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Cofermentation of kitchen waste with sewage sludge

Beňo Z.[a], Bořáň J.[a], Houdková L.[a], Dlabaja T.[a], Sponar J.[b]
[a] Institute of Process and Environmental Engineering, Brno University of Technology (UPEI-VUT), Technická 2896/2 616 69 Brno, Czech Republic
Tel. +420 541 142 323, e-mail: beno@upei.fme.vutbr.cz,
[b] Institute of Materials Chemistry, Brno University of Technology, Faculty of Chemistry,
Tel. +420 545 545 125, e-mail: sponar@fch.vutbr.cz,

Kitchen waste (falls into a broader category of biodegradable waste) means all sorts of food waste coming from restaurants, catering facilities and central as well as home kitchens. Waste Catalogue classifies kitchen waste as biodegradable kitchen and canteen waste no. 20 01 08 and thus it is obligatory to treat it in accordance with the act providing for wastes.
Kitchen waste makes up a significant part of biodegradable waste and thus it should be further processed. Anaerobic digestion and composting seem like the most suitable methods for kitchen waste processing.
This article aims at research in the area of biogas produced in cofermentation of kitchen waste from college canteen with sewage sludge from wastewater treatment plant Brno Modřice.

1. Introduction

Biodegradable waste (BDW) is a type of waste that is liable to spontaneous aerobic and anaerobic decomposition. Municipal BDW (MBDW), wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing, wastes from food preparation and processing, wood processing as well as wastes from the leather, fur and textile industries all fall into the category of BDW. MBDW makes up to 40 to 80 % of municipal solid waste (MSW) in the EU countries. Member states (MS) of the EU landfill less than half of the MSW produced, Czech Republic landfills at about 70 % of MSW. Fig. 1 displays the amount of generated and landfilled MSW in the Czech Republic and the EU (27 member states).

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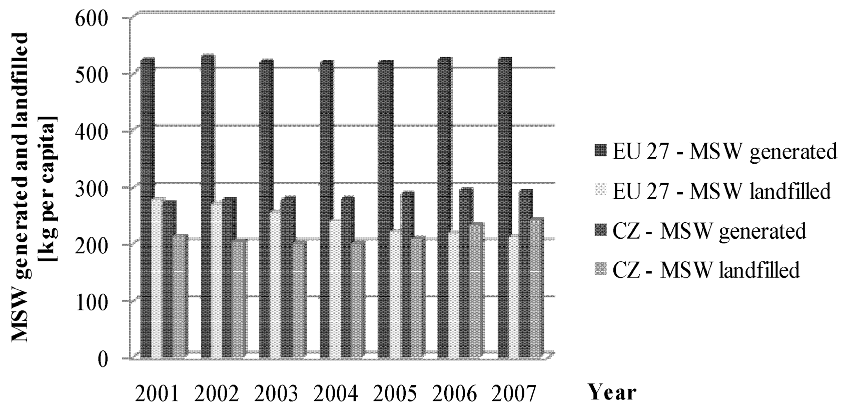

Fig. 1 Municipal waste generated and landfilled – comparison of the EU and CZ (Eurostat, 2009b)

Council Directive 1999/31/EC (The European Communities, 1999) providing for waste landfilling imposes to all of member states to reduce the amount of landfilled BDW. It further tries to support separate waste collection, waste separation and recycling. Aim of this directive is to decrease the amount of carbon released during biological decomposition of landfilled waste, partially turn it into carbon dioxide and partially retrieve it into soil. BDW contains not only organic substances but also plant nutrients (among those there are nitrogen, phosphor and potassium) and it is highly efficient to bring them back into natural circulation as organic fertilizers, such as compost, digestate, various types of substrate for plant cultivation or for terrain arrangements.

Landfilled biowaste serves as source of methane. This gas is produced during anaerobic decomposition of biodegradable part of the waste and is known to be greenhouse gas. It contributes to the greenhouse effect 21 times more than carbon dioxide, the main greenhouse gas.

The Landfill Directive was implemented into Czech legislation with Act regulating Waste 185/2001 Coll. (The Czech Government, 2001a) and its regulation 383/2001 Coll. (The Czech Government, 2001b) providing for details of waste treatment. Legislative requirements are incorporated in the Waste Management Plan of the Czech Republic (The Czech Government, 2003). This document requires reducing the amount of landfilled BMW as follows: to 75 % of 1995 levels by 2010, to 50 % of 1995 levels by 2013 and to 35 % of 1995 levels by 2020 of overall amount of BMW.

Primary way of fighting biowaste landfilling is in its separate collection and further utilization of this waste. It is very important no to mix it with other types of waste, which makes any consequent processing impossible.

2. Kitchen waste

Kitchen waste is classified under Waste code number 20 01 08 in Waste Catalogue (EWC, 2008) as a BDW from kitchens and catering facilities. This type of waste is organically compostable and should be treated in accordance with the Act regulating

Waste and also in accordance with European Parliament and Council Regulation 1774/2002/EC (The European Communities, 2002) providing for veterinary and hygienic requirements on animal by-products.
Since kitchen waste makes up a significant part of BDW, it is necessary to further process it. Composting and anaerobic digestion (AD) are some of the most efficient methods of processing kitchen waste. Nutrient rich soil is a final product of composting. Anaerobic processing produces not only fertilizing substrate but also biogas which can be later utilized. *Table 1* displays kitchen waste production in Czech Republic throughout 2001-2007.

Table 1 Kitchen waste production in the Czech Republic in 2001-2007 in thousands of tons (CSO, 2008)

Waste type / year	2001	2002	2003	2004	2005	2006	2007
20 01 08 Biodegradable kitchen and canteen waste	10.98	8.91	8.48	7.22	6.35	8.59	9.28

3. Research and development in the field of BDW processing – laboratory fermentation unit

In the scope of a research plan No. MSM 0021630502 "Waste and Biomass Utilization focused on Environment Protection and Energy Generation" of Ministry of Education, Youth and Sports of Czech Republic laboratory fermentation/digestion unit was designed and constructed. It is used for digestion of mixed substrates and to experimentally determine biological decomposition of BDW and consequently also biogas yield from various types of BDW and biomass. Results of experiments can serve as a basis for design and optimization of processes in real operations.
Fermentation unit is composed of 2 discontinuously filled, mechanically mixed digestion tanks, wet gasholder and accessory ensuring half-automatic operation with recording of main technological data and security features enabling safe operations.
Digestion tank is constructed as a double shell stainless insulated tank of 25 litters in volume. Content of the tank is heated by water circulated between shells. Water heating is maintained by HUBER thermo regulator. Substrate mixing is done via centric two propeller stirrer fuelled by asynchronous engine. Electromotor is equipped with a frequency changer for a fluent turn regulation. Volume of digestion tank can be mixed automatically or manually. Wet gasholder system is used for biogas collecting. Peristaltic dosing pump controlled by Magic XBC system are used for acid or alkali pH regulation. This system also enables recording of pH and temperature into the computer.

Fig. 2 Laboratory fermentation unit

4. Cofermentation of sewage sludge with kitchen waste

Following chapter will describe measuring of biogas production. College canteen kitchen waste together with sewage sludge from waste water treatment plant (WWTP) Modřice served as a digestion substrate. This combination is selected with respect to a prepared case study which takes into consideration utilization of all kitchen wastes from catering facilities at VUT which is a second largest university in the Czech Republic.

First measuring was carried out for food (fermenter A) and vegetable (fermenter B) leftovers separately without addition of sewage sludge. Amount of produced biogas and its composition was poor (contain of CH_4 was only 5 %).

During second measuring, the fermentation was carried out only in one fermentor. Substrate comprised food leftovers (48 %), vegetable (26 %) and sewage sludge in total amount of 26 % (mixed raw sludge (MRS) and digested sludge (DS) from WWTP Modřice). Amount of biogas was satisfactory, but its composition was still poor (contain of CH4 was only 3 %). Fig. 3 displays the amount of produced biogas and its composition.

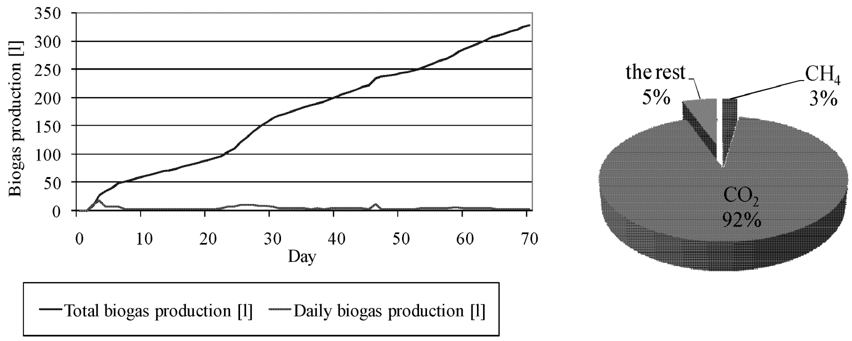

Fig. 3 Amount of produced biogas and its composition – measuring 2

Third measuring took place in two phases. In first phase, sludge from WWTP Modřice was used as process starter. Kitchen waste was dosed at the second stage of the process. Fermenter A fermented substrate of sewage sludge (77 %) with food leftovers (23 %) and fermenter B fermented sewage sludge (77 %) with vegetable leftovers (23 %). The valuable results were obtained especially from fermenter B. Fig. 4 displays the amount of produced biogas and its composition.

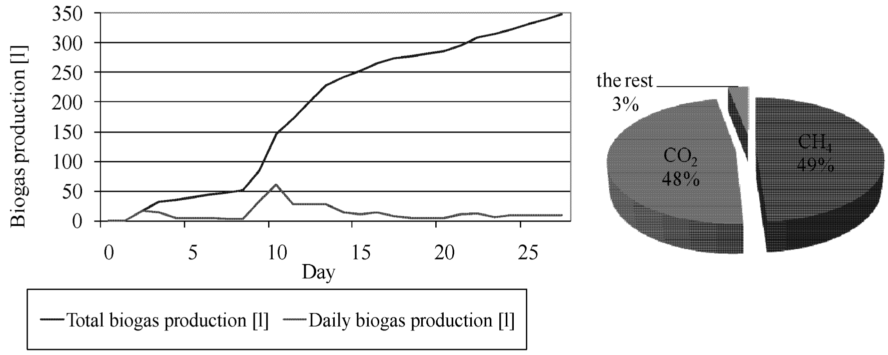

Fig. 4 Amount of produced biogas and its composition – measuring 3B

5. Conclusion

Article presents three initial experimental measurements of fermentation and cofermentation of kitchen wastes at laboratory experimental equipment located at Institute of Process and Environmental Engineering at Brno University of Technology. Conducted measurements allow for following conclusions:

- fermentation of vegetable as well as cofermentation of vegetable and sewage sludge produces highest amounts of biogas,
- fermentation of food leftovers was always accompanied by steep decline in pH which remained acidic all the way to the end of the process. Biogas production was very small and methane content very low. Amount of carbon dioxide was always more than 60 % of the volume.

Acquired data will serve as a basis for design of a pilot unit for kitchen waste processing at catering facilities at VUT.

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