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Effects of phenyl acids on different degradation phases during thermophilic anaerobic digestion

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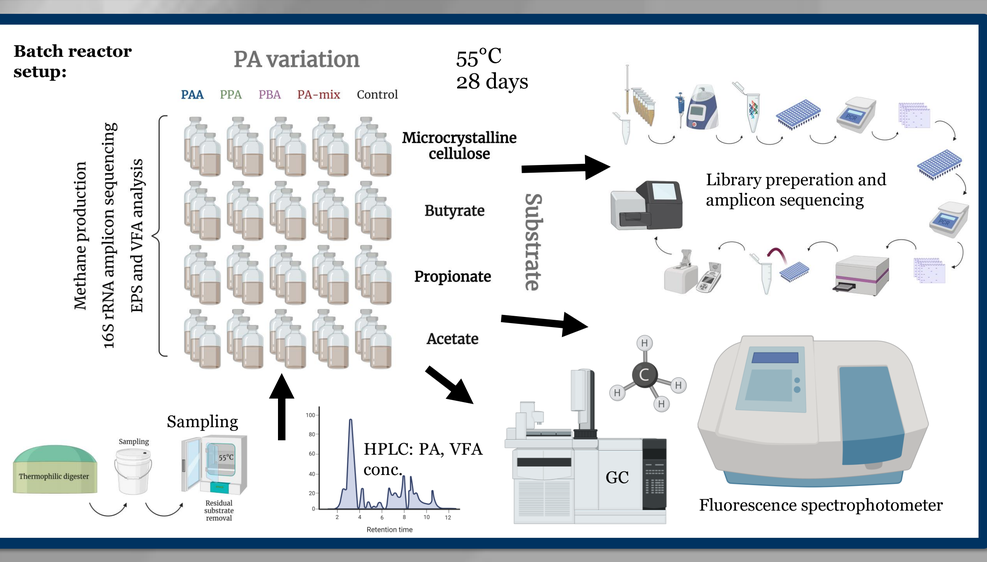
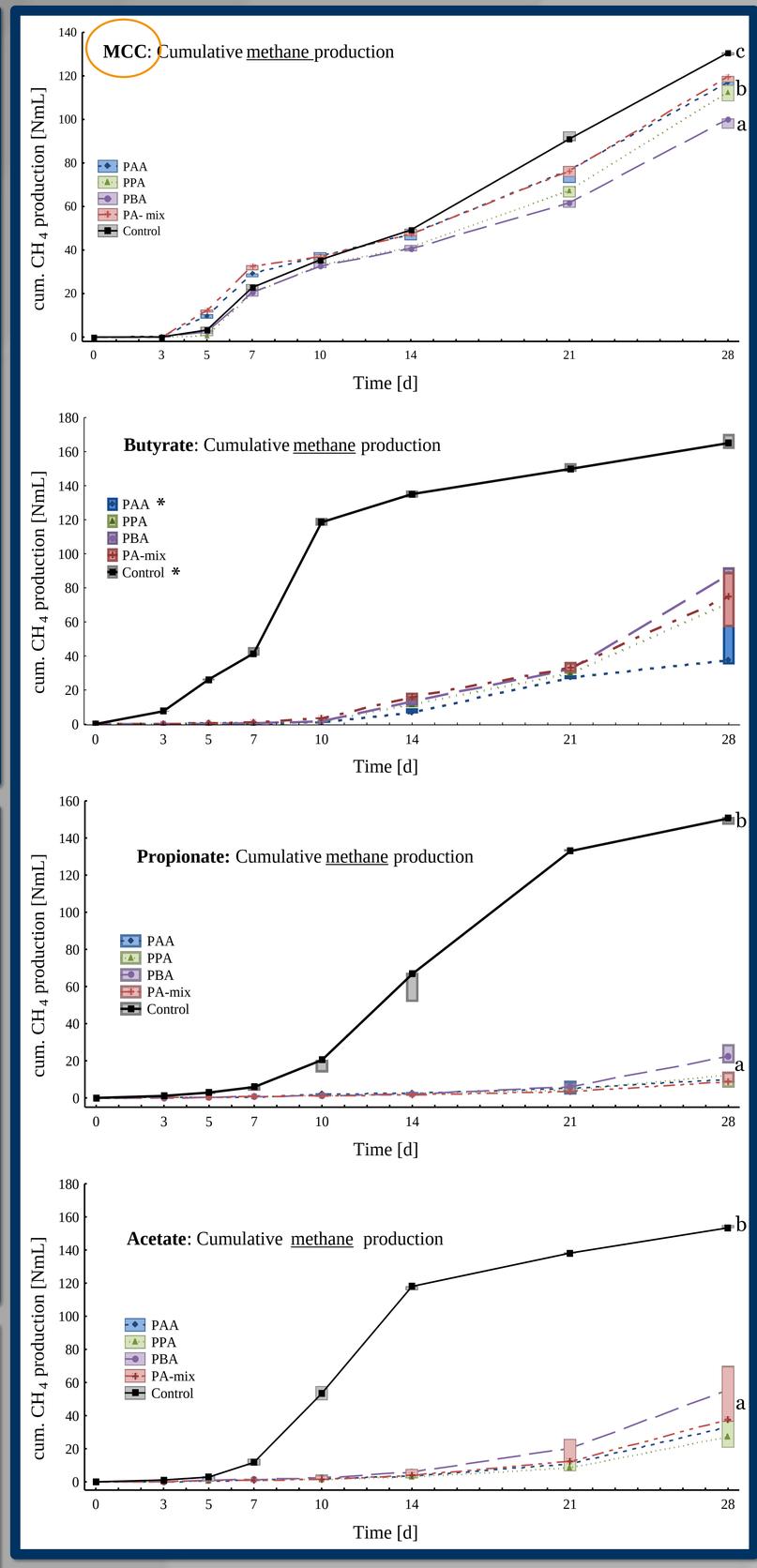
Background. Biogas production out of organic waste materials does not influence food prices, can prevent the expansion of monocultures and supports the infrastructure in remote areas. However, aromatic compounds like **phenyl acids** (PA) can accumulate during **anaerobic digestion** (AD) of organic wastes due to an increased entry of eg., lignocellulose, and thermodynamic challenges in degrading the benzene ring. Their effects can be various - from being highly toxic to being stimulating for methanogenesis - depending on many parameters like inoculum or molecular characteristics of the aromatic compound. To contribute to a better understanding of the consequences of PA exposure during AD, the aim was to evaluate the effects of **10 mM PA** on microbial communities degrading **different degradation-phase specific substrates** in thermophilic reactors.



Materials & Methods. Batch reactors were set up with 1:8 diluted thermophilic sludge coming from a OFMSW reactor (Roppen, Tyrol). The reactors were fed with microcrystalline cellulose (MCC), butyrate, propionate or acetate in concentrations that equal a chemical oxygen demand of 0.4 g O_2. For each substrate, five different phenyl acid variants were established: controls (no PA addition), 10 mM phenylacetic (PAA), phenylpropionic (PPA) or phenylbutyric acid (PBA), or 10 mM of a PA-mix (1:1:1). The reactors were incubated at 55°C for 28 days and analysed biochemically (volatile fatty acids (VFA), PA and biogas concentrations, and quantity and quality of extracellular polymeric substances (EPS)) as well as molecular biologically (16S rRNA amplicon sequencing).



Results. The impact of PA mainly depended on the type of substrate: When acetate, propionate or butyrate were digested, the effects of PA were more severe than in MCC assays: In **propionate** reactors, methane production was **reduced by up to 93%**, whereas a maximum methane reduction of **24%** was observed in **MCC** reactors. Acetate, propionate and butyrate assays exposed to PA showed a significant delay in degrading the respective VFA. PA concentrations remained constant within 28 days. Microbial diversity was significantly higher in **MCC** reactors due to the more complex substrate and broader spectrum of intermediate products. This is also reflected by a **higher quality and quantity of EPS** in those assays. *Methanosarcina* spp. was the dominant methanogen in VFA reactors without PA amendment, whereas *Methanothermobacter* spp. (with syntrophic VFA oxidising partners) was more prevalent in VFA reactors with PA exposure as well as in all MCC reactors – irrespective of the PA variation. This supports the role of **syntrophy**-coupled **hydrogenotrophic** methanogenesis at elevated PA levels. Due to the higher microbial diversity in MCC samples, EPS quality and quantity might have played an important role in attenuating the toxic effects of PA via **biofilms** and **granules**.