Studiengang Sustainable Energy Competence (SENCE)

Kurzfassung

Studienarbeit - Forschungsprojekt 1

Anaerobic utilisation of the organic fraction of municipal solid waste (OFMSW)

Influence of storage and temperature on energetically relevant parameters of organic household waste

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1. Introduction

Management of OFMSW in Germany, unlike organic residuals from food industry, agriculture, etc. which is privately organised, is regulated by public law and organised through urban and rural district administrations that hence have access to organic waste as a resource. Since 2015, OFMSW must be collected separately according to § 11 I KrWG (Waste Management Act - *Kreislaufwirtschaftsgesetz*), leading to increasing volumes for utilisation, though separate collection is not yet comprehensively introduced (Kern et al. 2012; Kern and Raussen 2014; Thärichen 2016). Composting is still the dominating method for treatment of OFMSW, but with a growing trend towards anaerobic digestion (AD) which is considered as the more environmentally sound method as it combines energy recovery through biogas generation with utilisation of the digestate (Kern et al. 2010; Kaltschmitt et al. 2016).

2. Material and methods

2.1. Framework and experimental set-up

The aim of this study was to characterise the influence of storage time and temperature on OFMSW as a substrate for AD to draw conclusions for optimised waste management. Further, selected samples were compressed and stored airtight similar to handling of maize silage as a substrate in agricultural biogas plants to test how energy content within OFMSW can be preserved during storage. Energetically relevant parameters of representative samples of fresh food waste based on an existing recipe were captured during two testing series every other day over 20 days of storage at 20°C respectively 5°C, both at 75% relative humidity (Figure 1). Sample composition was based on equal parts of fresh mass (FM) out of five food categories with 34 products in total.

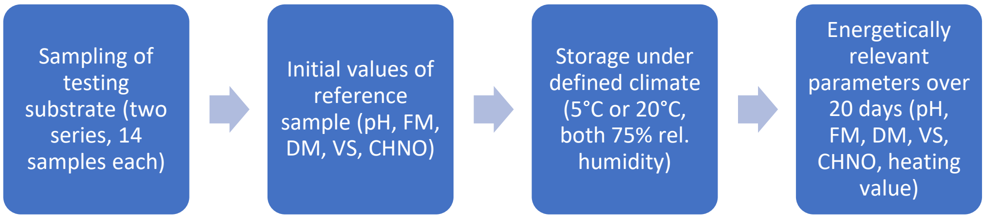

Figure 1: Experimental set-up

To compare how characteristics of the testing substrate change under ensiled storage conditions, for each of the two test series samples were filled into plastic bags, compressed and sealed airtight. These ensiled samples were analysed after 20 and 40 days to compare the results for different storage conditions.

2.2. Lab analysis

Visible signs of biodegradation, loss of FM, dry matter (DM) and volatile solid (VS) content, pH, as well as potential methane production based on elementary composition of CHNO were captured in the course of storage time. Additionally, the higher heating value of selected samples was determined to compare with calculated methane yields. Stoichiometric biogas potential was calculated according to Equation 1 based on (Buswell 1936) and complemented by (Boyle 1976):

$$C_nH_aO_bN_cS_d + \left(n - \frac{a}{4} - \frac{b}{2} + \frac{3}{4}c + \frac{d}{2}\right) H_2O \rightarrow \left(\frac{n}{2} - \frac{a}{8} + \frac{b}{4} + \frac{3}{8}c - \frac{d}{4}\right) CO_2 + \left(\frac{n}{2} + \frac{a}{8} - \frac{b}{4} - \frac{3}{8}c - \frac{d}{4}\right) CH_4 + cNH_3 + dH_2S$$

Equation 1: Stoichiometric biogas production

3. Results and discussion

Biodegradation visibly increased over storage time and at a much quicker rate for samples stored at warmer conditions, leading to loss of FM, especially through evaporation of water, but also reduction of the remaining DM and VS content. Especially for storage at 20°C, significant losses of VS resulted in reduced biogas potential of the remaining matter and thus less energy content (Figure 2). Determination of HHV shows very similar development as the energy content calculated based on stoichiometric biogas production and an assumed methane content of 60% with a heating value of 9,97 kWh/m^3_s. (Fachagentur Nachwachsende Rohstoffe e.V. 2016)

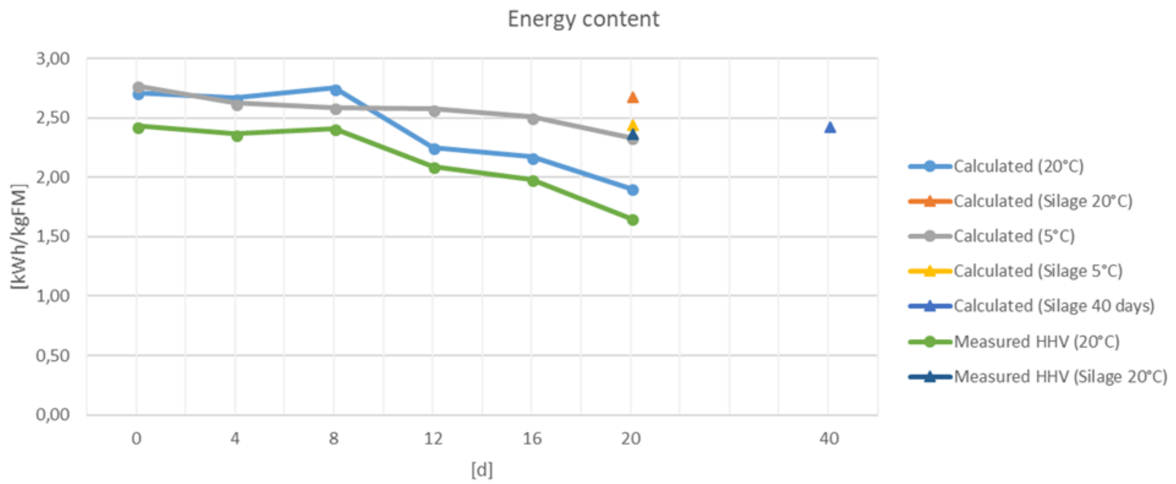

Figure 2: Energy content of testing substrate over course of storage time

It was tested how above-mentioned characteristics of the substrate change when stored under silage conditions at 20°C and 5°C, with regard to different pressure used for ensiling. Conservation of energy content in OFMSW was successful with FM and VS being largely preserved after 20 and even after 40 days of storage, accompanied by a reduction of pH pointing to an effective silage process as well as hydrolysis of the substrate. Influence of storage time and surrounding temperature could be minimised for the silage samples compared to those stored under aerobic conditions.

4. Conclusions and recommendations for biogas plant operations and optimized waste-management

Results of this study give detailed information how biodegradation of OFMSW during storage before treatment impacts its potential for AD, allowing waste management and AD plant operators to optimise waste logistics and feeding of biogas plants. The collected data allow to build the foundation for a tool on modelling storage conditions for organic waste, as the effects of external temperature and storage time on waste characteristics for other than the investigated conditions can be derived mathematically. Storage of OFMSW under silage conditions can be a perspective for future waste management systems and should be the focus of further research as it can minimise energy losses. The silage test carried out in this study lead to a decline in pH, conservation of water content and pre-hydrolysis of the substrate, which poses challenges through the risk for acidification and process instabilities (Campuzano and González-Martínez 2016), but at the same time can be seen as a pre-treatment step for AD (Nilsson Påledal et al. 2018), shortening the time that is needed for biogas generation.

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