Recovery of hygienically safe nutrients from black water through hyper-thermophilic anaerobic digestion

M.J. Moerland[1*], M.H.A. van Eekert[1,2], B. Meulman[3], G. Zeeman[1,2], C.J.N. Buisman[1]
[1] Sub-department of Environmental Technology, Wageningen University and Research, Bornse Weilanden 9, 6708 WG Wageningen, The Netherlands,
[2]LeAF, Bornse Weilanden 9, 6708 WG Wageningen, The Netherlands,
[3]DeSaH B.V., Pieter Zeemanstraat 6, 8606 JR Sneek, The Netherlands.
* Presenting Author: merijn.moerland@wur.nl

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INTRODUCTION

The growing world population causes high nutrients demands, and thus new nutrient resources are required. Human urine and faeces contains 68% of the phosphorous and 82% of the nitrogen in domestic wastewater (Kujawa-Roeleveld & Zeeman, 2006). However, in Dutch wastewater treatment plants these nutrients are often wasted away. Instead of recovery, phosphorous is obtained partly from phosphate rock mines of which the reserves are running out, and nitrogen from the energy-intensive Haber-Bosch process (Driver et al., 1999, Kuntke et al., 2012). Recovery of these nutrients in centralized wastewater treatment plants is impeded by low concentrations. Separation of toilet water (black water, BW) at the source could support nutrient recovery from domestic wastewater by providing more concentrated streams, however, hygienisation is an issue. BW contains, amongst other pollutants, the main human pathogen fraction (Winker et al., 2009). A method for pathogen free nutrient recovery from black water is hyper-thermophilic anaerobic digestion (HTAD), which is an anaerobic digestion process at a temperature of 70 °C for direct elimination of pathogens. Within Run4Life, an EU-funded project for recovery and utilization of nutrients for fertilizers, HTAD is proposed as innovatory BW treatment method. HTAD has not been applied on BW before, but solid waste and manure have been successfully digested at hyper-thermophilic conditions (Charleston, 2008, Nozhevnikova et al., 1999). BW is collected with ultra-low flush volume vacuum toilets which use up to 0.5 L per flush for further increase of the nutrient and organics concentration. In Table 1 the rough estimation for the most important concentrations in black water is shown.

Table 1 Rough estimation of ultra-low volume vacuum toilet collected black water contents.

Parameter	Estimated value
Volume (L/p/d)	3.5
COD (gCOD/L)	26
VFA (gCOD/L)	2.8
TS (g/L)	20
TN (gN/L)	4.1
TAN (gN/L)	3.0
Total P (gP/L)	0.6
Potassium (gK/L)	1.1

MATERIALS AND METHODS

Black water, collected with ultra-low flush volume vacuum toilets, is treated in a 1L upflow anaerobic sludge blanket reactor (UASB) which is heated to 70 °C using a water bath. The reactor is inoculated with sludge from a non-optimized reactor running at 70 °C. The OLR fluctuates between 3 and 5 grams per litre.

Gas Chromatography (GC01,USA) and a flame ionization detector (FID) was used to analyse alcohols and volatile fatty acids. Biogas was also analysed with gas chromatography GC (Shimadzu GC-2010, Japan) with thermal conductivity detection (TCD). The gas production was quantified with a µFLOW meter (Bioprocess Control). The COD concentration was measured with Hach-Lange cuvette tests.

RESULTS AND DISCUSSION

Figure 1 shows the preliminary results of the UASB reactor. During the first 13 days the organic loading rate was 4-5 gCOD/L/d. In the period thereafter the OLR dropped to approximately 3 gCOD/L/d, due to new feed. The methane production reaches a maximum of 0.9 gCOD/d after 11 days. After this point the methane production drops slightly, due to the lower OLR. From day 18 onwards 26% of the influent COD is converted to methane. Possibly the methane production efficiency is inhibited by relative high ammonia concentrations or suboptimal operating conditions. In a full paper it is expected that results can be shown on the reactor conditions for more efficient COD conversion to methane and on kinetics of the different microbial groups.

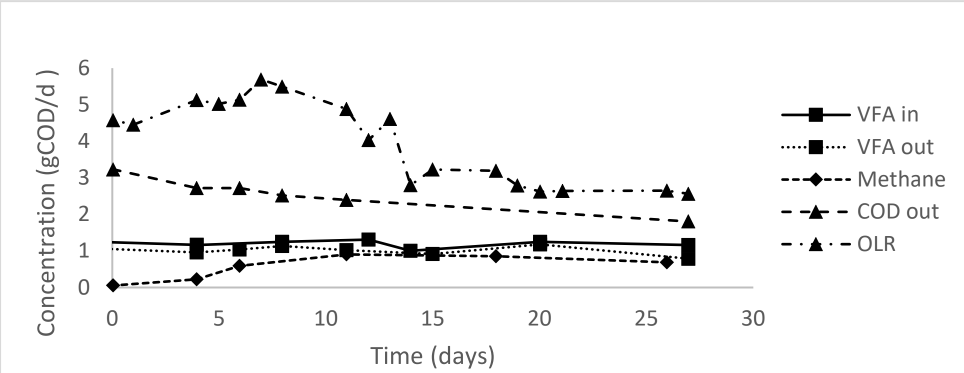

Figure 1 Influent and effluent COD total and VFA COD concentrations and methane production of the UASB reactor.

CONCLUSIONS

Methane production from black water at hyper-thermophilic conditions is feasible. In an UASB reactor roughly a quarter of the influent COD is converted to methane during HTAD. Currently optimization of methane production efficiency is being performed and kinetics are being determined.

REFERENCES

Charleston, L.O. 2008 Hyperthermophilic anaerobic digestion of food waste

Driver, J., Lijmbach, D. & Steen, I. 1999 Why recover phosphorus for recycling, and how? *Environ. Tehnol.* **20**(7), 651-662

Kujawa-Roeleveld, K. & Zeeman, G. 2006 Anaerobic treatment in decentralised and source-separation-based sanitation concepts. *Rev. Environ. Sci. Biotechnol.,* **5**(1), 115-139

Kuntke, P., Śmiech, K.M., Bruning, H., Zeeman, G., Saakes, M., Sleutels, T.H.J.A., Hamelers, H.V.M. & Buisman, C.J.N. 2012 Ammonium recovery and energy production from urine by a microbial fuel cell. *Water Re.*, **46**(8), 2627-2636

Nozhevnikova, AN., Kotsyurbenko, OR. & Parshina, SN. 1999 Anaerobic manure treatement under extreme temperature conditions. *Water Sci. Technol.* **40**(1), 215-221

Winker, M., Vinnerås, B., Muskolus, A., Arnold, U. & Clemens, J. 2009 Fertiliser products from new sanitation systems: Their potential values and risks. *Bioresour. Technol.,* **100**(18), 4090-4096