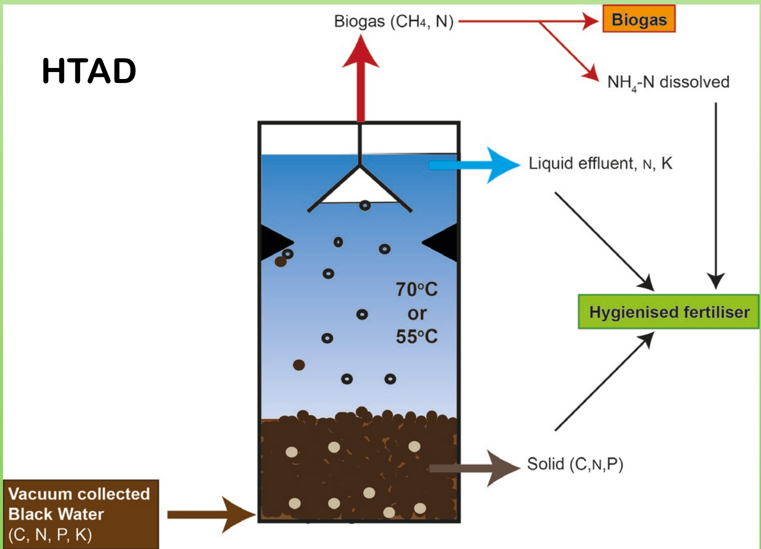
Recovery and utilisation of nutrients for low impact fertiliser

Deliverable 2.2 – HTAD and (Antibiotic-Resistant) Pathogen Removal

What is this deliverable about?

Fertilisers are produced via (hyper)thermophilic anaerobic treatment - (H)TAD - of blackwater collected from the ultra low flush vacuum toilets that were developed in the Run4Life project. Run4Life aims to recover nutrients from wastewaters, producing fertilisers that are safe to use in agriculture. This work describes the first steps to assess product safety by assessing the fate of pathogens during treatment of BW in UASB systems.



This factsheet

This factsheet is a summery of part of the work carried out for deliverable 2.2, which is made public via peer-reviewed papers. Detailed results of this particular study can be found here.

Black water (BW) and HTAD

BW is toilet wastewater that contains fecal matter and urine, toilet paper and flushing water. The vacuum toilets used in Run4Life have a low flushing volume. The high organic matter and nutrient concentration in the BW (compared to conventional toilet systems) enables treatment in UASB reactors operated at elevated temperatures (55° and 70°C).

Safe fertilisers

Domestic waste streams may contain pathogens, organic micropollutants and other constituents that can potentially be harmful when applied for food production.

What is the goal of Run4Life?

The goal of Run4Life is to demonstrate the feasibility of recovering nutrients from domestic waste streams for its subsequent application in agriculture. Run4Life proposes a new technological concept of circularity models for wastewater treatment and nutrient recovery. Success in these new circularity models requires a change in thinking from involved stakeholders and interested groups, regarding the technical, organisational, social and governance dimensions. In order to achieve this, we need to generate an understanding of how stakeholder groups currently view the context of wastewater reuse, how they interact and engage with one another and how this can be improved.

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(H)TAD and pathogens – why, how and what did we learn?

Why and how

Black water (BW) containing only toilet wastewater, is a valuable flow containing organic matter and nutrients. Nutrients recovered from BW (essentially human excreta) are currently considered unsafe for reuse in the food chain because of the presence of contaminants. For example, pathogens present even in the excreta of healthy humans and antibiotic-resistant pathogens may end up in recovered nutrients and thus in the food chain after application as fertiliser. The exposure to high temperatures is a well-known method to inactivate pathogenic microorganisms. Therefore, we apply treatment of BW at higher temperature (55° and 70°C) to produce hygienically safe fertilisers.

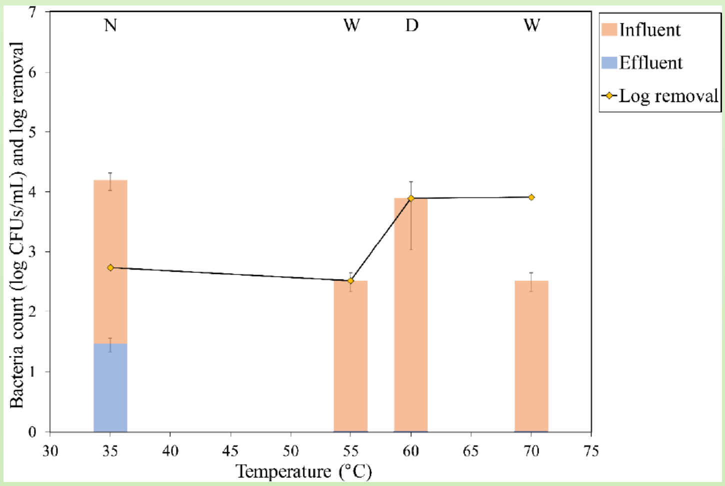
Anaerobic digestion (AD) is a widely applied technology for treatment and nutrient recovery from waste streams. UASB reactors are anaerobic systems commonly applied in wastewater treatment, that incorporate a separation between the solid and liquid fractions of the resulting digestate. In this study, we evaluated the effect of treatment temperature on (antibiotic-resistant) pathogens by comparing the BW collected with vacuum toilets with effluents of UASB reactors treating BW operated at different temperatures: 35°C (mesophilic), 55°C and 60°C (thermophilic) and 70°C (hyperthermophilic).

The AD was carried out at Noorderhoek, a site with source separated black water and food waste treated in a UASB at 35°C, the offices of DeSaH at Sneek (60°C) and the Wageningen University laboratory (55°C and 70°C). Samples were taken from influent and effluent of the reactors at regular intervals and checked for the presence of indicator pathogen microorganisms. These indicators were used instead of a full screening to limit the complexity of the study.

What did we learn?

The results of the study showed that thermophilic (55-60°C) and hyperthermophilic (70°C) anaerobic treatment had a higher (antibiotic-resistant) pathogen indicators removal than mesophilic (35°C) anaerobic treatment. (Hyper)thermophilic anaerobic treatment successfully removed *Escherichia coli* (an indicator pathogen) and the (antibiotic-resistant) extended-spectrum lactamases producing *E. coli* from vacuum collected BW and removal rates were higher than in mesophilic (35°C) anaerobic treatment. There was no significant difference in removal between 55, 60 and 70°C.

Concentrations for *E. coli* with influent and effluent from UASB reactors (Noorderhoek, DeSaH, and WUR, indicated in the figure as N, D, W, respectively) treating concentrated BW at 35, 60, and 55 or 70°C, respectively. A flat blue line indicates that the mean colony concentration was below the detection limit or too low to form a visible bar. Influent and effluent data is plotted on a logarithmic scale with base 10. The black line shows the total log removal.

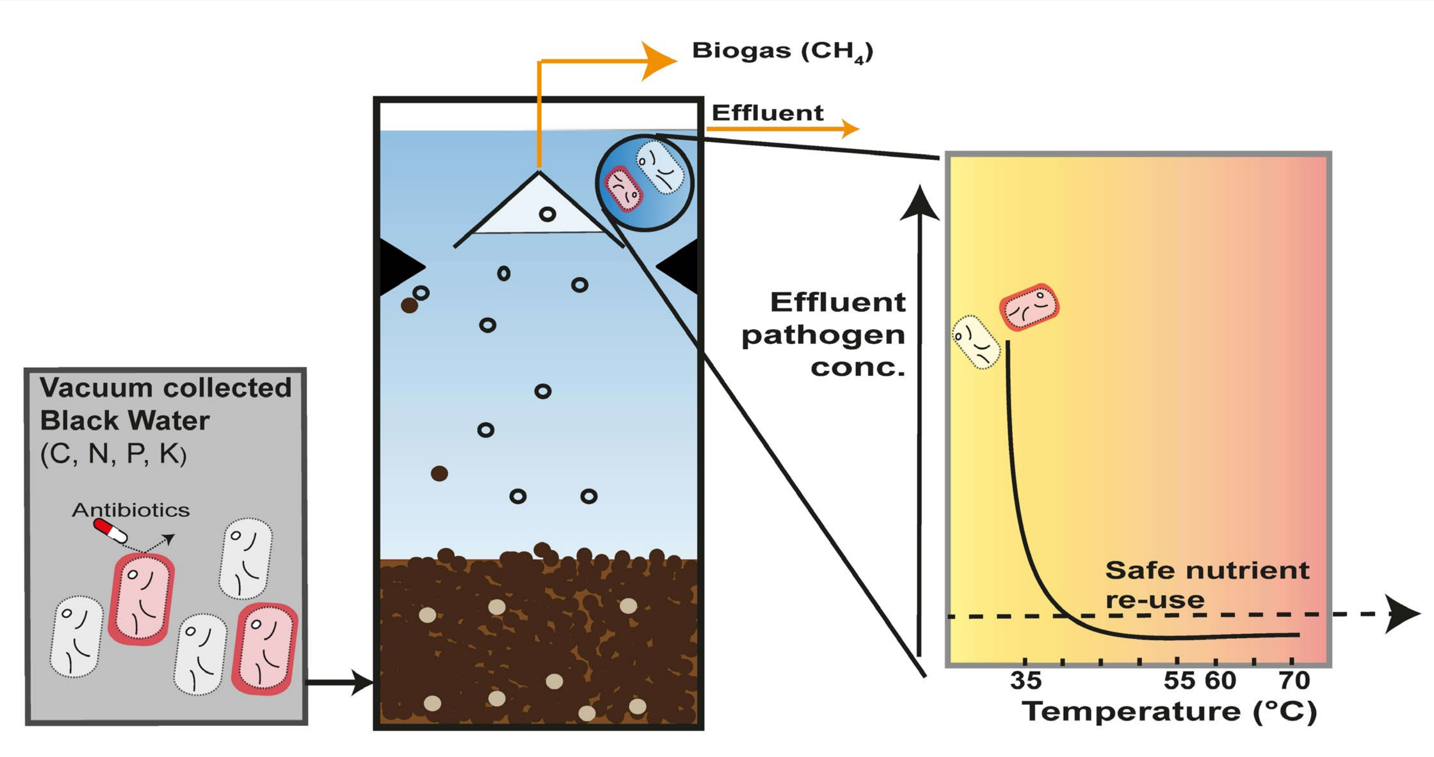


Summary and key messages

Summary – the paper in short

(H)TAD treatment leads to effective removal of antibiotic-resistant pathogen indicator organisms. The results suggest that it is possible to produce fertilisers that are safe to reuse in agriculture from black water collected in vacuum toilets. Read the full paper.

(doi:10.3390/su12229336 www.mdpi.com/journal/sustainability)



Key message 1

This study is the first to quantify (antibiotic-resistant) *E. coli* in concentrated toilet wastewater (10–40 gCOD/L) and to show that both thermophilic and hyperthermophilic anaerobic treatment can adequately remove these pathogen indicators.

Key message 2

Both thermophilic (55-60°C) and hyper-thermophilic (70°C) anaerobic digestion removed pathogen (indicator) organisms to levels below or close to the detection limit. At 35°C only an incomplete removal (2.7 log reduction) was achieved.

Key message 3

We propose thermophilic AD for treatment of (concentrated) BW to recover hygienically safe fertiliser products.

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