Methane production from liquid waste: leachate from composting of biowaste and glycerine

Katarzyna Bernat, Thi Cam Tu Le, Dorota Kulikowska

Department of Environmental Biotechnology, Faculty of Geoengineering, University of Warmia and Mazury in Olsztyn, Sloneczna 45G, 10-709 Olsztyn, Poland

Keywords: anaerobic digestion, co-digestion, leachate, waste glycerine, volatile fatty acids, mesophilic conditions.

Presenting author email: bernat@uwm.edu.pl

The mass of municipal solid waste (MSW) has been increasing due to the growth of urbanization and the global population. In some EU countries, over 60% of household waste goes to landfills, which has been a huge environmental problem, especially because of a significant share of organic waste. The Council Directive (1999/31/EC) indicated that the amount of biodegradable municipal waste had to be significantly reduced. The solutions for the reduction of the mass of organic waste before being landfilled are mechanical-biological treatment (MBT) installations. They previously were managed with mixed MSW, and in the biological part of the plants, the organic fraction of municipal solid waste (OFMSW), separated on a sieve, was stabilized (Bayard *et al* 2018, Bernat *et al* 2021a, Bernat *et al* 2021b). During the stabilization of OFMSW, its biodegradability decreases, and the emission of greenhouse gases reduces. However, the final product of OFMSW stabilization can only be landfilled (Jędrczak *et al* 2020, Połomka and Jędrczak, 2019). To produce a valuable final product – compost, biowaste from municipal solid waste should be separately collected, and then composted. Such actions have been already implemented. However, during the process, leachate (L) is generated. The organics- and nitrogen-rich leachate have fermentative potential, thus, before its discharging into the environment it is proposed to be anaerobically treated. Anaerobic digestion has many advantages such as not only organic waste treatment but also renewable energy generation (biogas).

Another liquid waste product is waste glycerine (Gly) from saponification, which is characterized by a high content of organics and low nitrogen content, thus, it does not constitute a suitable substrate for mono-fermentation. So, these two liquid waste products can be co-fermented. Leachate can serve as a solvent for glycerine and provides more stability to the reactor due to the high alkalinity content needed for the fermentation process. In addition, leachate provides macro- and micronutrients that are important for bacterial growth. The characteristics of leachate and waste glycerine are given in Tab. 1.

Table 1. Characteristics of leachate after biowaste composting and waste glycerine

Characteristics	Units	Leachate	Waste glycerine
COD	mg/dm^3	41260	100000
N_{tot}	mg/dm^3	1440	600
COD/N_{tot}	–	~29	~170
VFA	mg/dm^3	17500	n.d.*

In this study, the methane potential of the L from composting of biowaste and of the L with the addition of Gly was determined. The following variants were used: L only (with the COD/N ratio of 28.7), three mixtures of L and Gly in the proportions of 70:30, 60:40, and 50:50 (v/v), which resulted in raw Gly content of 3, 4, and 5% (v/v), and the COD/N ratios of 55.2, 68.7 and 86.2, respectively. Three repetitions of each variant were performed. The experiment was conducted in the Automated Methane Potential Test System (AMPTS II) (Fig. 1) under mesophilic conditions (36ºC) at an initial organic loading rate (OLR) of 7.5 kg COD/m^3. The inoculum for MP measurements consisted of anaerobically digested sewage sludge from the municipal wastewater treatment plant. The AMPTS II has three units: water bath, CO_2 absorption trap, gas volume measuring device. In the sample thermostatic incubator, 500 mL bioreactors, containing sample and inoculum, are incubated as long as a plateau in methane production is achieved. The bioreactors possessed small stirrers and are mixed (80 rpm for 1 min every hour).

During the experiment, besides methane production (MP), the effectiveness of anaerobic digestion was assessed based on the decrease of organic compounds (expressed as COD, chemical oxygen demand, and VFA, volatile fatty acids).

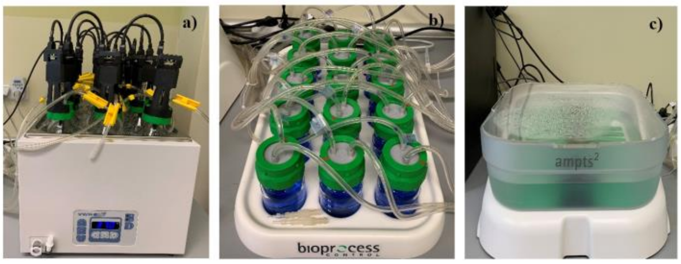

Fig. 1. The AMPTS II system a) water bath; b) CO_2 absorption trap, and c) gas volume measuring device

It was found that at an initial OLR of 7.5 kg COD/m^3, with all variants (L and L+Gly), during the first few days, over 80% of the total MPs were achieved, and the maximum cumulative MPs, of ca. 300 L/kg COD_{added}, were reached by the 10th day of measurements. This means that leachate from biowaste composting and glycerine from saponification can be successfully co-fermented and the methane potential of the leachate and the mixtures of leachate and glycerine is high. However, the addition of 3-5% of raw Gly slowed down the MP. This resulted from the fact, that during the first days of the measurements, VFA was intensively produced, which correlated with a slight reaction decrease (to 6.21-6.52 pH). With 3% Gly content in the mixture with L, high concentration of VFA (ca. 3000 mg/L) was noted up to 3rd day of measurements. With 4% and 5% of Gly content, this high VFA concentration maintained up to 4th and 5th day of the methane production. After VFA concentration decreased, the reaction recovered up to a value higher than 7 pH, and then methane was intensively produced. The present study has shown that leachate from biowaste composting and glycerine from saponification can be successfully co-fermented. However, glycerine slowed down the production of methane, because VFAs accumulated. Thus, the share of glycerine should be established under operational conditions not to disturb methane co-fermentation.

References

European Union. Council Directive 1999/31/EC of 26 April 1999 on the Landfill of Waste. Off. J. Eur. Union 1999, 182, 1–19.

Bayard, R.; Benbelkacem, H.; Gourdon, R.; Buffiere, P. Characterization of selected municipal solid waste components to estimate their biodegradability. J. Environ. Manag. 2018, 216, 4–12.

Bernat, K.; Wojnowska-Baryła, I.; Kamińska, A.; Zaborowska, M. Towards a circular economy for stabilized residual from organic municipal solid waste processed at an MBT installation – the potential of SR recycling and recovery. Desalination Water Treat. 2021, 244, 63–76.

Bernat, K.; Zaborowska, M.;Wojnowska-Baryła, I.; Samul, I. Insight into the composition of the stabilized residual from a full-scale mechanical-biological treatment (MBT) plant in terms of the potential recycling and recovery of its contaminants. Sustainability 2021, 13, 5432.

Jędrczak, A.; den Boer, E.; Kamińska-Borak, J.; Kozłowska B.; Szpadt, R.; Mierzwiński A.; Krzyśków, A.; Kundegórski, M. Analysis of waste management costs – assessment of investment needs in the country in the field of waste prevention and waste management in connection with the new EU financial perspective 2021–2027, IOŚ-PIB, NFOŚiGW, Warszawa (in Polish) (unpublished report), 2020.

Połomka, J.; Jędrczak, A. Efficiency of waste processing in the MBT system. Waste Manage. 2019, 96, 9–14.

Funding

Project financially supported by the Minister of Education and Science under the program entitled "Regional Initiative of Excellence" for the years 2019-2023, Project No. 010/RID/2018/19, amount of funding 12.000.000 PLN.