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SPONSORED BY THE Federal Ministry of Education and Research
An Initiative of the Federal Ministry of Education and Research WavE Water Technologies: Reuse

Enhancement of biogas production of laundry wastewater by hydrodynamic cavitation

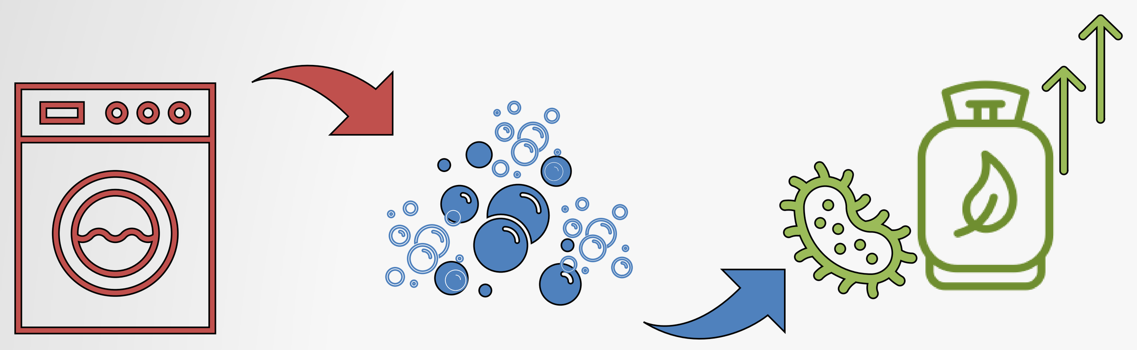
Theoretical background

The laundry wastewater contains COD values between 1,000 mg COD/L and in the case of a concentrate approximately 20,000 mg COD/L. The produced wastewater with correspondingly high COD values is suitable for anaerobic degradation with the aim of biogas production. This method of treating wastewater that is strongly loaded with organic substances shows great potential in other industrial sectors as well [1].

However, laundry wastewater contains a matrix of diverse detergents, surface-active agents or disinfectants. These substances usually consist of complex molecular structures, making them biologically less degradable or even toxic to the anaerobic process, resulting in an inhibition of the biological process and thus a reduction of the biogas yield [2].

Goal

The goal is to increase the biogas output with the help of an additional upstream cavitation treatment unit. Cavitation is a physico-chemical procedure where a liquid medium is temporarily converted into its gaseous state by decreasing the pressure in the medium to the vapor pressure. This results in the formation of small gas bubbles which implode after a short time [3]. During these implosions, microjets are formed. Additionally, temperatures above 5,000 K and pressures above 1,000 bar occur. Cavitation also results in the formation of highly reactive free radicals, such as HO•,H•, HOO• and HO2• [4,5]. It is expected, that once the substances contained in the wastewater are exposed to such extreme conditions, the covalent bonds of the molecules responsible for inhibition are broken and a downstream biological stage is thereby facilitated, which results in an increased biogas production.



Experimental setup

The laboratory setup consists of a circulation loop, a tank, a pump, a cavitation reactor, control valves and measurement gauges (See Figure 2). The wastewater is pumped from the reservoir into the plug flow tubular cavitation reactor. At the venturi throat the cavitation develops, filling the downstream area with cavities (See Figure 1), that are responsible for the transformation of the substances in the wastewater. In order to verify whether there is an improvement in biodegradation and biogas yield, samples of wastewater are taken from the circulation system at time 0, 1 and 2 hours. These afterwards undergo anaerobic fermentation, where the produced amount of biogas is continuously measured. In addition, a UV-VIS scan is taken at 10-minute intervals to detect any other effects of cavitation on the wastewater.

Figure 1: Development of cavitation

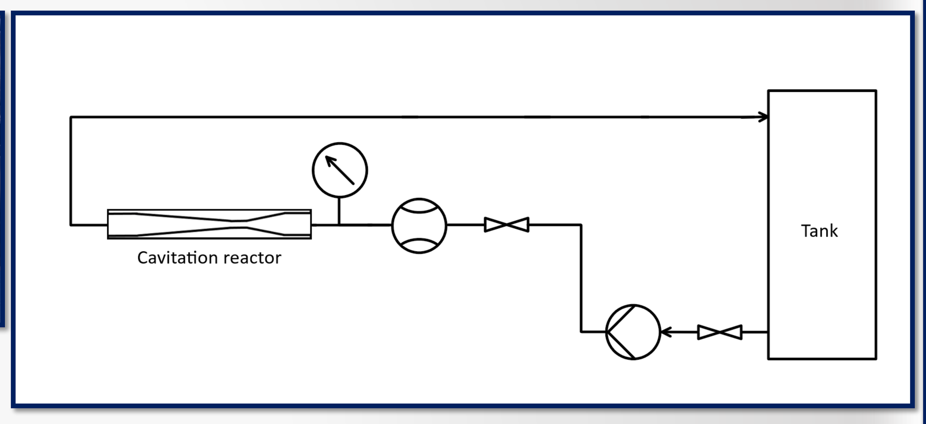


Figure 2: Experimental setup

ReWaMem

Results of UV-VIS scan

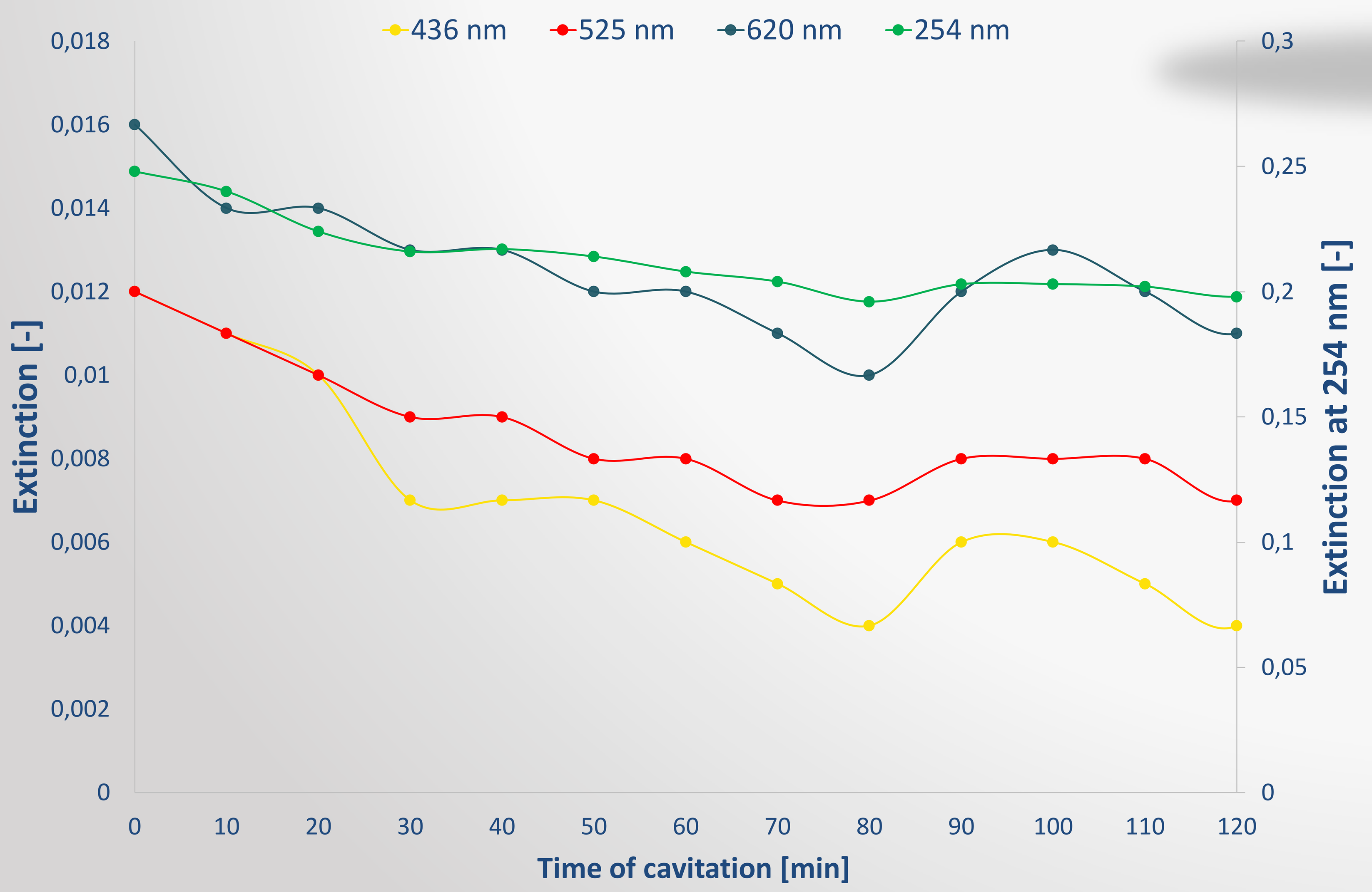


Figure 3: UV-VIS scan

254 nm C-C bonds; 436 nm, 525 nm and 620 nm extinction maxima for the corresponding color spectra

Results in biogas production

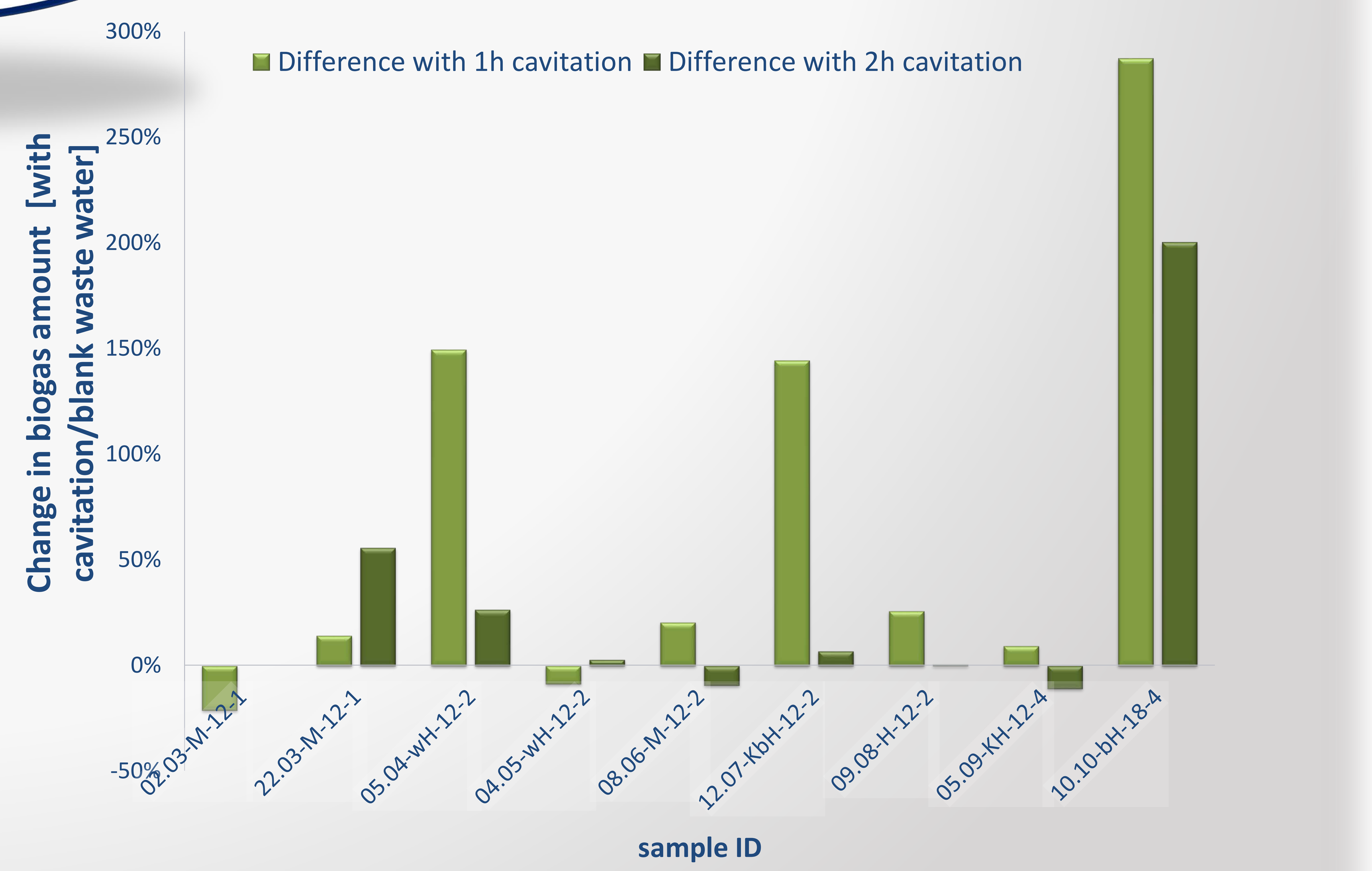


Figure 4: Effect of cavitation on the biogas yield

w/b H – white/blue Towel wastewater; M – mat wastewater; Kb/H – UF/NF concentrate wastewater

Summary

- **Cavitation can improve biogas yield significantly (See Figure 4) for complex and harsh wastewater matrix with e.g. detergents up to more than 200%**
- **The extinction scan indicates a gradual decrease in the coloration and in the concentration of organic substances in the wastewater (See Figure 3).**
- **Time dependency shows better results by smaller cavitation times. Recombining of macromolecules with longer cavitation possible.**

[1] Mata-Alvarez, J., Macé, S. & Llabrés, P. (2000). Anaerobic digestion of organic solid wastes. An overview of research achievements and perspectives. *Bioresource Technology*, *74*(1), 3–16.
[2] Chen, Y., Cheng, J. J. & Creamer, K. S. (2008). Inhibition of anaerobic digestion process: A review. Bioresource Technology, 99(10), 4044–4064.
[3] Introduction the Main Features of Cavitating Flows. (2005). Fluid Mechanics and Its Applications, 1–14.
[4] Tao, Y., Cai, J., Huai, X., Liu, B. & Guo, Z. (2016). Application of Hydrodynamic Cavitation to Wastewater Treatment. Chemical Engineering & Technology, 39(8), 1363–1376.
[5] Gogate, P. R. (2010). Hydrodynamic Cavitation for Food and Water Processing. Food and Bioprocess Technology, 4(6), 996–1011.

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