Valorization of medical plants residues through anaerobic digestion.

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Abstract

Over the last decade, as a response to the negative effects mainly caused by the economic crisis, young Greeks have turned to the primary sector. In contrast to the traditional cultivation schemes, young farmers have invested in the establishment of alternative crops, among which, are included the lavender (Lavandula sp.) for the production of essential oils, as well as the industrial hemp (Cannabis Sativa L.) for the production of fiber, food, and medicines. These alternative crops play an important role in the regional development with positive environmental, economic and social impacts, i.e. enhancement of biodiversity; job creation and improvement of human life.

Apart from the benefits resulting from the production of the aforementioned high added value products, the management of the by products remained after the processing of raw plant materials could also contribute to the further development of local economies. The collection, recovery and processing of agricultural origin wastes could lead to the creation of a suitable feedstock for alternative uses.

This study aims to investigate the biomethane potential Lavender residues, C.Sativa residues, C.Sativa pellets and a mixture of Lavender and C.Sativa residues.

Introduction

At European and global level, the largest percentage of waste comes from livestock activities, whose waste or by-products can be further used for energy production. The collection, recovery and processing of agricultural origin wastes could lead to the creation of a suitable feedstock for alternative uses such as anaerobic digestion.

The lavender straw, the by-product obtained from the distillation process for the extraction of essential oil, include valuable chemical compounds of commercial and industrial interest. Additionally, agricultural residues remained at the field or the wastes produced by the processing of hemp, are considered a promising feedstock for bioenergy purposes.

Anaerobic digestion is an attractive technology that combines waste treatment of any type of waste and renewable energy recovery. Digestion is a complex biochemical process in which organic material is decomposed by several groups of microorganisms in the absence of oxygen while renewable energy such as biogas is generated.

Material and Methods

Analytical methods

The measurements of TS, VS, COD, NH_4^+, TOC and TN were carried out according to APHA Standard Methods. The pH was measured using a digital pH-meter (Hanna, HI2260). For the quantifications of TOC and TN of inoculum and digestate, a TOC analyser (Shimadzu, TOC-L) was used. Ultimate and proximate analysis carried out for the medical plant residues.

Inoculum and Substrate

Anaerobic sludge was used as inoculum (microbial culture) for the biomethane potential test arrays and obtained from a commercial mesophilic anaerobic digester plant in the area of Eordea (Western Macedonia).The substrates for the digestion process were Lavender residues,C.Sativa residues and C.Sativa pellets from the production process of cannabis essential oil. The medical plants residues are from established units in Western Macedonia. The calculation for the SIR ratios were determined according to the VS of the substrate and the inoculum. During start-up, flushing with N_2 took place and all samples were incubated at mesophilic conditions (35 +/-2°C) about two months. All batch tests were performed in triplicate.

Biomethane Potential Test

BMP test is a technique to determine the biodegradability and methane potential of any type of waste. Batch experiments carried out using the Automated Methane Potential Test System II (AMPTS II). Each of the AMPTS' reactors had 500 ml bottles with 400ml working volume, was equipped with an individual mechanical stirrer for agitation and operated as a bench scale anaerobic glass reactor. The produced biogas from each glass reactor passed through a 3 M NaOH solution to absorb CO_2 and H_2S.

The upgraded biogas passed through a flow cell (one for each glass reactor) which measured gas productivity through water displacement. The digital impulse was registered by computer. The results of BMP test experiments are expressed as normalized mL. Four tests performed. Three tests were the herbs residues as received after grinding and one test was a co-digestion of Lavender and C.Sativa residues.

Results and Discussion

The cumulative biomethane yield during of BMP tests of all substrates are shown in Figure 1. The batch test lasted 48 days until little or no biogas production was obtained. According to Table 1, Lavender residues produced the lowest biomethane yield per g VS added and C.Sativa the highest. In particular, Lavender residues produced 19,23 Nml CH_4/ g VS added and C.Sativa 250,5 NmlCH_4/g VS added.

As illustrated in figure 1b, a high biomethane flow rate is observed from the 1st day for C.Sativa batch experiments and was continued until the 19st day. After the 21st day is observed a continuous reduction of C.sativa residues flow rate, until the cease of the batch experiments at the 48th day. The biomethane flow rate of Lavender was lower compared to the other batch tests flow rate. The degradation of VS (VS_{deg}) for all batch tests are shown in Table1.

Table 1. Main Characteristics of the lab scale bioreactors (BMP), during the start-up and after the end of the experiment.

Parameter (unit)	Lavender		C.Sativa		Lavender-C.Sativa 1:1		C.Sativa Pellets	
	Start	End	Start	End	Start	End	Start	End
pH	7,90	7,91	7,79	8,02	7,96	7,74	7,78	8,06
VS(g/L)	39,0	14,0	39,0	18,0	39,0	19,0	41,0	7,0
mL CH4/g VS	19,23		250,5		166,26		183,5	
Test Days	48		48		48		48	
VS_{deg} (%)	64,10		53,84		51,28		82,92	

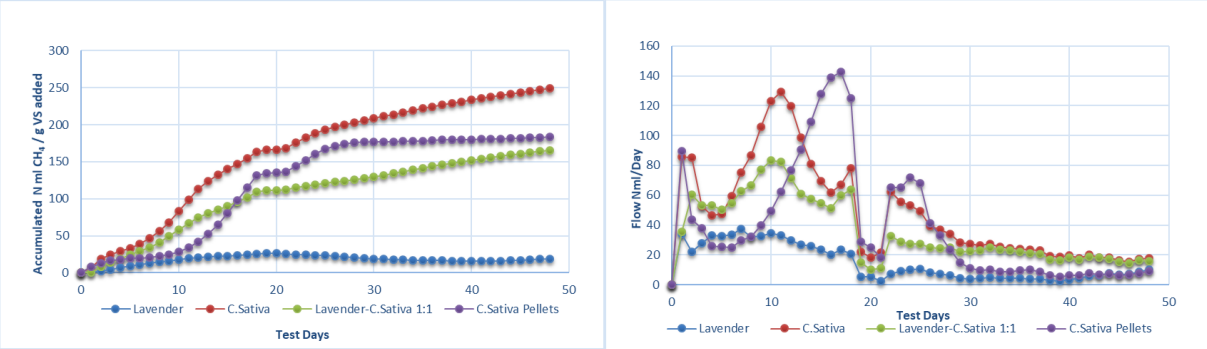

Figure 1. (a)Accumulated Nml CH4/g VS added of herb residues and (b) Flow (Nml/day).

Conclusions

The results from mesophilic anaerobic digestion shows that is possible to produced renewable energy from these type of waste instead of other techniques for energy production such as combustion. According to experimental results, C.Sativa residues, co-digestion residues and C.Sativa pellets have higher biomethane yield compared to Lavender residues. The degradability of VS from Lavender residues, C.Sativa, the co-digestion residues and the C.Sativa pellets were 64,10 %, 53,84 %, 51,28 % and 82,92 % respectively.

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