Water Hub @ NEST: Review and Challenges of Source Separated Wastewater Management

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INTRODUCTION

The NEST building (nest.empa.ch) is a modular building, consisting of a steady "backbone" and exchangeable modules to test research under realistic conditions. The different modules of the living lab provide office space, accommodation, as well as a gym and spa unit. However, it is a dynamic system with regular implementations of new units allowing accommodation for more residents and expanding its offers. The Water Hub (www.eawag.ch/waterhub) is the core of NEST's wastewater research, which is located in the basement. Novel urine-diverting toilet prototypes were installed within the building. This new system allows separation of urine and faeces at the source. Separated wastewater streams are transported by pipes to the Water Hub where individual treatment can be conducted. As illustrated by Larsen et al. (2013), recovering nutrients is more efficient when wastewater is separated at the source. In the Water Hub, urine is biologically stabilised via the Vuna (www.vuna.ch) process to produce Aurin, a plant fertiliser (Etter et al., 2015). Energy will be recovered from faeces (Ward et al., 2017) and greywater is treated biologically and in the future reused in the NEST building for different purposes (Etter et al., 2016). The new urine-diverting toilets are regularly used by office workers, inhabitants and visitors. After the first testing phase, a review on robustness, functionality and use can be conducted. This paper describes the findings and challenges encountered by running a source-separation system under realistic conditions in NEST and the advances in nutrient recovery from urine.

MATERIALS AND METHODS

Urine-Diverting Toilets

Within NEST the wastewater streams are separated at the source by ten novel urine-diverting toilets (Etter et al., 2017), allowing the separate collection and treatment of urine and faeces. Electronically controlled separation valves receive a signal from sensors within the toilets. These sensors detect whether urine or water is present and open or close the separation valve respectively. The sensors are located inside the sidewall of the toilet. In order to detect urine, the liquid has to reach the sensor's vicinity at about 2-3 cm maximum distance. If the urine touches the bowl's surface further away, the separation valve remains closed and the urine is flushed down the blackwater pipe.

Unfortunately, the urine diverting toilets are no longer produced and the entire development process halted, as the industrial partner abandoned the development project. Important investments would have been necessary to achieve a market readiness. For NEST, this means that currently, no source separation toilets can be implemented. Therefore, new units have to be equipped with standard toilets. However, all separate pipe connections are installed within new units in order to be able to integrate urine-diverting toilets, as soon as new prototypes are available.

Urine

Urine is collected as described above and from waterless urinals, the volume is recorded regularly and ammonium is measured every two weeks. With the objective to produce fertiliser, urine is stabilised in the first step. A granular activated carbon (GAC) column was added as a new process step and lastly water is removed by distillation (www.vuna.ch). A study conducted by Köpping et al. (2017) investigated the pharmaceutical removal by granular activated carbon. The experiments were conducted in prospect of implementing this treatment step and certifying the safe use of Aurin fertiliser.

RESULTS AND DISCUSSION

Urine-Diverting Toilets

Overall, the urine-diverting toilets are mostly appreciated by their users and separate the sources sufficiently. However, despite first evaluations of well-functioning separation valves (Etter et al., 2017), deficiencies were observed. The valves do not open and close consistently with the presence or absence of urine. It became evident that the urine beam has to be pointed at the sensor's vicinity within the toilet bowl. This appeared to be one problem of the urine-diverting toilets. Additionally, it was observed that urine collected in NEST was more diluted than the urine collected from Eawag's main building Forum Chriesbach (FC). Measurements over four months indicated a 40% lower ammonium concentration in NEST in nine out of ten samples. This was attributed to a lag of the urine valves in the toilets, allowing flush water to enter the urine pipe in NEST.

The production stop of urine-diverting toilets results in a limited urine collection, complicating the urine treatment process, as a certain storage volume is necessary for stable management. Especially after extended holiday periods, very low urine volumes were recorded, which reduced the yield of the fertiliser production.

Urine

Köpping et al. (2017) demonstrated that the pharmaceutical residue concentrations can be reduced substantially, if the stabilised urine is treated in a granular activated carbon column. Additionally, a large decrease in pharmaceutical residue concentration was observed in the storage of the stabilized urine prior to the GAC column. Therefore, the additional treatment step featuring this GAC column was introduced.

OUTLOOK

NESTs urine-diverting toilet prototypes have shown promising results and allow research on source separated wastewater management. However, to promote source separation, the development of urine-diverting toilets and the improvement of required sensors is inevitable. A future urine-diverting toilet has to be low-maintenance, easy to use and contain a reliable separation mechanism. In any case, odour emissions must be prevented.

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