ENHANCED BIOMETHANE RECOVERY FROM WASTE ACTIVATED SLUDGE

Department of Environmental Engineering, Marmara University
ENVE4198 Graduation Project

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OBJECTIVE

The aim is to develop a sludge treatment process that increases the amount of biomethane produced from waste activated sludge by anaerobic digestion with vacuum support at mild temperature (40-65°C). During the experiment, to find the optimum conditions for maximum methane production, experiment conditions such as temperature, pressure, pH, and hydraulic retention time will be changed. It is supposed that vacuum application will to some extent disintegrate the waste activated sludge (WAS) and thus will increase the methane yield and daily biomethane production.[1]

INTRODUCTION

→ Aim is to enrich the methane content in biogas (>85%) by taking advantage of the solubility differences of CO_2 and CH_4 gases in water with the vacuum process applied on the anaerobic sludge digester sludge return line.

→ Experiments has been done with batch vacuum tests, different pH, temperature and vacuum pressure was applied to find the optimum. The effects were demonstrated by BMP tests. By applying vacuum in continuous systems, the effects of this application on the operating parameters of anaerobic digesters were shown and it was determined how much the methane gas ratio in the biogas could be increased.[2]

→ Sewage sludge with a very stable structure, which is biologically difficult and slow to decompose and is released as a result of the treatment of urban wastewater with a long-ventilated activated sludge system was used.

MATERIAL AND METHODS

Conducted in 1 L of glasss bottle, airtight, vacuum resistant material.

Pressure, temperature, pH were tested to find which one is the most prone to increase sCOD.

Performed under various conditions and compared the CH_4 producing capacity.

Two experiments conducted at the lowest temperature at which boiling could be achived via the vacuum effect.

Constant pH value with a temperature rise to 65°C.

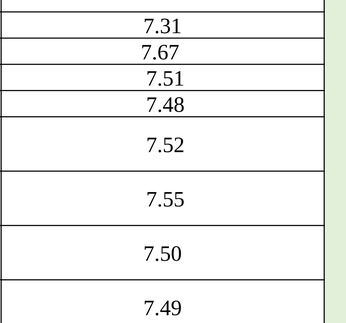


Figure 1. Batch Vacuum Test Setup

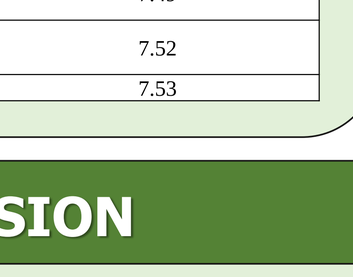


Figure 2. GC-TCD

Table 1. Parameters tested in batch vacuum experiments

Test No.	Pressure (kPa)	Temperature (°C)	Duration (min)	pH	The number of repetitions
I	5.8±1	42±2	120	7.5	6
II	29.9±0.9	65.5±0.09	120	7.5	3
III	28.4±0.32	65.2±0.19	120	10	4

Table 2. Conditions of BMP test

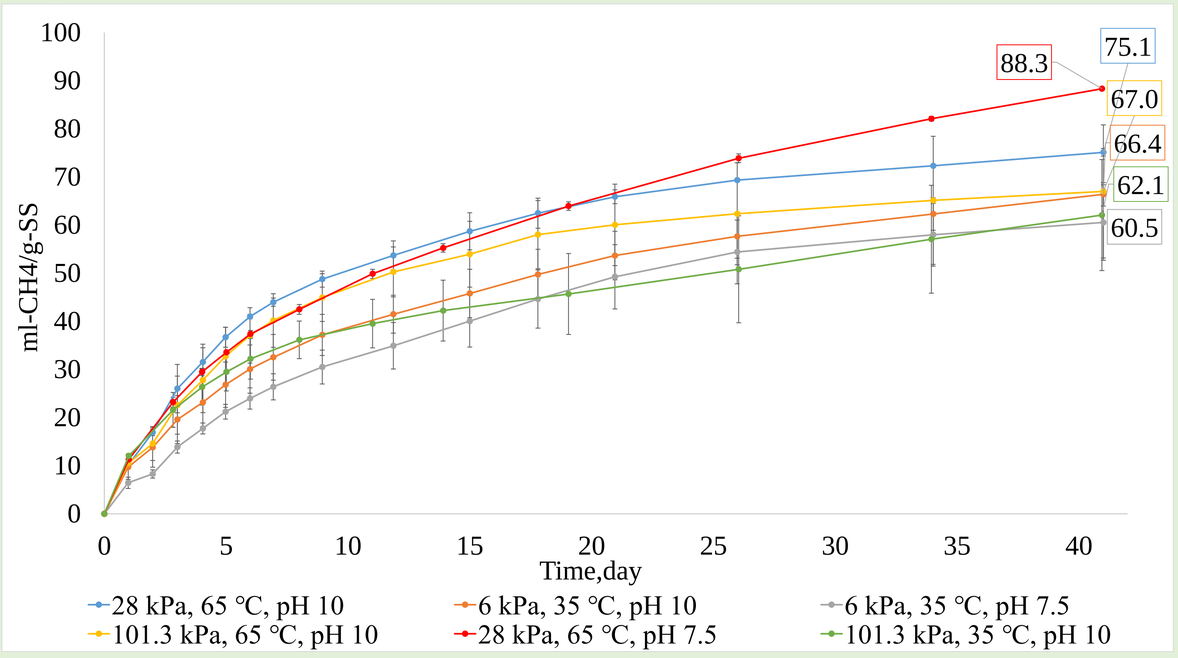
	Set No.	Pressure (kPa)	Duration (min.)	Temperature (°C)	Assay pH	pH during installation of BMP bottles(adjustment with acid or base)
BMP -1	28 kPa, 65°C, pH 10	28	120	65	10.06	7.57
	6 kPa, 35°C, pH 10	6	120	35	10.00	7.46
	6 kPa, 35°C, pH 7.5	6	120	35	7.93	7.57
	65°C, pH 10	101.3	120	65	10.00	7.50
	28 kPa, 65°C, pH 7.5	28	120	65	8.21	7.30
	35°C, pH 10	101.3	120	35	10.07	7.31
BMP -2	35°C, pH 7.5	35	120	35	7.67	7.67
	35°C, pH 10	35	120	35	9.98	7.51
	65°C, pH 10	65	120	65	9.88	7.48
	28 kPa, 65°C, pH 7.5	28	120	65	8.35	7.52
	28 kPa, 65°C, pH 10	28	120	65	9.92	7.55
	65°C, pH 7.5	101.3	120	65	7.98	7.50
	6 kPa, 35°C, pH 7.5	6	120	35	8.38	7.49
	6 kPa, 35°C, pH 10	6	120	35	10.00	7.52
	65°C, pH 7.5(2)	101.3	120	65	7.71	7.53

RESULTS AND DISCUSSION

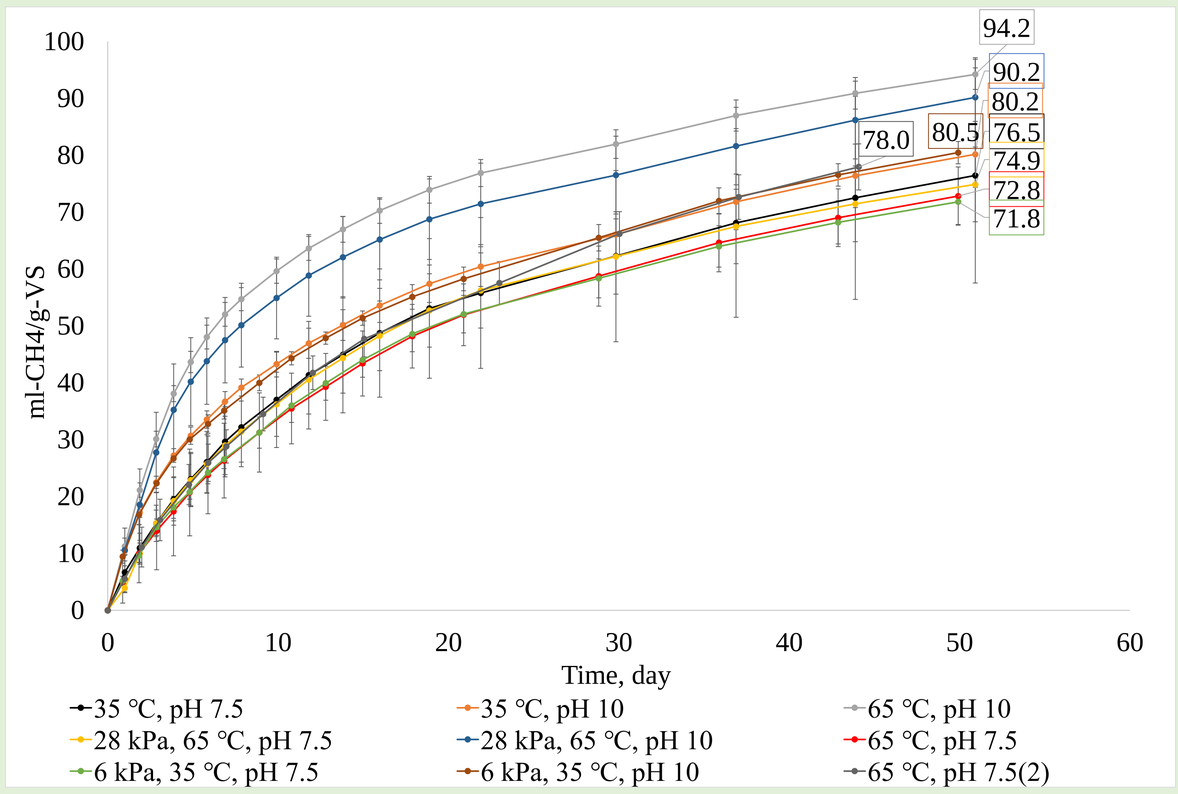
→ In the BMP test, pH (7.5 and 10), temperature (35 and 65°C) and vacuum (6 kPa, 28 kPa and 101.3 kPa) values were studied in different combinations. At the end of the 40th day, the highest methane yield was observed at 28 kPa, 65°C, pH 7.5. The most effective degradation was at 65 °C. The test sets performed at 65°C had 21.9% higher methane yields than the test sets performed at 35°C.

→ While 28 kPa vacuum application at 65°C had a positive effect, increasing the pH to 10 under the same vacuum conditions did not have a positive effect on cumulative methane production. On the other hand, it is understood that high pH at both 35°C and 65°C increases the rate of methane production. But does not have a positive effect on total methane production, especially at low vacuum values..

Graph 1: First BMP Test Results



Graph 2: Second BMP Test Results



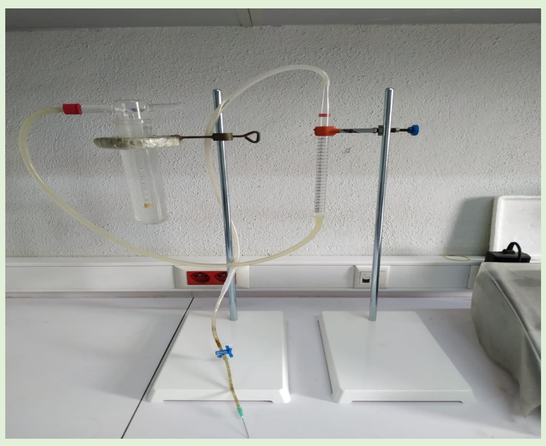


Figure 3. U-tube manometer system used to measure the amount of biogas produced in BMP test bottles

Figure 4. Incubator used to keep the temperature of BMP test bottles at 35°C

CONCLUSION

→ The biogas production potential of the digester at different temperatures and pressures was investigated. It has been observed that vacuum application both provides high crushing efficiency and increases the amount of biogas produced.

→ The highest efficiency was obtained when other parameters were changed with vacuum application. To clearly see the effects of different parameters on methane production efficiency, the BMP test was carried out in 6 different combinations.

→ It has been revealed that the most important factor causing an increase in methane production is the increase in temperature from 35°C to 65°C, and the increase in vacuum and pH are secondary parameters affecting methane production [3].

References:
[1] Abbassi, B. E. (2003). Improvement of anaerobic sludge digestion by disintegration of activated sludge using vacuum process. *Water Quality Research Journal of Canada*, *38*(3), 515–526.
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[3] Appels, L., Degrève, J., van der Bruggen, B., van Impe, J., & Dewil, R. (2010). Influence of low temperature thermal pre-treatment on sludge solubilisation, heavy metal release and anaerobic digestion. Bioresource Technology, 101(15), 5743–5748.