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Impacts of urban typologies on efficiency of source-separation systems with decentralized treatment

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Introduction

The aim of this study is to develop a tool capable of analysing the impact of the urban typologies where is implemented source separation system on wastewater regarding energy balance. By separating the wastewater flows before mixing into the sewer, each flow keeps their characteristic, and could be valorised separately. Urine contains the large part of the nutrients (around 80% of the nitrogen and 50% of the phosphorus from domestic wastewater (Meinzinger and Oldenburg, 2009) whereas faeces contains the large part of the organic matter (around 60% (Meinzinger and Oldenburg, 2009)). Several studies analysed the environmental impacts of source separation (Landry and Boyer, 2016; Remy, 2010) but a few by taking into account the urbanism form where it is implemented (Meinzinger et al., 2010). This is why, this work studies two different separations (urine and black water) regarding different urban forms. Correlation between urban form and type of source separation will be analysed. Furthermore a sensitivity analysis will be carried out on the size of the district.

This work is the first part of the French project MUSES (Urban modelling of source separation systems) which aims to build a decision support tool to evaluate the different solutions of source separation (urine separation, black water separation...) in a specific urban implementation with real case studies. This tool will be further used to support the emergence of pilot project.

Material and Methods

Two different solutions of source separation system are studied: 1) urine source separation; 2) black water collection (urine and faeces), and compared to the conventional collection and treatment of wastewater. In the first solution, the urine is transported by truck from storage near the production and until the treatment point. The rest of the wastewater is transported by conventional sewer and discharged into the wastewater treatment plant. In the second solution, the black water is collected by vacuum sewer and treated in decentralized system. The greywater is sent to the wastewater in a first option and in a second variant it is treated locally.

The 6 typologies representing European cities described by (Bonhomme et al., 2012) are studied: discontinuous pavilions, continuous pavilions, continuous blocks, discontinuous blocks, high-rise towers, ancient centre.

The modelling approach is composed of four blocks: 1) the district with each urban form; 2) the collection and transport of flows (pipes or trucks); 3) the treatment of each flow; 4) the valorisation of by-products.

The first block uses the statistical parameters highlighted by (Bonhomme et al., 2012) as building density, land coverage ratio, road density ..., for the creation of the 6 theoretical districts. The second block designs the network collection regarding distance and wastewater flows. The urine is collected by truck and the black water by vacuum sewer. The treatment

block consists in the modelling of each treatment unit: anaerobic digestion of the black water, precipitation of struvite from urine and the conventional wastewater. In the valorisation block the transport and the use of co-products, here struvite, digestate and energy is simulated. A variant scenario will be the use of urine after precipitation to agriculture. Each simulated scenario is analysed with energetic assessment on the whole system.

Results and Discussion

The study will highlight by a sensitivity analysis the effect of urban typology on the source separation system. For that two main aspects are studied. First, the effects of the scale of decentralisation for black water treatment are carried out. The size of the district with source separation is modified. The feasibility of black water digestion (size of the digester) is compared to the energy consumption linked to processes and especially the transport. The same analysis is conducted for urine treatment and transport. Secondly, the results of this study is analysed regarding the combination between type of separation and urban typology, in order to highlight if a specific source separation system seems most suitable in a particular urban typology. In this part, the specific significance of each parameter regarding each typology is investigated in order to assess the urban drivers for source separation. The figure 1 shows typical results obtained from the simulation.

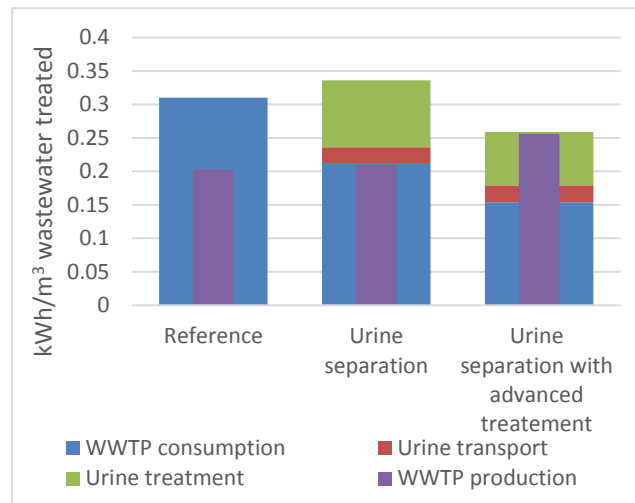


Figure 1: Typical results (energy balance) which are obtained by the simulation (from (Besson et al., 2015; Bisinella de Faria et al., 2015))

This analysis on energy balance is the first step of analysis for construction of the tool. In a second part of the project, several criteria (environmental assessment, economic balance) will be used to assess the link between urban form and source separation system.

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