MICRO4 BIOGAS

Module 2.4

Testing in lab-scale and pilot-scale bioreactors

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement **No 101006361**

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Introduction

This module covers various laboratory reactors:

- Set up of the experiments
- Reactor types
- Terms of use

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2 Selection process

Initial inoculum selection

- **Environmental microbial consortia:**
  Digestate, manure, wastewater,...

- **Feedstock:**
  Food waste, sludge,...

Applied selective pressure

- **Environmental parameters:**
  OLR, pH, temperature,...

- **Selection consortia with desired characteristics:**
  High methane production, high tolerance to high OLR,...

Monitoring and evaluation

- **Key parameters:**
  Methane yield, volatile solids reduction, VFA concentration, microbial diversity,...

- **Optimization:**
  After testing different inocula and conditions, the most efficient microbial consortia can be identified

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3 Benefits of lab-scale reactors for microbial selection

- **High replicability:** statistically more relevant data
- **Performance evaluation:** various organic wastes (e.g., food waste, agricultural residues)
- **Adaptative studies:** microbial consortia adaption to different substrates, nutrient levels, or environmental stresses over time
- **Genetic and functional diversity:** sequencing techniques, revealing the most active and effective microbes
- **Resilience testing:** stress conditions (e.g., high ammonia or salinity) to identify resilient consortia that can perform well in real-scale scenario

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4 Small scale experiments

- batch experiments up to 2l
- used to perform a large number of experiments in a short time
- parameters set up at the beginning of the experiment
- during the experiment no changing of the parameters

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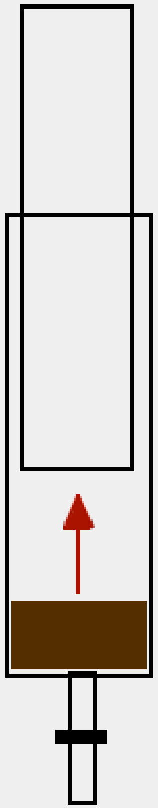
4.1 Piston probers

- 100 ml glass syringes → 20 mL sludge / sample
- quick testing possible
- many piston probers at the same time
- period 14 days and / or until gas formation stops
- Due to gas formation, the piston is pushed upwards → amount of gas formation can be measured



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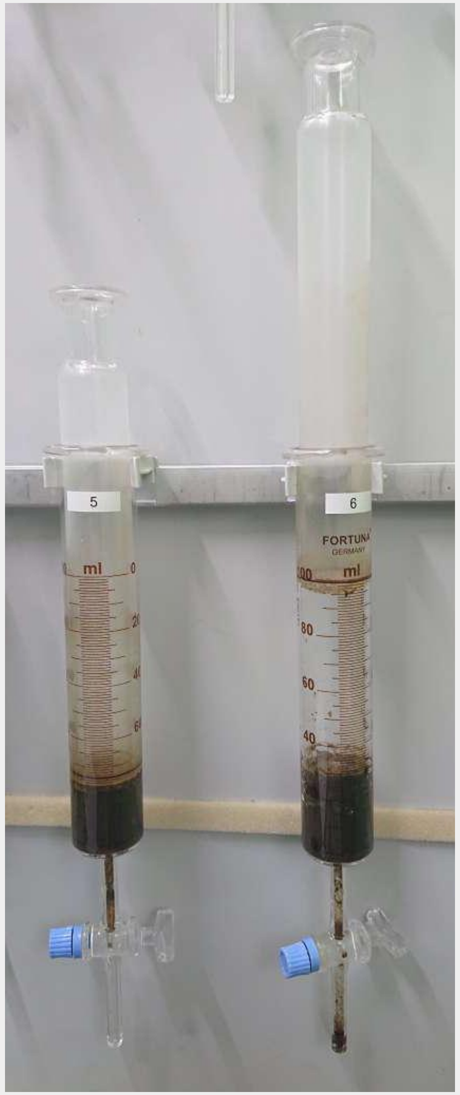
4.1 Piston probers

In Micro4Biogas project:

- Filled with 20 ml biogas- or sewage sludge
- Inoculation with different bacterial strains and feeds
- Performed in triplicate



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4.2 1l batch

- Complete filling of the batch reactor with inoculum
- Semi-batch: feeding in intervall
- Addition of feed and microbial strains at day 0
- At day 5 and day 10 additional feeding
- Daily documentation of gas formation and gas content
- Experiment ends after 14 days

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4.2 1l batch

In Micro4Biogas project

- In 1l airtight bottles, up to 800ml inoculum was added (20% should remain air space in case foaming occurs)
- Incubation temperatur at 37°C, shaking
- Amount of whole gas formation and was measured via eudiometer
- Additional gas content was measured, too

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5 Medium scale experiments

- Approach to real systems
- continuous feeding
- continuous measurement of test parameters such as pH value, COD, FOS/TAC, F420-microscopy
- tests can take a few weeks or several months

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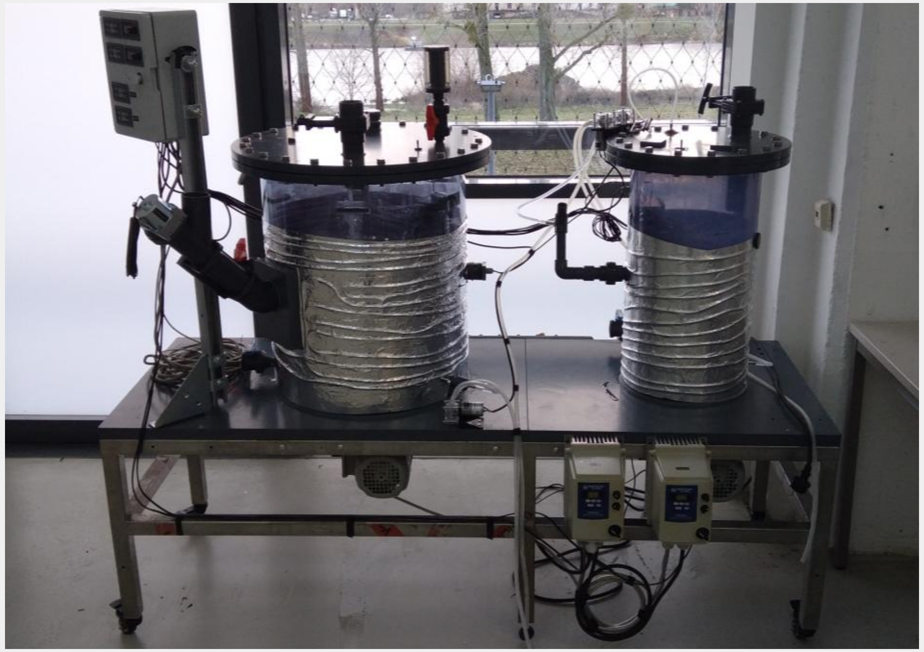
5.1 20l, 40l and 60 fermenter

In Micro4Biogas project:

- filling volume up to 60l
- process temperatur 37°C
- circulation via pumps or agitator
- gas volume is measured via gas flow meter
- sampling and feeding directly into the system possible without entry of oxygen



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6 Large scale experiments – Pilot Plants

- large-scale systems that represent real conditions
- need several weeks to work stable before the experiment can be started
- tests run for months to years

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6.1 1 m^3 plant

In Micro4Biogas project

- $1 m^3$ working volume
- gas formed is measured and collected
- without circulation and heating

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6.1 5 m³ plant

In Micro4Biogas project

- $5m^3$ working volume
- filled with biogas sludge
- continuous circulation via pump
- heated via heating circuit (37°C)
- continuous measurement of test parameters
- run-in phase and test phase for months to years

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7 Summary

- laboratory systems help to understand processes and test different approaches
- Benefits of small system: faster, more throughput
- the transfer to reality becomes more accurate after scale up the experiments

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