Integrated management of foodwaste leachates : Recovery of added value products and biomethane production.

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Abstract
Over 100 kg of foodwaste per person are disposed of annually, according to European Commission. The importance of foodwaste extends beyond environmental pressures to economic and social impacts. It is imperative to find innovative and sustainable solutions for the growing global challenge of managing foodwaste. This study proposes an integrated management approach focused on foodwaste leachates, with the goal of recovering added value compounds and enhancing the biomethane production.

Introduction

A significant concern, at European and global level, in contemporary society is the high quantity of food waste. It is estimated that in European Union, the year 2021, about over 58 million tonnes of food waste (FW) were generated. These tonnes correspond to 131 kg/inhabitant per year [1]. Approximately, 54 % of this quantity per individual, were originated from households [2]. As reported by European Commission [3], the estimated value of the discarded foods amounts to 132 billion euros.

FW contains compounds with beneficial properties for living organisms. These compounds, called as bioactive, could be isolated and provide functional benefits. Several extraction techniques have been reported for the isolation of these compounds and further determination for their identification using high precision analytical equipment.

In terms of reducing energy demands from fossil fuels, foodwaste leachates (FWL) can serve as an alternative source of energy production through anaerobic digestion. FWL are rich in hydrocarbons, protein and lipids, and their decomposition results in high yield of Volatile Fatty Acids (VFAs). The latter are being precursors compounds for biomethane production.

The purpose of this study is to investigate the possibility of obtaining valuable compounds from FWL and, thereafter the generation of biomethane from the extracted residues.

Material and Methods

Analytical methods

The measurements of TS, VS, COD, NH_4^+, TOC and Alkalinity were carried out according to APHA Standard Methods [4]. TN content based on ASTM D8083**.** The pH was estimated 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. The concentration of VFAs was calculated as described by Kapp et al [5] and expressed as Acetic Acid equivalents (HAceq). COD, NH_4^+ and Total Phenolic Content (TPC) quantified with a HACH DR2800 spectometer.

The volatile compounds of FWL were identified with Solid Phase Microextraction/Gas Chromatography Mass Spectrometry (SPME/GCMS). The biomethane potential yield carried out using the Automated Methane Potential Test System II (AMPTS II).

Substrate and Inoculum

Anaerobic sludge was obtained from a commercial mesophilic anaerobic digester plant in the area of Eordea (Western Macedonia) and was used as inoculum. Substrates for the digestion process were Foodwaste leachates (FWL) and extracted Foodwaste leachates (FWLe). The FWL were mainly composed by fruits and vegetables. The SIR ratio was determined based on the VS content of the test materials.

Biomethane Potential Test

Used 500 ml glass bottles with 400ml working volume, equipped with an individual stirrer of each bottle, for agitation and operated as a bench scale reactors. The generated biogas from each glass reactor passed through a 3 M NaOH aquatic solution to absorb CO_2 and H_2S. For anaerobic conditions, nitrogen gas was used at the beginning of the batch experiments. The tests were carried out under mesophilic conditions (35 +/-2°C).

The purified biogas was passed through a flow cell unit (each bottle is equipped with an individual flow cell) and the gas productivity was evaluated by water displacement. A computer recorded the digital signal. The results of BMP assays are expressed as normalized mL. All biomethane production tests were performed in triplicate.

Results and Discussion

Table 1 demonstrates the main characteristics of the inoculum and FWL. The retrieved volatile compounds using SPME/GCMS technique (Table 2) were identified according to those listed in the NIST 2020 library.

Table 1. Main Characteristics of inoculum and foodwaste leachates.

Parameter (unit)	Inoculum	FWL
pH (-)	8,3	5,42
TS (g/L)	56,0	41,2
VS (g/L)	39,0	34,5
TOC (g/L)	3,65	17,0
Alkalinity (g/L)	10,2	9,2
VFAs (g HACeq/L)	2,2	14,0
COD (g/L)	4,0	55,0
NH_4^+ (g/L)	1,9	1,1

Table 2. Identification of volatile compounds emitted by foodwaste leachates.

No.	Rt(min)	Identified Compound
1	5,00	Butanoic acid, ethyl ester
2	9,19	Butanoic acid, propyl ester
3	9,31	Pentanoic acid, ethyl ester
4	10,48	α-Pinene
5	10,89	Butanoic acid, 1-methylpropyl ester
6	12,23	b- Pinene
7	13,39	Hexanoic acid, ethyl ester
8	14,50	D-limonene
9	15,52	Gamma terpinene
10	17,23	Nonanal

Conclusions

This study aims to highlight the recovery of bioactive compounds and generated energy from foodwaste, utilizing a circular economy and biorefinery framework. FWL demonstrated a high organic content, thereby rendering it an ideal substrate for anaerobic digestion. Several bioactive compounds were identified that could be isolated and used in the cosmetic, pharmaceutical and food industry.

References

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