

# Enhancement of methane production from anaerobic digestion of sewage sludge by low-thermal pre-treatment in semi-technological scale

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Currently, one of the most challenging issues in wastewater treatment plants is sludge management. Due to a growing population, urbanization and industrialization all over the world production of sewage sludge is increasing (Samolada & Zabaniotou, 2014). The high amount of sludge is unavoidably generated during all the treatment stages. Thus, there is a need to develop more economical and environmental friendly technologies for sewage sludge management and converting for bioenergy recovery.

## Introduction

Among various methods used for stabilisation of sewage sludge, the most popular is anaerobic digestion (AD). In this process, sludge is biologically stabilized in the absence of molecular oxygen by a microbiological activity. Usually, this process consists of the four sequential stages: hydrolysis, acidogenesis, acetogenesis and methanogenesis (Yang et al., 2015). This environmental-friendly method can allow to obtain methane-enriched biogas stream. However, waste activated sludge (WAS) which is usually used for anaerobic digestion is unfavourable substrate mainly during hydrolysis step, which is rate-limiting stage of all AD process. In order to highly-effective disrupt and lyse bacterial cells present in WAS, some pre-treatment technologies can be applied before AD. The most popular groups are: chemical, mechanical, biological and thermal techniques. Combining pre-treatment with AD techniques can allow to achieve increased organic loading capacity in existing digesters, reduced retention time in digesters, reduces biosolids volume for disposal and enhanced biogas production rate (Kor-Bicakci & Eskicioglu, 2019).

In low-thermal pre-treatment (LT-PT) of sewage sludge, the initial temperature is increased to a desired final temperature (<100°C), and held for a defined period of time with in aerobic condition. During this process both extracellular substances and also intra-cellular organics are easily degraded and solubilized. The main advantages of this technique is increase rate of AD and biogas production, enhanced biodegradability of substrates and reduces of digestate volume (Nielsen et al., 2011). To the best of author's knowledge, application of LT-PT in semi-technological scale are not described exhaustively in scientific literature.

**The objective of this work was to investigate the effect of temperature and duration time of low-thermal pre-treatment of sewage sludge in semi-technological scale on biogas production during anaerobic digestion process.**



The low-thermal disintegration experiments were carried out in at small WWTP located in Kożyczkowo (Pomeranian Voivodeship, Poland) serving rural community ( $Q_{av}=720 \text{ m}^3/\text{d}$ ;  $PE=5500$ ).

## Materials and methods

Bioreactor system with total volume 1m<sup>3</sup>, especially designed for LT-PT in semi-technological scale was used in this study. Secondary sewage sludge was subjected to LT-PT at: 45°C, 50°C and 55°C with the mixing frequency 30 Hz. In order to control the efficiency of the process, the following parameters were tested: pH, conductivity, redox, dissolved oxygen concentration (multi-parameter meter HL-HQ40d, HACH, Germany), volatile fatty acids (VFAs), chemical oxygen demand (COD), ammonia (N-NH<sub>4</sub><sup>+</sup>), total nitrogen (TN), total phosphorus (TP) and ortho-phosphate phosphorus (P-PO<sub>4</sub><sup>3-</sup>) using spectrophotometer.

The methane production during anaerobic digestion of pre-treated sewage sludge was determined using Automated Methane Potential Test System II (AMPTS).



Fig.1. Bioreactor



Fig.2. AMPTS

## Results and Discussion

Biogas production from pre-treated sewage sludge was performed for three different temperature and treatment duration. An overview of the results is shown in figure 1. From this table it is clear that pre-treated sludge allow to obtain higher methane production during AD. The highest BMP values were obtained from sludge treated at 55°C by 24h (488,93 Nml/g VS). For each treatment temperature, BMP values were the highest by 24h of experiment, but even samples after 6h-pretreatment BMP values are higher in compare to untreated sludge.

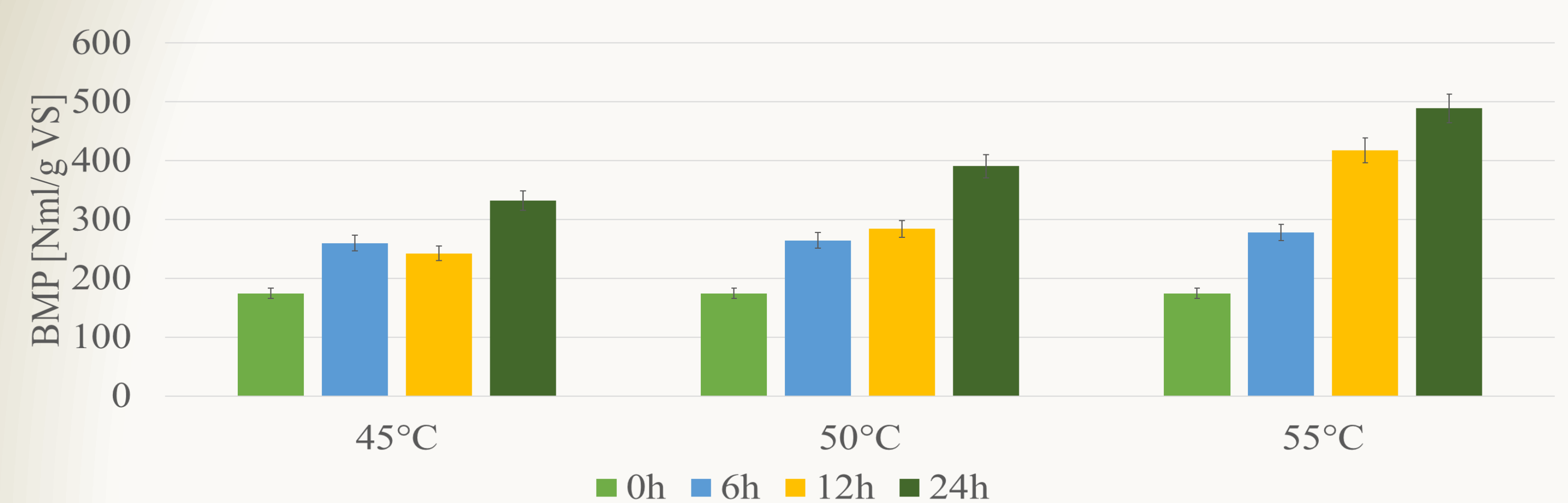


Fig.3. Biomethane production during anaerobic digestion of pre-treated sludge in different condition.

## Conclusions

Low thermal pre-treatment of sewage sludge performed in semi-technological scale results better degree of solubilization (increase of VFAs and COD concentrations) and higher biogas production during AD if compared with untreated sludge. The highest value of methane production was observed after disintegration performed by 24 hours in temperature 55°C. Many operation related with pre-treatment of sewage sludge aimed to improve hydrolysis phase of AD are recently incorporated. However, the main limitation of these methods are economical aspects. In comparison to other, the operation cost of LT-PT are significantly lower, thus this technology can be promising especially for smaller WWTPs.



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