Recovery and utilisation of nutrients for low impact fertiliser

Deliverable 2.2 – Micropollutants removal in (H)TAD treatment of BW

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 micropollutant removal during (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 (H)TAD

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.

Key message 1

First analyses of micropollutants during (H)TAD of BW.

Key message 2

TAD and HTAD showed similar micropollutant removal.

Key message 3

High removal rates were independent of the micropollutant loading rates.

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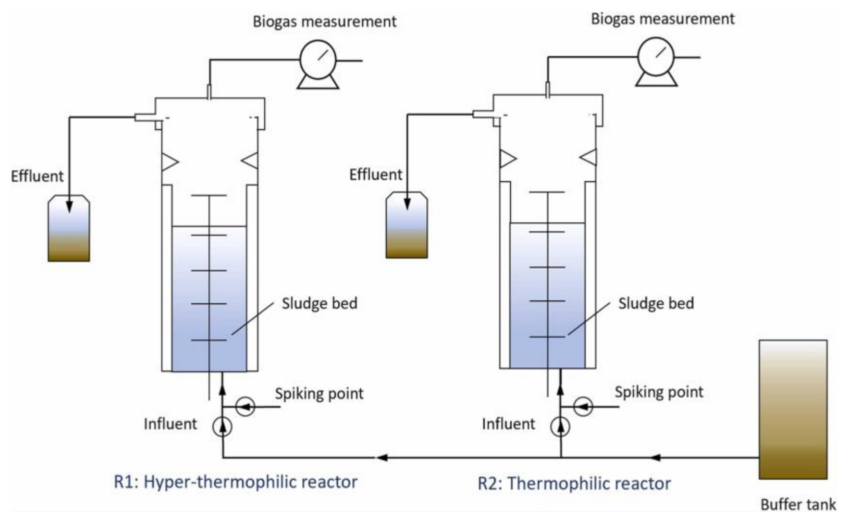
(H)TAD and pathogens – why, how and what did we learn?

Why and how

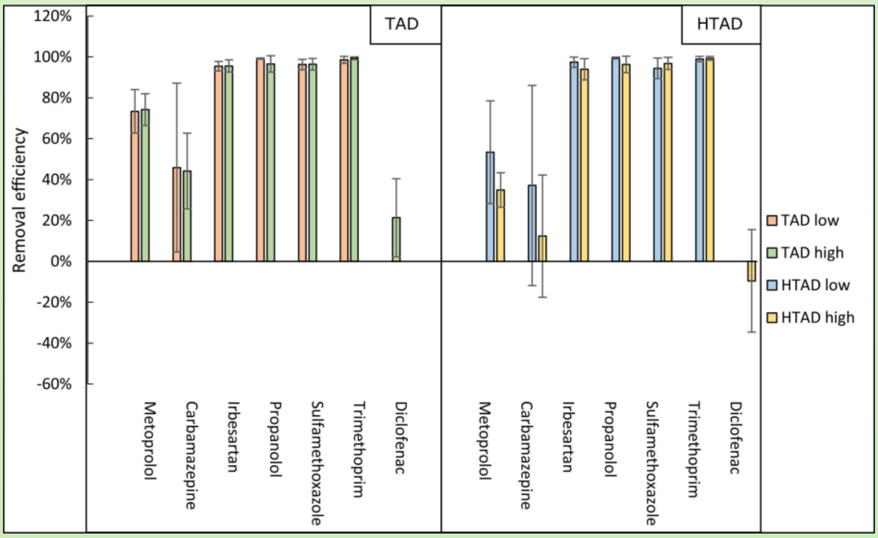
Black water (BW) is a valuable flow containing organic matter and nutrients. Nutrients recovered from BW (essentially human excreta) are currently considered unsafe for reuse in the food chain because of the presence of contaminants. The exposure to high temperatures is a well-known method to inactivate pathogenic microorganisms. Therefore, we apply treatment of BW at higher temperature (55° and 70°C) to produce hygienically safe fertilisers. However, the fate of organic micropollutants (MPs), such as pharmaceuticals, during (H)TAD treatment of black water was not yet assessed.



A total of eight widely used pharmaceuticals were selected based on their occurrence in black water, namely two antibiotics (trimethoprim and sulfamethoxazole), two beta blockers (metoprolol and propranolol), one anti-inflammatory (diclofenac), one cardiovascular agent (irbesartan), one anti-epileptic (carbamazepine), and one stimulant (caffeine). These MPs were spiked into the BW.

What did we learn?

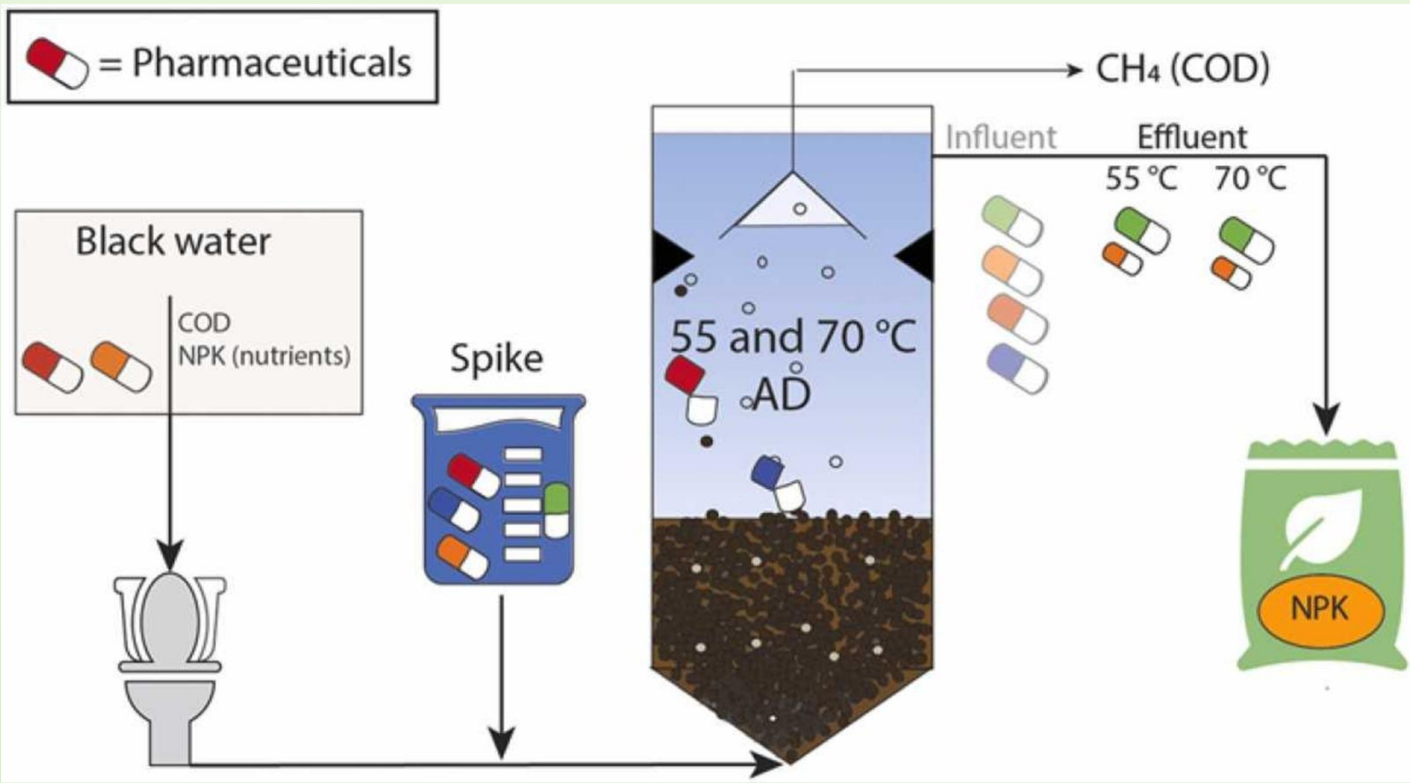
This study showed that, independent of the applied MP loading rates, high removal (>94%) of irbesartan, propranolol, sulfamethoxazole and trimethoprim were achieved under thermophilic and hyper-thermophilic treatment of concentrated BW. Metoprolol had lower removal efficiencies of roughly 70%. The three other tested MPs, carbamazepine, diclofenac and caffeine, were removed to a lower extent possibly which appears to be influenced by various processes, i.e. either by a limited sorption capacity (carbamazepine, especially at high MP loading rates) and/or insufficient sludge adaptation (diclofenac). Negative removal of caffeine was observed as a result of desorption from solids.



MP removal was assessed for the first time during HTAD of concentrated BW, however this did not result in elevated removal efficiencies compared to TAD. Therefore, TAD appears to be the most suitable treatment technology for concentrated BW in terms of mitigating MP contamination of recovered nutrients.

Summary – the paper in short

Source separated toilet water (black water; BW) is an important alternative nutrient source for agriculture. However, reuse and recovery of nutrients from BW is restricted because of the presence of pollutants, such as pathogens and micropollutants. In this study, the fate of micropollutants during thermophilic and hyper-thermophilic anaerobic digestion (AD) of concentrated vacuum collected BW was assessed. A total of eight pharmaceuticals were selected and spiked with two distinct loading rates in concentrated BW. This stream was then treated in an Upflow Anaerobic Sludge Blanket Reactors (UASB). The removal of these micropollutants was followed by measuring concentrations in the liquid phase. It was shown that the micropollutant loading rate did not affect the removal efficiency. Irbesartan, propanolol, sulfamethoxazole and trimethoprim were almost completely removed under both conditions (>95% removal). Metoprolol had 74% removal under thermophilic conditions. Caffeine showed high desorption from BW solids, whereas carbamazepine is thought to be removed by sorption to the sludge in the UASB reactor. Diclofenac removal was < 30% during both temperature conditions, which may have been caused by the lack of sludge adaptation which limits the biodegradation. There were no differences in micropollutant removal efficiencies between thermophilic and hyper-thermophilic AD of concentrated BW. Therefore, it is concluded that thermophilic AD is sufficient for safe nutrient recovery in terms of micropollutants presence. https://doi.org/10.1016/j.jece.2022.107340



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