Benefits of source separating sanitation in terms of energy and nutrient recovery

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Abstract
With help of data gathered from source separated household wastewater of student dormitories and key parameter from the literature, the recovery potential of energy and main nutrients was evaluated for conventional mixed sewage and source separated sanitation systems. The outcomes indicate that the introduction of source separation substantially increase the recovery potential of energy by methane conversion from 30 to up to 60% of COD mass load and nitrogen from <5 to up to 80% of N-load.

Keywords: Source separation, nutrient recovery, energy recovery

Introduction

In recent years, source separating sanitation gained an increasing interest within water resource management (1). Several studies pointed a separate collection and treatment of different fractions in domestic wastewater as beneficial for recovery of water, nutrients, energy via conversion in to methane (CH_4) (1,2,4,6,8). In analysing data on source separated wastewater fractions greywater (GW) and blackwater (BW) from a student dormitory in Norway, this study tries to quantify these stated benefits of energy and nutrient recovery more in detail and compare it to traditional resource recovery form municipal wastewater.

Methods

For estimating the energy and nutrient recovery potential, presently applied key technologies where identified and selected for a more detailed assessment with a mass balance study. The latter was conducted with both own data material from comprehensive wastewater analysis from Kaja student dormitory in Ås Norway. The dormitories have 40 inhabitants and are equipped with source separating sanitation that are comprehensively analysed over several years (2).

Energy recovery with transformation of organic matter into methane

Figure 1 gives an overview over the estimated maximum transformation of COD mass load into methane (CH_4) for mixed domestic wastewater compared to different types of source separated wastewater fractions. In traditional municipal wastewater treatment, energy is recovered via separating and subsequent anaerobic digestion of sludge where 50-65% of the COD contained in the sludge can be transformed into CH_4 (3). Considering the figures of Kaja dormitories, particulate COD accounts for 54% of COD load from a household (2). Discharged as a mixed sewage, 90% of particulate COD might be retainable with advanced conventional primary treatment technology. Soluble COD compounds on the other hand are passed into an aerated secondary stage where 40-60% is yielded as secondary sludge. The latter is usually also passed to anaerobic digestion. However, net energy surplus of secondary sludge is negligible due to the energy input for its production in the aeration step. Based on these consideration, approximately 30% of the total COD load from mixed household wastewater can be recovered into methane in a modern traditional treatment system.
In opposite to mixed sewage, BW is feasible for a direct treatment anaerobic reactor systems (4,5), where up to 80% of the COD load can be converted into CH_4 under optimized conditions (5).

Anaerobic digestion was also applied to greywater, however the COD conversion into CH_4 was shown to be relatively low (6). Main obstacle is the low COD concentration in GW, which might be reduced with a further segregation of bathroom wastewater, which accounts for a high volume fraction but only a minor fraction of organic load in GW. Considering these potential further developments in source separation, up to 60% of COD load from source separated sanitary systems may be recoverable into CH_4 compared to 30% from traditional sewer systems with mixed sewage.

Nutrients

Nowadays traditional wastewater treatment plants only retain phosphorous (>90%) while nitrogen is mainly transformed into N_2 and only retained to a minor degree in form of biomass (<5%). These nutrients retained in separated sludge are mixed up with potentially hazardous components (pathogens, heavy metals) and often little bio available due a strong binding alumna or ferric precipitants as typically applied in traditional treatment processes (7).

In combination with onsite treatment of greywater collecting of BW will recover a majority of the nutrients (Fig. 1B). One popular treatment option for collected BW is precipitation of struvite in which N recovery is however limited to its stoichiometric ratio to P (8). Considering the figures from Kaja dormitories (3), without adding an external P-source only 6-7% of N can be recovered via struvite. An alternative option might therefore be the removal of organic matter in an anaerobic treatment with a subsequent processing into a liquid fertilizer via a polishing and disinfection step giving >80% recovery for both N and P (Fig 1B). By reducing volume with ultra-low or vacuum flush toilets, a transportation of raw or processed BW over a certain distance seems feasible.

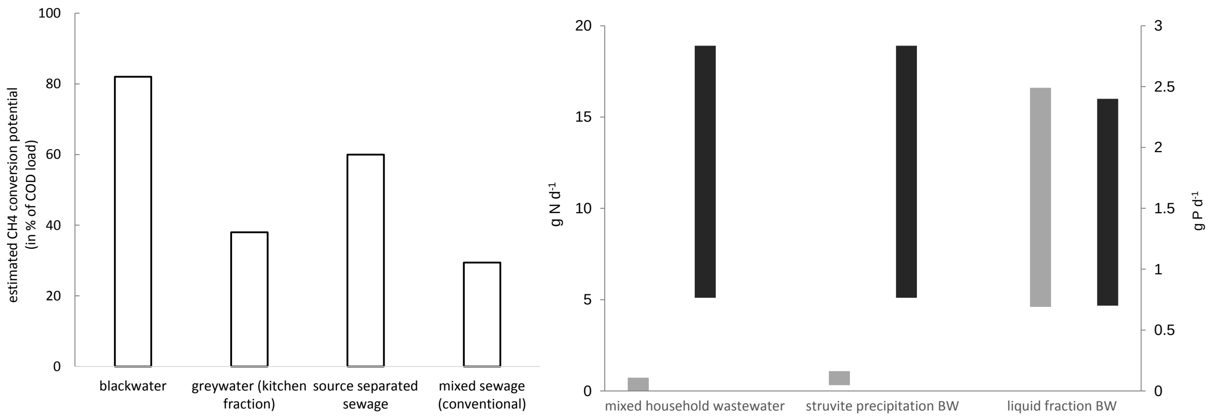

Figure 1: right: recovery potential of nitrogen ■ and phosphorous ■ per capita from traditional. The calculations were done with data on the composition of domestic wastewater presented in Todt et al. (2014)

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