Cosubstrate strategy for enhancing biomass degradation during low-thermal pre-treatment

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1. Introduction

Agricultural waste (AW) is defined as unwanted or unsalable materials produced from many agricultural operations directly related to the growing of crops or raising of animals. The main component of AW are usually animal waste, food processing waste, crop waste and hazardous agricultural waste such as insecticides, pesticides and herbicides (Kasinath et al., 2021). Considering increasing amount of AW produced of all the world, in many developing countries, they are dumped or burnt. In a results the air pollution, soil contamination, harmful gases, smoke and dust are produced and accumulated in environment.

The composition of agricultural waste can differ significantly. For this reason, selection of appropriate techniques used for treating of AW is important technological challenges (Kor-Bicakci & Eskicioglu, 2019). The most popular method used for sewage sludge is anaerobic digestion (AD) which also is used for other substrate such as agricultural waste. However, due to complex microbiome structure of some types of wastes, methane yield production during AD can be not profitable. One of the possible operation which can be applied before AD is pre-treatment of substrates. In terms of AW, mechanical, ultrasound, chemical and thermal pre-treatment techniques can be usually applied (Carrère et al., 2009).

Thermal pre-treatment techniques are divided into two groups - low-thermal (<100°C) and thermal hydrolysis (≥100°C). In many cases, highly effective degradation of organic matter can be obtained using thermal hydrolysis, but in most cases energy consumption of this process are relatively high. For this reason, in recent years low-thermal pre-treatment of AW have become increasing popularity (Kelessidis & Stasinakis, 2012).

In literature there is lack of comprehensive studies about optimization of thermal pre-treatment of AW to increase their conversion into biogas during AD. The objective of this work was to study a LT-PT of various types of agricultural waste for enhancing biomass degradation.

2. Materials and methods

In this study mixtures: cow dung with corn and distillery with beet pellet was used as a substrates. Low-thermal pre-treatment was performed in lab-scale in 20l reactors consist heating system, mechanical stirrer and automatically air-pumping system. Treatments were applied during 48h at temperatures: 45, 50, 55 and 60°C. Directly after the pre-treatment, samples were centrifuged (50,000g, 10 000 RPM, 30 min, 20°C). The supernatant (which represented the liquid or soluble phase) were stored at 4 °C before analysis, not longer than 24h. In order to control the efficiency of the low-thermal pre-treatment of AW used in this study, the following parameters were determined in substrate both before and after LT-PT: pH, conductivity, redox, dissolved oxygen concentration (multi-parameter meter HL-HQ40d, HACH, Germany). Additionally, in supernatant volatile fatty acids (VFAs), chemical oxygen demand (COD), ammonia ($N\text{-}NH_4^+$), total nitrogen (TN), total phosphorus (TP) and ortho-phosphate phosphorus ($P\text{-}PO_4^{3-}$) concentrations was obtained using XION 500 spectrophotometer Dr. Lange (GmbH, Germany).

3. Results and discussion

A results of LT-PT of substrates used in this study is degradation and transfer of some particulate matter into the supernatant. As shown in figure 1, the release of VFAs into the liquid phase increases with the duration time of LT-PT. The highest values of VFAs were obtained for both substrates after 48h. In comparison to untreated substrates, even after 24h VFAs concentrations were significantly higher, which is related with enhances degradation of organic matter present in AW.

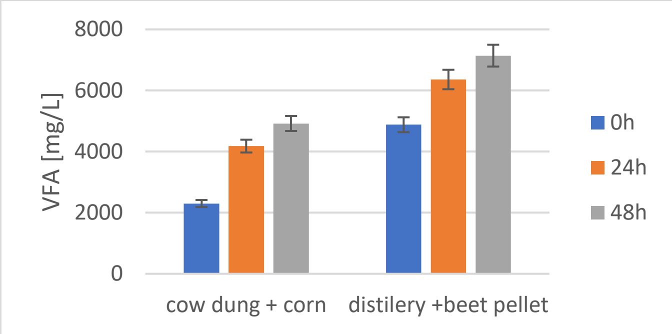

Fig.1. Changes in volatile fatty acids concentration in two substrates: cow dung + corn and distilery +beet pellet during low-thermal pre-treatment at 55°C.

Figure 2 present example the effect of LT-PT of substrates used in this study on degree of solubilisation based on the changes in COD values for disintegration performed at 55°C. Based on these data, it can be observe that especially for mixture cow-dung and corn, COD values significantly increase after LT-PT with duration time 24h. For this substrate COD values obtained after 24h and 48h were similar, which can indicate that intensive degradation of organic matter for this substrate occurs mainly in the initial phase of process.

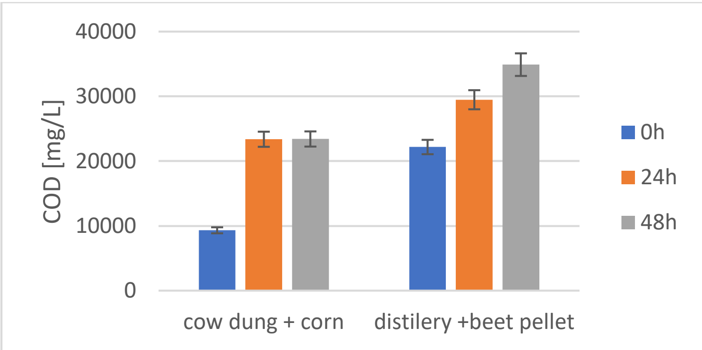

Fig. 2. Changes in chemical oxygen demand concentration in two substrates: cow dung + corn and distilery +beet pellet during low-thermal pre-treatment at 55°C.

4. Conclusions

Low thermal pre-treatment at temperatures ranging from 40 to 60°C allowed the transfer of organic matter from the particulate to the soluble fraction of agricultural waste. Increase of COD and VFAs concentration in AW after LT-PT confirm higher bioavailability of organic substances, which can be readily used by methanogenic bacteria. Therefore, low thermal pre-treatment of AW can be regarded as a promising method to enhance biogas production during AD.

5. References

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