state conditions. Concerning the results, the reactor operated successfully with the applied OLR of 2, 2.5 and 3 g COD/(L_R·d). However, at OLR 4 g COD/(L_R·d) the pH value decreased (less than 7) while concurrently the concentration of propionic acid increased at approximately 1161-2664 mg/L, indicating that the system performance has reached its limits. The methane content was in the range of 54-62% for all the tested OLRs, while the COD removal ranged between 54-59% for the OLR of 3 and 4 g COD/(L_R·d), proving thus a successful performance for the selected feedstock.

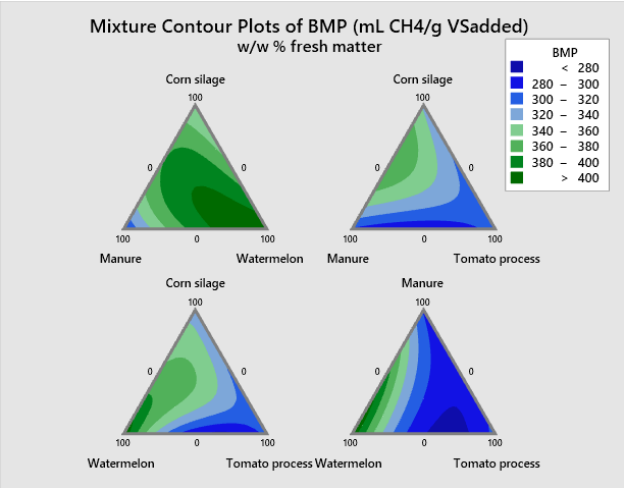

Figure 1*:* BMP results in relation to the individual components in Southern Greece spring/summer mixture (% w/w)

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