Enhanced Enzymatic Anaerobic Fermentation of Organic Residues (EnzyFOR)

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Research objectives
Aquatic sludge degrading worms offer great opportunities to investigate the way nature efficiently hydrolyses complex organic matter. The aim of this research is to explain the increase of sludge biodegradability, observed in worm predated excess activated sludge. This research will give insight into ways to mimic the biological activity of these worms for large scale processes in order to increase the valorisation of waste streams by degradation of complex organic substrates.

Project outline
Introduction
The activated sludge process is most used process to remove organic carbon and other pollutants from waste water. The organic fraction of waste water is aerobically respired and partly converted into biomass. The surplus biomass is a by-product of this process and is called excess activated sludge. The main constituents of activated sludge are biomass, organic matter and water. In general, this sludge stream is partly converted in biogas and partly processed e.g. incinerated. The major problem, associated with activated sludge technology, is the cost for processing and disposal of the large amounts of excess sludge.

The major fraction of excess activated sludge consists of complex organic matter, which could be utilized if transformed into VFA precursors for use in (bio)-chemical industrial processes or biogas. Hereby increasing the valorisation of sludge and reducing the amount of sludge associated with further processing and disposal costs.

It has been shown that the aquatic worm *Aulophorus furcatus* increases the biodegradability of excess sludge significantly, in terms of process time and methane potential, compared to other sludge reduction methods currently available (Tamis et al., 2011). Worms feed on complex bio matter present in sludge by hydrolysing the polymeric substances (e.g. biomass and possible other polymeric substances) and convert these into VFA and simple sugars. However the mechanisms in the intestines of the worms are unknown.

Approach
Due to unavailability of the aquatic worm *Aulophorus furcatus*, *Tubefix tubefix* is being studied in this research project. A lab scale worm reactor is operated at the waste water treatment plant Harnaschpolder, Delft, The Netherlands. The full scale worm process, described by J.Tamis *et al.* (2011) will be validated at lab scale. Furthermore, worm predated sludge will be compared to untreated sludge, both processed under the same conditions. Also a distinction between the

hydrolytic activity of the aquatic worms and the intestinal microbial flora is researched in order to make sound conclusions on who is responsible for the increased hydrolytic activity observed in the worm process. In a later stage conditions of the worm track will be mimicked to enhance the hydrolysis step of excess sludge digestion or VFA production.

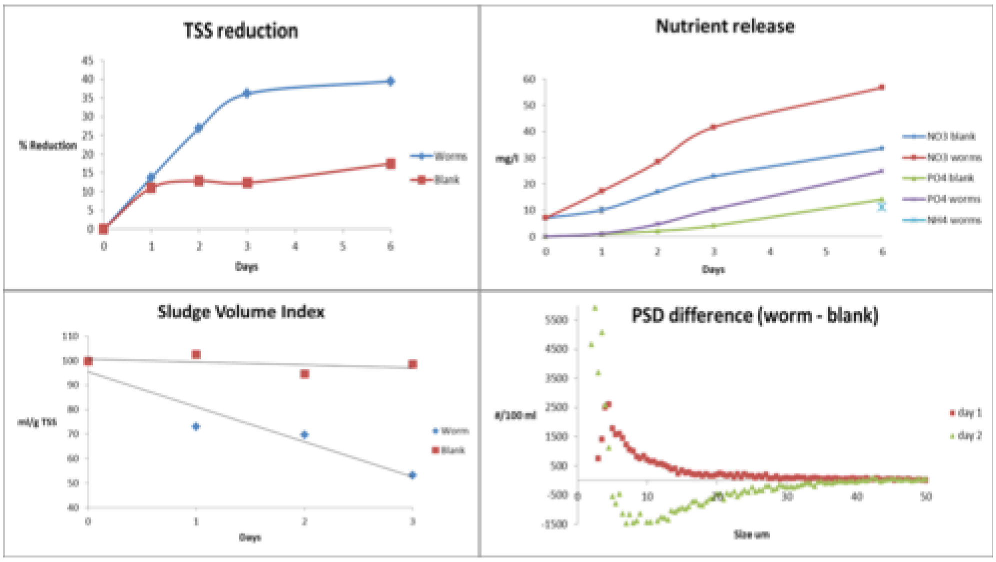

Figure 1: Aspects of worm predation. Batch experiment with (Worms) and without (Blank) worms. Activated sludge as substrate, 12g/l Worms, DO> 5 mg/l, pH 7. 1: Total Suspended Solids reduction. 2: Inorganic nutrient release. 3: Sludge Volume Index. 4: The difference in particle size between blank and worms over the course of 2 days.

The first step in this project was to characterize the worm process (figure 1). The following was found: The presence of aquatic sludge degrading worms clearly has an effect on the rate of digestion. This rate increased almost 3 fold compared to the endogenous sludge decay rate. The amount of degradation is in the same order of magnitude as is reported by other authors using aquatic worms for sludge reduction (Hendrickx, Temmink, Elissen, & Buisman, 2009; Lou, Sun, Guo, Wu, & Song, 2011; Tamis, van Schouwenburg, Kleerebezem, & van Loosdrecht, 2011; Tian, Lu, & Li, 2012).

The effects of worm activity on the characteristics of sludge was also monitored. The reported release of inorganic nutrients, namely nitrate and phosphate, was also confirmed. The TSS reduction was accompanied by a shift in particle size in the 2 – 50 µm range. There was a large increase in the 2 – 5 µm particles accompanied by decreasing sizes in the 5 – 50 µm range. The smaller and more compact sludge flocs have a significant effect on the settlebility of the predated sludge: The Sludge Volume Index dropped almost 50% during a 3 day batch.

Additionally a preliminary distinction was made regarding the source of the hydrolytic activity associated with the worms. Worms were treated with antibiotics and the hydrolytic activity of the bacteria living inside the worms was suppressed (figure 2). It was found that there is a dependence on the intestinal bacteria for hydrolysis.

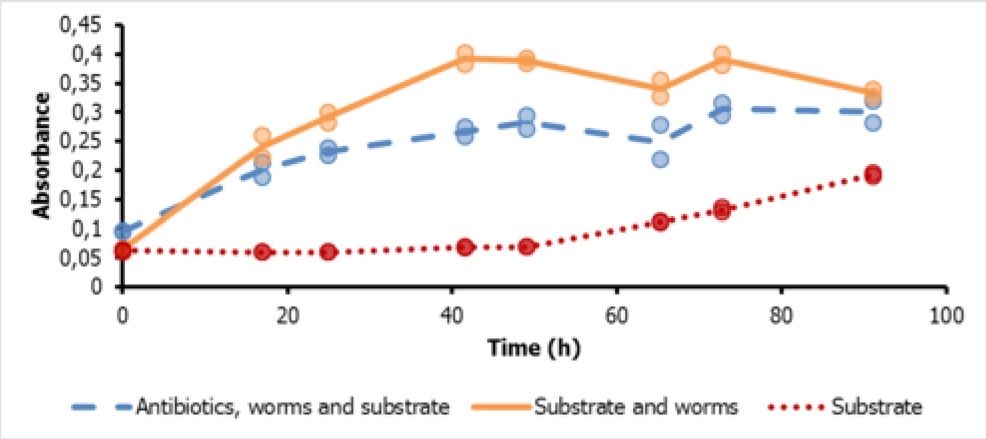

Figure 2: Preliminary results if the effect if antibiotic treated worms on the hydrolysis of azocasein. Azocasein hydrolysis was monitored by measuring the optical density of the Azo-dye that is released upon hydrolysation of the azocasein.

Scientific relevance

This project will give insight into the hydrolysis of complex organic molecules. Developing a cost effective process for the degradation of complex organics into VFA or biogas is in the scope of this research.

Social relevance

In order to achieve a sustainable bio-based society, we should be able to transfer complex organic waste into useable products, as VFA. Furthermore. Disposal of excess sludge of wastewater treatment is costly. This project aims on enhancing product formation from excess sludge by increasing its biodegradability by hydrolysing complex organic matter. Therefore, disposal of the waste sludge will decrease and production of useful components of waste, as VFA or biogas, will increase.

Literature

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