Formation of foam in the process of anaerobic digestion

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Introduction

Foam formation is one of the major causes of upsets during the biogas formation process in biogas plants [1].

Foam-related problems in biogas reactors are [2]:

- crust formation on the reactor wall,
- failure of pushers,
- dirt and blockage of gas and condensate pipes as well as recirculation pumps due to the retention of foam solids,
- over-foaming and a complete standstill of the plant.

In consequence, both the biogas yield and the economic profit of the biogas plants decrease. For this purpose, a project was started to investigate the causes of foam formation in biogas plants and the effects of antifoam agents on the biogas production process.

Aims and realisation of the investigation

- Deduction of options for occurrence and avoidance of foam by analysing the operating data of twelve cooperating biogas plants and long-term sampling of two biogas plants based on digestion of
  - i) waste materials and
  - ii) renewables.
- Testing of antifoam agents by examination of their effects on
  - the destruction of foam and
  - the process of biogas generation.

Results

Experiences of biogas plant operators show, that the most common causes of foaming in biogas plants are:

- wet, foul or mouldy maize silage as well as corn-cob-mix (CCM),
- tensides (e.g. residues from soap and bioethanol production),
- overdosage of animal protein, poultry manure, sugar beets and grain (mainly sorghum, rye and barley),
- wastewater from potato processing and from dairy,
- filamentous microorganisms during anaerobic treatment of waste water,
- lack of nutrients,
- overfeeding or too high volumetric loading,
- insufficient stirring.

The most common methods of fighting foam are:

- elongation of stirring period,
- omitting of dosage of problematic substrates,
- dosage of antifoam agents, for example :
  - industrial biodegradable defoamer,
  - vegetable oils.

The effect of addition of an industrial biodegradable antifoam agent on the biogas production process was tested in small-scale batch cultures, as a control the cultivation was carried out without antifoam.

Figure 1 shows that:

- the antifoam agent has an inhibitory effect on the biogas production process at the beginning of the cultivation,
- nevertheless, the biocenosis is able to adapt to the antifoam agent and
- the microorganisms utilise the antifoam agent for biogas formation at the end.

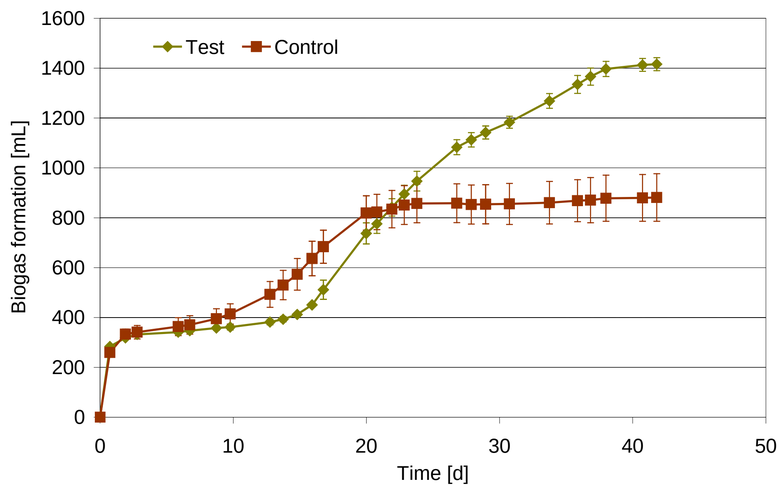

Figure 1: Influence of antifoam agent addition on the biogas production process. (Conditions: experimental set-up according to guideline VDI 4630; 135 g seeding sludge, 1.5 g glucose, 2 mL antifoam agent; working volume: 200 mL; T = 37 ° C).

Figure 2 shows that:

- higher maximum specific methane production rates were reached in cultures containing antifoam agent than in control experiments (32.1±1.6 mL/d vs. 44.8±6.1 mL/d),
- the peak of maximum specific methane production rate occurred at a later time for cultures containing antifoam agent.

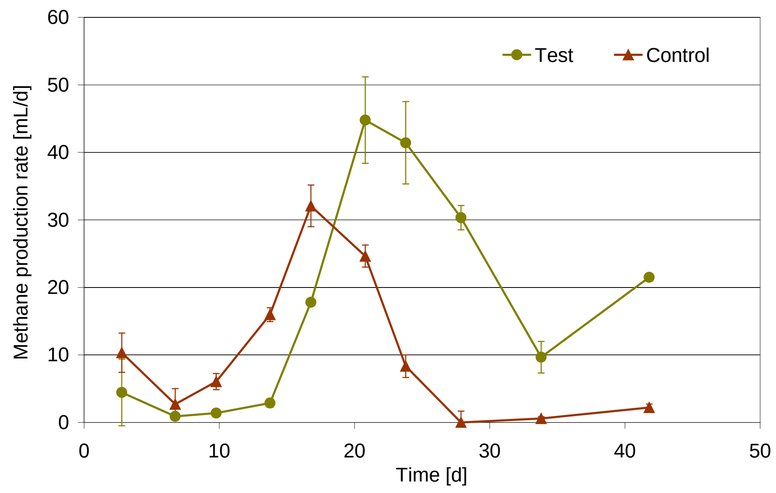

Figure 2: Influence of antifoam agent addition on methane production rate. (Conditions: see Figure 1; methane concentration was measured by GC-WLD)

Conclusions and Outlook

- Data collection from cooperating biogas plants resulted in a list of operational conditions as well as substrates which are connected with the appearance of foaming in biogas digesters. No relation between atmospheric phenomenons and foaming was observed.
- Long-term analysis of two biogas plants, which had problems with foaming in the past, showed stable processes without any kind of disturbances during the sampling period.
- First experiments for testing the effect of antifoam agents on biogas production process were carried out.
- Another six antifoam agents are going to be tested in the near future in small scale batch experiments. Furthermore, the effect of these antifoam agents on both the surface tension and the foaming tendency will be investigated.

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

References:

[1] Schumann W., Gurgel A.: Schwachstellenanalyse an ausgewählten Biogasanlagen in Mecklenburg-Vorpommern. In: 1. Rostocker Bioenergieforum. Bioenergieland Mecklenburg-Vorpommern (2007), Universität Rostock, pp. 155-169.

[2] Moeller L., Herbes C., Müller R., Zehnsdorf A.: Schaumbildung und –bekämpfung im Prozess der anaeroben Gärung. Landtechnik (Agricultural Engineering) 2010, 65, 204-207. (English version online: Formation and removal of foam in the process of anaerobic digestion).

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