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[1.] P.V.R. KOVÁCS, [2.] S. BESZÉDES, [3.] L. LUDÁNYI, [4.] C. HODÚR, [5.] G. KESZTHELYI-SZABÓ

EFFECT OF TEMPERATURE ON BIOGAS YIELD OF MICROWAVE TREATED WHEY

[1.] Department of Engineering, Faculty of Engineering, University of Szeged, Moszkvai 9, Szeged, HUNGARY
[2-5.] Department of Process Engineering, Faculty of Engineering, University of Szeged, Szeged, HUNGARY

Abstract: Anaerobic digestion of cheese whey is a cost-effective way to dispose the wastewater safely and at the same time benefit could be realized directly from the energy recovered in the form of biogas. Microwave irradiation as a method for sludge treatment has gained widespread popularity, mainly due to enhance biodegradability and increase yield of biogas. In this study the effect of the final temperature of the microwave treated whey on biogas yield was investigated. Treatment was performed in a continuous flow treating system at different irradiation power levels, whey concentrations and flow rates. Experiments indicated that both the yield of biogas and the final temperature of the concentrated whey were higher than the whey's at the same set treating parameters. But the energy demands were higher in cases of concentrated whey because of the energy demand of membrane separation.
Keywords: microwave pre-treatment, biogas production (BP), anaerobic digestion

1. INTRODUCTION

Positive results of rapid technical development are evident to all of us. However, not sufficiently thought out innovations have a negative effects as well. Establishing new guidelines is necessary to eliminate these problems; each of the solutions must be closely related to strategy of sustainable development. The international energy research and development efforts, as well as the EU's energy policy have an increasingly emphasis in the "waste-to-energy" concept, which simultaneously provides a solution to the production of usable energy, in addition to waste management problems as well. The wastewater treatment technologies for municipal and industrial sources are becoming more emphasized in technical and environmental developments. The high content of organic wastewaters has highly environmentally harmful effects, but even the high organic matter content ensures the production of biogas using anaerobic fermentation process.

Studying the effect of microwave radiation on the municipal sewage sludge it was found that enhanced organics water solubility (Eskicioglu et. al., 2008) and volatile organic compounds (Pino-Jelcic et. al., 2006) can be achieved by microwave energy than conventional heat treatment processes. Easier access to the decomposition of organic matter by microorganisms results higher biogas yield during the anaerobic fermentation (Eskicioglu et. al., 2009), and accelerate the pace of dismantling.

2. MATERIALS AND METHODS

2.1.Materials

Whey is a by-product of cheese production. This component is separated from milk after curdling. Cheese whey can be used in many ways; the most common practice is supplying as feed for animals, because of its nutritional value. Another way to utilize whey is to recover lactose and whey protein separately and be further used for other applications. There are certain disadvantages inhibiting these practices to be fully applied. The major disadvantages are its high

content in water that must be removed; the high energy cost of drying process and the competitive products are already available in the market. However, markets are developing continuously; there is still a surplus of whey produced above and beyond the market for whey products. In this respect, the anaerobic digestion of cheese whey is a cost-effective configuration for the cheese producers who owe to dispose the wastewater safely and, at the same time, could benefit directly from the energy recovered in the form of biogas. (Antonopoulou G., et. al.)
Two concentrations of whey were examined. One of these is the original whey (whey) coming from a milk-processing factory (Csongrád, Hungary), and the other is concentrated by membrane separation (concentrate). The ingredients of the samples can be found in Table 1.

Table 1. Ingredients of examined whey

	Protein [%]	Lactose [%]	Fat [%]	Total solids [%]
Whey	0.47±0.13	2.61±0.04	0.18±0.01	3.24±0.07
Concentrate	0.73±0.16	3.59±0.09	0.34±0.08	5.36±0.24

2.2. Methods

Treating of samples was carried out in a microwave pre-treating system. It contains a magnetron operating at 2450 MHz. High-voltage power supply feeds the magnetron. It consists of two transformers; one of them produces cathode heating voltage and heating current, the other produces the anode voltage which can be controlled by the primary circuit of an external auto-transformer. Power of the magnetron can be set by this device as well. Electromagnetic energy of the magnetron spread over a resonant slot. Getting through this slot the energy gets in the toroidal resonator. (Kovács et al, 2012). During the operation of toroid resonator energy is given to the treated material. As a result of energy transmission the temperature of the material rises and the dielectric properties change continuously. The effect of the microwave energy intake, variable power, impedance and dielectric relationships are formed in the microwave resonator. Some of these can be measured (eg. power dissipation, reflected power), some of them can only be determined by calculation, knowledge of the other parameters (J. Zhu et al, 2007). Material is transferred in the continues-flow microwave treating system by a membrane pump with variable flow.

Microwave pre-treatment

Treatments were carried out at different powers of magnetron, and at different flows. These set parameters are shown in the table bellow (Table 2).

Table 2. Microwave pre-treatment conditions

Number of sample	Treated material	Flow [l/h]	Power of magnetron [W]	Max. temperature of whey [°C]
1	Whey	6	350	63
2	Whey	6	850	82,9
3	Whey	25	350	27,1
4	Whey	25	850	42,7
5	Concentrate	6	350	66,8
6	Concentrate	6	850	89,5
7	Concentrate	25	850	34,2

Fermentation process, biogas measurement

Digestion was performed at mesophilic temperature range (35 °C). Whey samples were inoculated with anaerobic sludge, the whey: fire sludge volume ratio was 4:1.
BOD OxiTop PM manometric measuring system with 12 mini continuously stirred digesters was used for measuring biogas yield. (Fig.1.)

3. RESULTS and DISCUSSION

In our experiments the effect of the final temperature of treated samples was investigated, which was characterized by cumulative biogas production.
Cumulative biogas productions for different samples and conditions of whey are shown in Fig.2. Biogas production rate and the final temperature were higher for all the concentrated samples.

Differences in the value of the final temperature is related to the dielectric properties of materials In practice, the real focus of interest is on the dielectric constant or permittivity ε’ and the dielectric loss factor ε”, the real and imaginary parts of complex dielectric constant. The real dielectric constant shows the material's ability to absorb energy from the electromagnetic field, the heat loss factor proportional to the rate of energy converted to heat.

Based on the measurement results of another study (Kovács et. al., 2013.), we can determine that the biogas yield itself doesn't characterize a pre-treatment process, amount of energy investment must be taken to consideration with the use of biogas quantity can be reached.

Figure1. BOD OxiTop PM

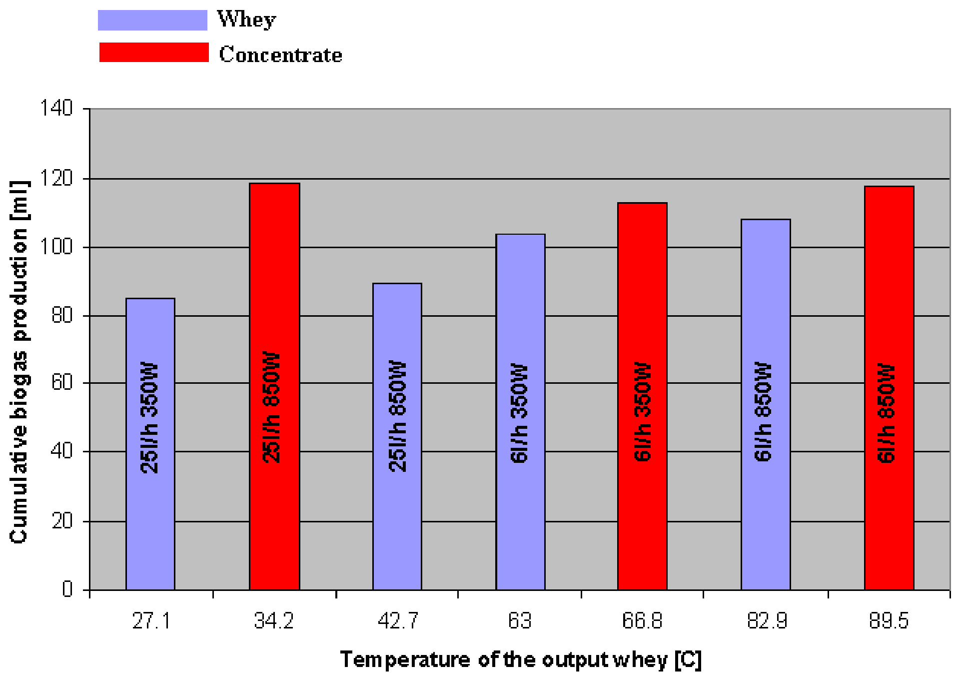

Figure 2. Cumulative biogas production at different conditions

The most energy-efficient treatment was at low flow-rate, low power of magnetron.

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