Detailed investigations of high terpene concentrations in biogas laboratory trials

Authors:

Lukas Knoll[1]
Marion Sumetzberger-Hasinger[2]
Magdalena Nussbaumer[1]
Dennis Dalnodar[1]
Andreas Paul Loibner[2]
Bernhard Drosg[1]

[1]BEST – Bioenergy and Sustainable Technologies GmbH, Area 3

[2]University of Natural Resources and Life Sciences, Vienna Department IFA-Tulln

Bioconversion & Biogas Systems

Background

Biogas plants fed by industrial by-products, such as **waste sludge**, **residential and food industry organic waste and manure**, are of highest interest, because they do not compete with food production, though the kind of impurities and their quantities in the gas vary. In addition, there is a growing trend for biogas plant operators to focus on **biomethane** in order to either use the methane as fuel or feed it into the gas grid. Due to the strict standards, the gas needs to be of high quality. Beside carbon dioxide, hydrogen sulphide, ammonia and siloxanes, terpenes are **classified as impurities** and therefore the focus of the investigations.

Definition, occurrence and risks of terpenes

Terpenes are a diverse class of **organic compounds** mostly produced by plants. Beside the strong odour, they are linked to several problems both in the liquid and the gas phase like **inhibition of the anaerobic degradation process**, **blocking** of filters or **weakening** plastic and rubber parts of the plant. Terpenes are present in several feedstocks like:

- orange peels (limonene, cymene)
- clover (ocimene)
- carrots (cymenes)
- wood chips (pinenes)
- eastern thuja (thujene)

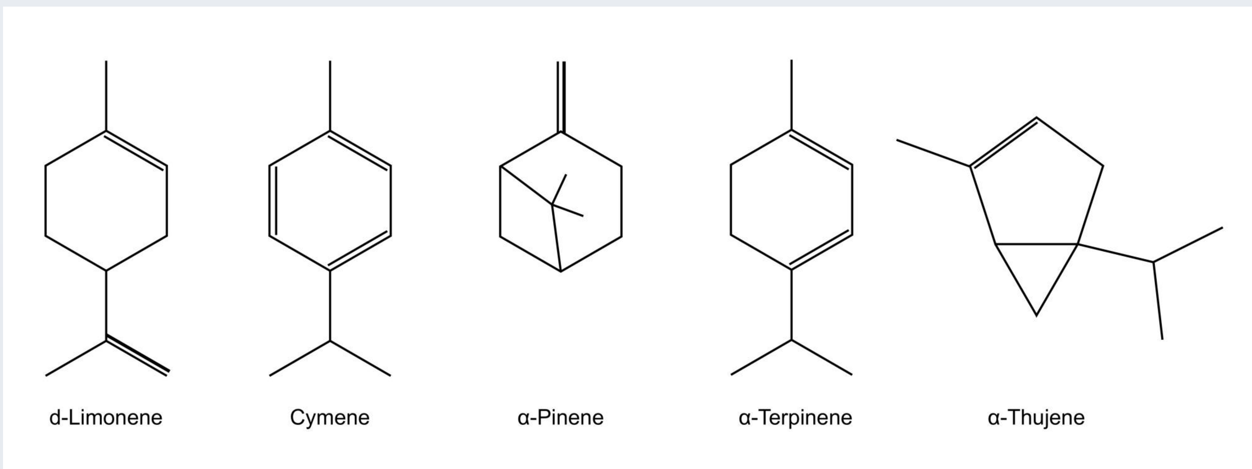

Figure 1: Structure of terpenes

Materials and methods

The aim was to investigate the effect of terpenes on the **anaerobic digestion** process. For this reason, batch tests with increasing amounts of **limonene** added to the substrate as well as orange peels as substrate which is known to produce terpenes in biogas were performed.
Besides the batch tests also semi-continuous experiments were carried out to investigate the impact of terpene containing substrates on anaerobic digestion as well as the transition of terpenes from the liquid to the gas phase.

	Batch tests	Semi-continuous experiments
Implementation:	Eudiometer	stirred reactor
Temperature:	Mesophilic conditions (36° C)	
Reactor:	1L glass flasks	2L glass flasks
Substrate:	cellulose | orange peels	pig manure and orange peels
Inoculum:	sludge from biogas plant	
Duration:	30 days	100 days
specification:	Varying limonene concentrations (0, 500, 1000, 2000 mg/kg)	varying organic loading rate (0.5 - 2.5 gVS/(L*d))

Table 1: Conditions of the experiments

Figure 2: Eudiometer batch tests (a), semi-continuous experiments (b), terpene sampling (c)

Results and discussion

The results of the batch tests show a **significant inhibition** of the microorganisms with increasing limonene concentration. The biogas potential is hardly influenced at limonene concentrations of 1000 mg/kg whereas the kinetics slowed down. At a concentration of 2000 mg/kg, an inhibition of the biogas potential of more than 50% was observed.

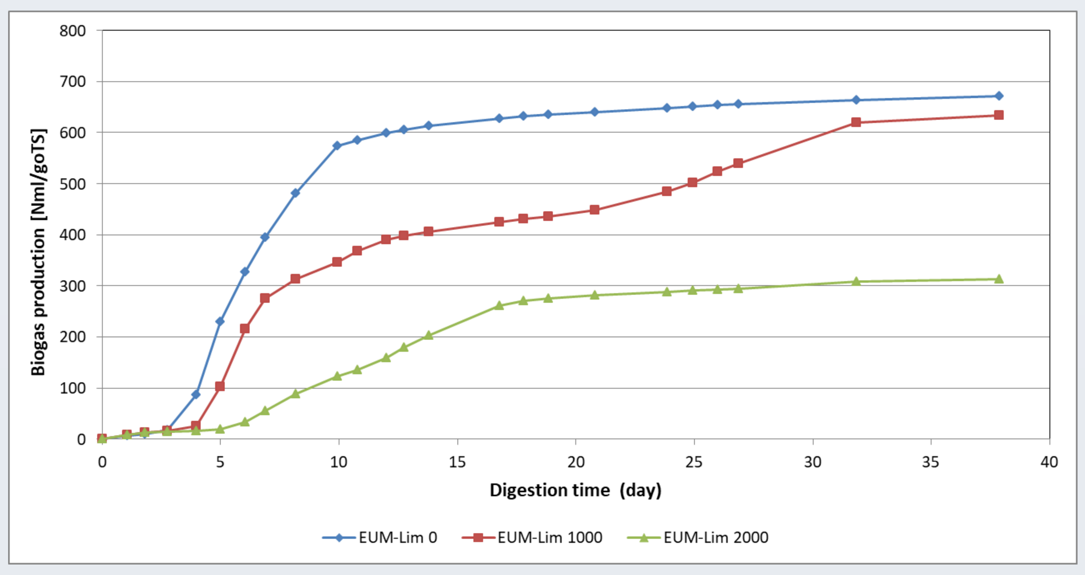

Figure 3: Comparison of biogas production of cellulose (with or without limonene)

The continuous experiments show that terpenes were **detectable in the biogas** after only a few days. For the analysis, a GC-MS method for the determination of terpenes in biogas, developed by our project partner BOKU, was used. With the increase of the OLR the limonene concentration in the produced gas rose from 1.88 µg/L to 12.30 µg/L. At a certain point the **process became unstable**. Despite a reduction in OLR and a decrease in the amount of orange peel supplied, the volatile fatty acids increased. At the same time, the concentration of terpenes in biogas decreased significantly, because the degradation process of the orange peels was inhibited.

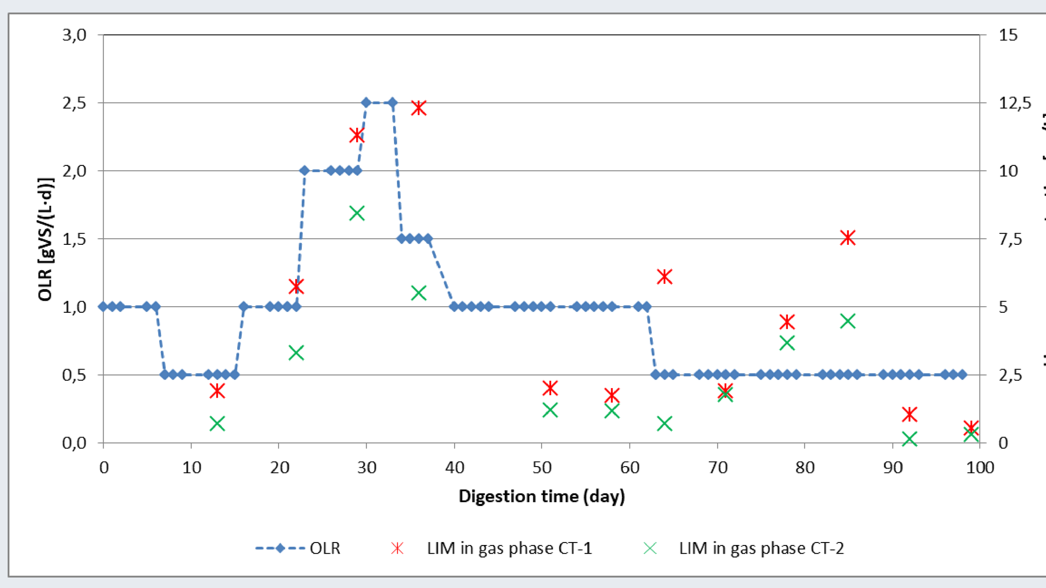

Figure 4: Limonene concentration in the gas phase

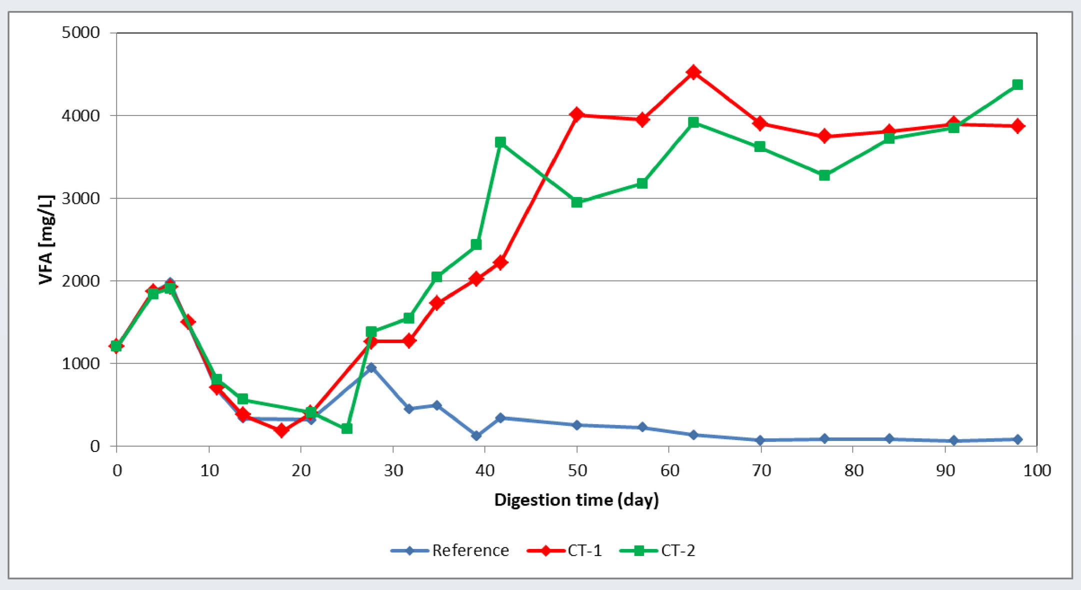

Figure 5: Volatile fatty acid development

Acknowledgement: We gratefully thank the Austrian Research Promotion Agency (FFG) for the funding of the Project: BIOFEGG – Biogas for Future Electric and Gas Grids (FFG-project number: 863537), funded in the ERA-NET Bioenergy call 2016.

BEST – Bioenergy and Sustainable Technologies GmbH

Head Office Graz
Inffeldgasse 21b
A 8010 Graz

P +43 5 02378-9201
office@best-research.eu
www.best-research.eu