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A simulation platform for the design, monitoring and optimisation of decentralised resource recovery from wastewater

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Abstract: Decentralised treatment of wastewater has a number of potentialities, including efficient resource recovery. It is claimed here that a simulation platform specially tailored for decentralised treatment plants can be used to face a number of challenges including design of novel technologies, monitoring with infrequent presence of operators and process optimisation. A short description of the simulation platform is given and some results of process simulation.

Keywords: Decentralised wastewater treatment; resource recovery; process simulation

Introduction and motivation

Decentralised wastewater treatment has the potential of becoming a solution replacing combined sewers and wastewater treatment plants (WWTP) in new housing developments, sparsely populated areas, and specific buildings such as hospitals. In many cases, black water is neither mixed with rainwater nor with grey water, thus presenting high concentrations of COD, nitrogen and phosphorous and being more apt to separation and resource recovery (Zeeman & Kujawa-Roeleveld 2013).

Several key aspects preventing the spread of decentralised treatment can be, at least partially tackled, by tools related to mathematical models:

- *Challenges in process design*. A number of the technologies used in decentralised treatment are not as mature as in WWTPs as they are only now being developed specifically for this kind of processes, or they are operated at very different conditions of loading, concentrations, flowrates, etc. Indeed, classic mathematical models describing units in WWTPs such as activated sludge models (ASM) or the anaerobic digestion model no.1 (ADM1) have not been meant to be used in highly concentrated processes. Therefore, it is necessary to adapt currently used models to the conditions of decentralised treatments or to develop brand new ones focusing on the challenges of these facilities.

- *Need of real-time monitoring*. Decentralised treatment facilities must be able to be operated with limited staff, ideally with remote monitoring and regular (but occasional) visits to the site. Dynamic models reproducing the process behaviour can assist the design of monitoring schemes with predictions of future trends, as a benchmarking comparison for the plant state and establishing limits for alerts to the operators.

- *Complex process optimisation*. Resource recovery gives place to a number of design trade-offs between the different units and alternatives technologies. As the knowledge on decentralised processes is more scarce than for conventional WWTPs, the use of mathematical models and process simulation can be used to assist decision making in technology selection and process optimisation.

The Run4Life simulation platform.

This simulation platform is being developed in H2020 project RUN4LIFE[1] and is implemented in Matlab/Simulink based on information set up in Excel spread sheets, facilitating the applications by non-expert users. It is based on a modular approach similar to the plantwide modelling paradigm (Grau et al. 2007). Each of the modules represents a technology (Fig. 1) and are made input/output compatible so that they can be linked to one, enabling the simulation of a large variety of layouts.

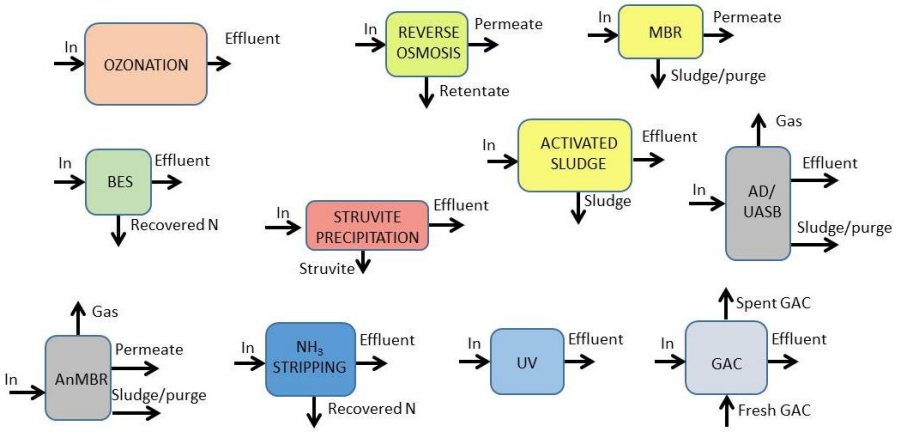

Figure 1. Collection of technologies implemented in the simulation platform, including the stream connectivity

An example of a simulation for a black water treating system featuring in series a UASB, a bioelectrochemical system (BES) and UV is shown in figure 2, allowing to follow the concentration evolution in the liquid effluent of nitrogen, COD and two selected micropollutants.

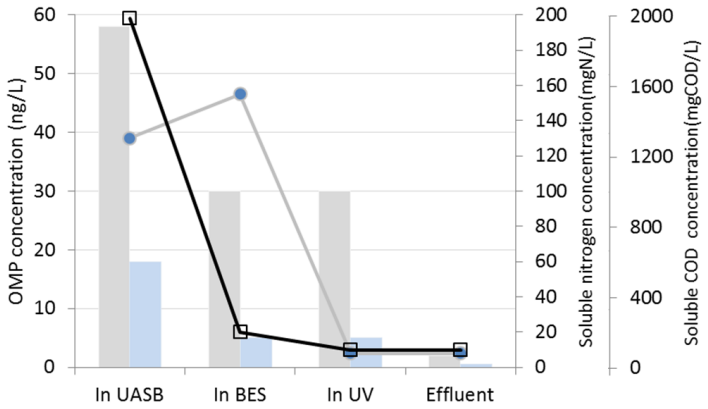

Figure 2. Evolution of soluble nitrogen (—●—), soluble COD (—□—) and two selected organic micropollutants: diclofenac (▒) and tonalide (▒) in a simulated decentralised site treating black water.

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[1] www.project-run4life.eu