Influence of the temperature of anaerobic fermentation on sewage sludge dewatering

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Changes in regulations and economic conditions mean that it is necessary to implement appropriate and increasingly improved technologies for the fermentation of sewage sludge. Each sludge (substrate) has different dynamics and a different decomposition potential of organic matter, and therefore, in order to achieve the highest efficiency of the process, it is necessary to ensure appropriate chemical and physical conditions in installations. The efficiency of the process depends on a number of factors, including maintaining an appropriate pH, temperature, mixing, stability of the supply and the presence of the proper bacterial microflora. The process can take place in selected temperature ranges, namely in psychophilic, mesophilic and thermophilic conditions. However, due to the low efficiency of the process, only a few installations operate at a temperature of 10 – 25ºC. Processing plants operating at psychophilic temperatures can be found in Mediterranean countries, where the average air temperature is much higher than in Poland. It is worth noting that, e.g. in terms of biogas production, the fermentation process is most effective in thermophilic conditions. This is due to the greater activity of microorganisms at elevated temperatures. In addition, in the process of thermophilic fermentation, pathogenic microorganisms and pathogens are neutralized. However, ensuring a high temperature is associated with higher operating costs of the installation.

One of the methods of sewage sludge stabilization is the process of anaerobic fermentation. During the fermentation process, organic compounds contained in the sludge are decomposed, and biogas is produced. The most common are mesophilic (MDS) (30 – 39°C) and thermophilic (TDS) (49 – 57°C) fermentations, as well as their combinations. The use of a high temperature can increase both biogas production and the potential for recovering nutrient from the effluent stream that comes from the dewatering process. The disadvantage of increasing the temperature is the increased demand for thermal energy, an increased concentration of ammonia in the effluents, and a higher concentration of extracellular polymeric compounds (EPS). These compounds can negatively affect the degree of sludge dewatering (Zhou et. al., 2002; Sheng et. al., 2010), and also increase the demand for a flocculant (Hyrycz et. al., 2022). The paper presents the influence of the type of fermentation on capillary suction time and sediment filtration resistance with regards to the flocculant dose.

Flopam FO 4800 SH flocculant, which is manufactured by SNF, was used in the tests. The concentration of the flocculant solution was 0.4%. Sediment samples were taken from a local sewage treatment plant with a population equivalent (PE) of 1.2 mln. The characteristics of the fermented sludge are presented in Table 1. The fermentation process was carried out on full scale in digesters with a volume of about 5000 m^3 each. The digesters were fed with a mixture of excess and primary sludge (RS) in the volume ratio of 1:2, and in a TSS ratio of 1:1.4. The loading of the digesters was 2.2 kgTSS/m^3d and 1.7 kgVSS/m^3d.

Table 1. Sludge parameters

Parameters	RS	MDS	TDS
Total suspended solids (mg/L)	4.64 ± 0.84	2.89 ± 0.32	2.69 ± 0.28
Volatile suspended solids (mg/L)	77.8 ± 2.2	64.0 ± 2.0	60.1 ± 0.7
Temperature (^oC)	16.2 ± 1.0	36.8 ± 1.0	50.1 ± 1.0

A sludge sample taken from the fermentation chamber was mixed with a flocculant solution, and then dehydrated under a pressure of 800 kPa with the use of a Buchner funnel and filter paper. Using equation (1), the filtration resistance was calculated with regards to the flocculant dose (Figure 1).

$$\frac{t}{V} = \frac{\mu \cdot r \cdot \rho}{2p \cdot A^2} \cdot V + \frac{\mu \cdot r_m}{p \cdot A} \tag{1}$$

where:
t – time (s),
V – volume of filtrate (m^3),
μ – viscosity (Pas),

r – specific cake resistance (m/kg),
ρ – solid particle concentration (kg/m^3),
p – pressure (Pa),
A – filtration area (m^2),
r_m – medium resistance (1/m).

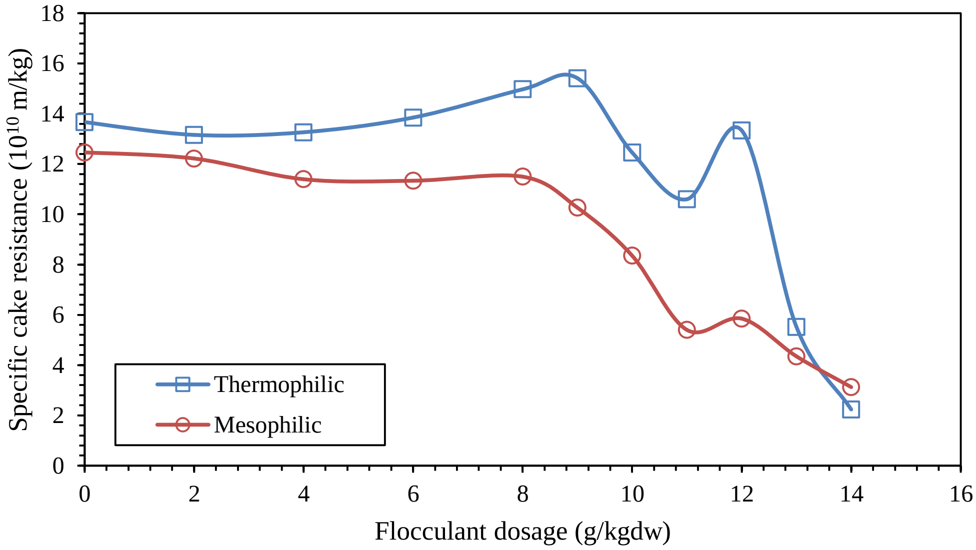

Figure 1. Dependence between the specific cake resistance and the flocculant dose.

Based on the obtained results, it was found that increasing the fermentation temperature causes an increase in the sludge's filtration resistance. In the case of the sludge after mesophilic fermentation, the decrease in filtration resistance occurred at a dose 5 g/kgdw lower than in the sludge after thermophilic fermentation. An increased temperature of fermentation causes a greater reduction of organic compounds, but the resulting digestate is more difficult to dehydrate. Therefore, when considering a change in fermentation temperature, the additional cost of the dehydration process should be taken into account. The applied process solution conducted in psychophilic, mesophilic or thermophilic conditions should therefore be adapted not only to substrates, but also to local conditions and investment opportunities.

References

Hyrycz M., Ochowiak M., Krupińska A., Włodarczak S., Matuszak M., A review of flocculants as an efficient method for increasing the efficiency of municipal sludge dewatering: mechanisms, performances, influencing factors and perspectives, Science of the Total Environment 820, 153328-1-153328-15, 2022.

Sheng G.P., Yu H.Q., Li X.Y., Extracellular polymeric substances (EPS) of microbial aggregates in biological wastewater treatment systems: A review, Biotechnology Advances, 28(6), 882-894, 2010.

Zhou J., Mavinic D.S., Kelly H.G., Ramey W.D., Effects of temperatures and extracellular proteins on dewaterability of thermophilically digested biosolids, Journal of Environmental Engineering and Science, 1(6), 409-415, 2002.

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