Biochemical methane potential of various promising agricultural residues in Southern and Northern Greece

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Greece is an agricultural country and significant proportion of its biomass consists of crop residues and livestock manure. Greece's agricultural residues include: a) the remaining matter after harvesting such as cereal straw, shoots from tobacco plant, cotton, sunflower, etc., b) materials collected during the pruning of fruit trees, olive trees and vineyards, c) the by-products of agricultural industries such as nut shells, kernels, tomato peels etc., and d) wastes generated in animal breeding farms such as manure, wastewater etc. Huge quantities of agricultural and animal waste are dumped uncontrollably in the environment or in landfills, while farmers continue to burn the residual biomass in the fields. Uncontrolled combustion leads to significant impacts on both the environment and human health, but also to loss of large amounts of energy and unexploited biomass.

For the needs of this study, Greece was divided into a Northern and a Southern part and relevant plans were made for residual biomass valorization through energy production via anaerobic digestion. For Northern Greece this study concluded that the most abundant residues, which are also suitable for anaerobic digestion, are those of corn, cattle manure and malt (the main by-product of breweries). For Southern Greece the most abundant residues suitable for anaerobic digestion are those of corn, watermelon, cattle manure and residues of tomato, orange and olive processing. The choice of residues was also based on their characteristics and ease of collection.

Anaerobic digestion has been frequently considered as the best environmental and economic solution for energy recovery from different biodegradable waste. More specifically, anaerobic co-digestion has proven to be an effective, low-cost and promising solution for overcoming process inhibition problems due to the presence of toxic substances such as heavy metals, phenolic compounds etc. contained in single waste streams. Anaerobic digestion is a well-known biological process that has been investigated for many years. However, in Greece there is a lack of experimental knowledge on the co-processing of locally available substrates including residues from the three main categories that have been identified in Greece, i.e. crop residues, agro-industrial residues and animal manure.

Following our estimations and conclusions, samples have been collected from all promising feedstocks for anaerobic digestion to conduct biochemical methane potential (BMP) assays in order to assess the wastes' real potential for biogas production and define, thus, the most promising mixtures of those based on detailed experimentation. More specifically, the raw residues that were evaluated in the current work included (a) crop residues (corn silage and unsuitable for human consumption watermelon), (b) agro-industrial residues (tomato processing residues) and (c) livestock (cattle) manure. BMP assays testing the single substrates and various mixtures were conducted, for the evaluation of the methane yields. The experimental design of BMP assays was organized according to DOE (Design of Experiments). In this design of experiments, the proportions of the mixtures' constituents are variable while their total amount remains unchanged. The determination of the maximum experimental value of methane was carried out based on the protocol "Defining the biomethane potential (BMP) of solid organic wastes and energy crops" by Angelidaki et al (2009) and the biogas composition analysis was measured using a gas chromatographer (Agilent Technologies 7890A) with a thermal conductivity detector (TCD).

Concerning the results of the BMP assays, the highest methane yield was exhibited by watermelon as mono-substrate (421 ml CH4/g VS_{added}). After the evaluation of the mixtures and mono-substrates results, one of the most promising mixtures seemed to be the case of 12.5% corn silage-12.5% cattle manure-62.5% watermelon-12.5% tomato processing residues (w/w). The proposed feedstock mixture not only exhibited high yield (almost 90% of the maximum experimental BMP value), but is also characterized by high moisture due to the increased ratio in watermelon, leading to its valorization in wet anaerobic digestion systems. Additionally, most of the mixtures indicated synergistic effects during co-digestion compared to the single substrates' efficiency.

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