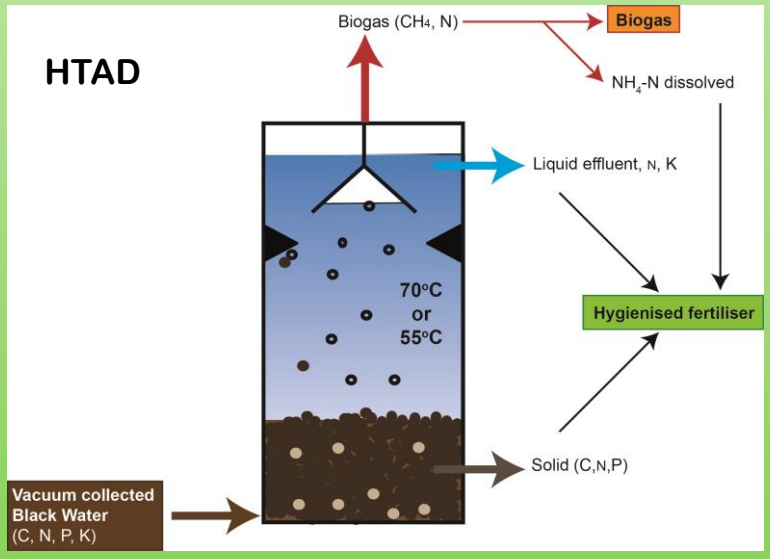
Recovery and utilisation of nutrients for low impact fertiliser

Deliverable 2.2 – (H)TAD as novel treatment for black water

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 tests to assess the efficiency of (hyper) thermophilic anaerobic treatment of blackwater.



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. It 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.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no 730285.

https://run4life-project.eu

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

Why and how

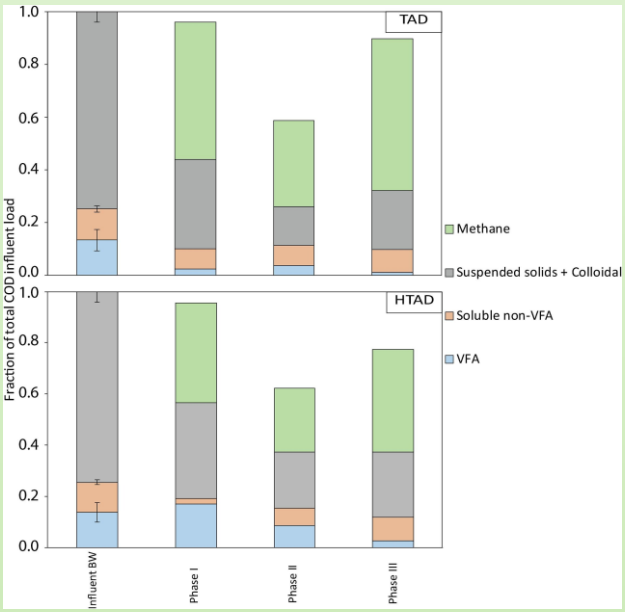
Black water (BW) is a valuable flow containing organic matter and nutrients. Nutrients recovered from BW (essentially human excreta) are currently considered unsafe for reuse in the food chain because of the presence of contaminants. The exposure to high temperatures is a well-known method to inactivate pathogenic microorganisms. Therefore, we apply treatment of BW at higher temperature (55° and 70°C) to produce hygienically safe fertilisers.

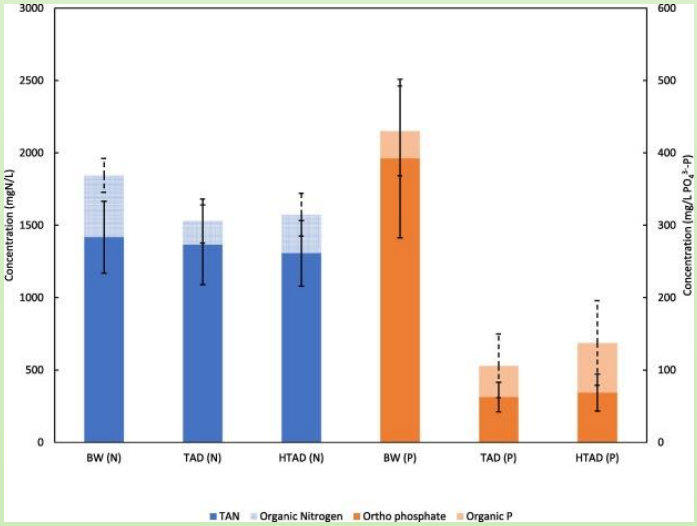
Anaerobic digestion (AD) is a widely applied technology for treatment and nutrient recovery from waste streams. UASB reactors are anaerobic systems commonly applied in wastewater treatment, that incorporate a separation between the solid and liquid fractions of the resulting digestate. In this study, we showed the potential of thermophilic (55 °C) and hyper-thermophilic (70 °C) anaerobic digestion of vacuum-collected BW with UASB reactors.

To assess the feasibility of TAD and HTAD, three glass UASB reactors (internal diameter 110 mm, height 675 mm) with a working volume of 4.9L were operated at 55 °C (two reactors) and 70 °C respectively.

What did we learn?

The results of the study showed that thermophilic (55°C) (TAD) digestion is a suitable technology for concentrated BW treatment. It achieves similar results as mesophilic AD and outperforms HTAD. Additionally, TAD has potential for pathogen-free nutrient recovery through precipitation of phosphorous and ammonia stripping. TAD of concentrated BW results in in 75% P removal and 70–80% COD removal. Furthermore, 60% of the total COD in the concentrated BW is converted to CH_4 at a SRT of 30 days and lower HRTs (6–9 days) as shown in previous long-term mesophilic and thermophilic studies on AD of concentrated BW.



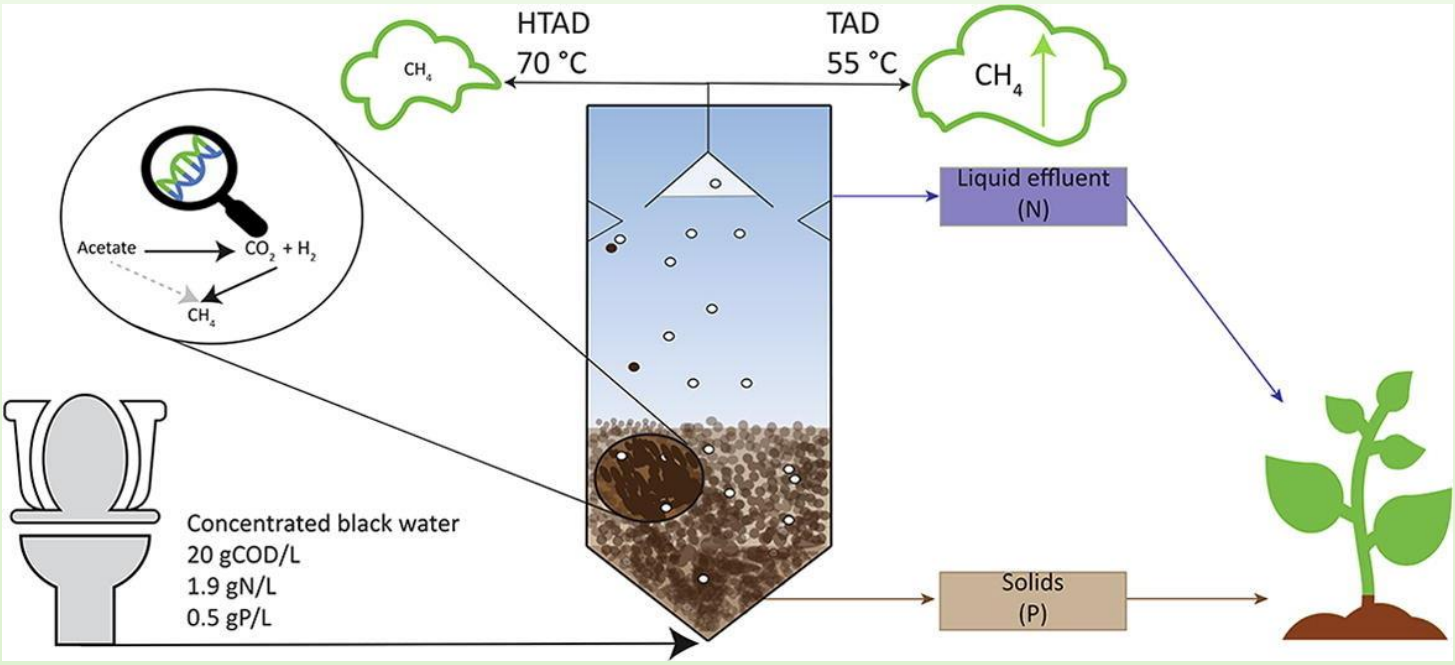


Summary and key messages

Summary – the paper in short

Thermophilic and hyper-thermophilic anaerobic digestion (AD) are promising techniques for the treatment of concentrated black water (toilet fraction of domestic wastewater collected by low flush volume toilets; BW), recovery of nutrients and simultaneous pathogen removal for safe recovery and reuse of those nutrients. This study showed that thermophilic AD (55 °C) of concentrated BW reaches the same methanisation and COD removal as mesophilic anaerobic treatment of BW (conventional vacuum toilets) and kitchen waste while applying a higher loading rate (OLR) (2.5–4.0 kgCOD/m^3/day). With a retention time of 8.7 days, and an OLR of >3 kgCOD/m^3/day, COD removal of 70% and a methanisation of 62% (based on COD_t) was achieved during thermophilic AD. Hyper-thermophilic (70 °C) reached lower levels of methanisation (38%). Start-up time of thermophilic AD was 12 days.

https://doi.org/10.1016/j.biortech.2021.125705



Key message 1

Thermophilic AD of black water (BW) results in 70% CODt removal.

Key message 2

Compared to mesophilic AD, higher loading rates can be applied during TAD of BW.

Key message 3

A thermophilic UASB treating BW can be started up in 12 days.

Key message 4

Hyper-thermophilic AD of BW results in 38% methanisation of CODt.

Contact:
Miriam van Eekert,
miriam.vaneekert@wur.nl