Urine on tap: Collection tank at Eawag (Photo Ruedi Keller)

Work package Nova 3

Storage and transport

Research background

Nova 3 is concerned with the transport of urine from the NoMix toilet and a local tank to a central treatment plant. Various options exist for transporting locally stored urine – tankers, separate pipes, or the existing sewer system. The latter could be used at a relatively low cost, for example, by transporting urine at night – i.e. at a time when in many catchments only small amounts of water, largely unpolluted, flow through the sewers [1, 2]. However, this strategy involves certain risks, as it would entail the passage of highly concentrated urine through the sewer system for a short time. Thus, in the event of unforeseen excessive rainfall, large quantities of urine could enter receiving waters untreated. In addition, odour nuisances could arise. As a transition scenario, therefore, Novaquatis investigated another option for transporting urine through the sewer network: the nitrogen load is distributed over 24 hours, leading to improved utilization of capacity at an existing wastewater treatment plant (Nova 3-1). This strategy would make it possible to gain experience concerning the reliability of rain forecasts without running any major risks, since at no time would the amounts of urine passing through the sewers be larger than at present.

An alternative to the difficulties of urine transport would be local treatment, based on the results obtained in Nova 4.

Nova 3-1: Urine source separation and "waste design"

(Wolfgang Rauch, Willi Gujer, Tove A. Larsen)

The concept of "waste design" involves retaining portions of the domestic or industrial wastewater that arises and only transporting it when capacity is available for the processing of these streams at a wastewater treatment plant [3]. This system is particularly appropriate in the case of urine: because most people use the toilet when they get up, a "morning peak" of urinary nitrogen is recorded at wastewater treatment plants. To allow this peak load to be processed, treatment plants currently have to be designed with significantly larger dimensions than would actually be required – with a corresponding increase in construction costs. If household urine was stored and then released in a controlled manner throughout the night, treatment plants would be exposed to more evenly distributed nitrogen loads. In addition, it would be beneficial to retain stored urine during periods of heavy rain, as in such cases – at present – some wastewater is discharged untreated into receiving waters via combined sewer overflows.

Nova 3-1 elaborated a virtual case study based on stochastic modelling. Using data from the Zurich region, it assumes a complete changeover to NoMix toilets. According to this study, a 10-litre storage tank integrated into each NoMix toilet and a simple control strategy would yield the following results: firstly, a reduction of more than 50 % in the annual volume of urine released by combined sewer overflows and, secondly, a decrease of approx. 30 % in the peak load of nitrogen under dry-weather flow conditions. The first of these may be an economically attractive option, as it reduces inputs of toxic ammonia to surface waters during rainfall [4]. The second leads to an increase in the performance of a nitrifying wastewater treatment plant commensurate with the reduction in peak load. In certain cases, the (costly) expansion of existing treatment facilities could thus be effectively avoided or deferred ([5]; see also Nova 3-3 and 7-2).

Nova 3-2: Storage and transport

(Luca Rossi, Judit Lienert, Tove A. Larsen)

An extensive series of measurements provided information on the functioning of the NoMix technology under real-life conditions [6]. The findings of this research are important as they indicate the need for urine to be correctly collected in the NoMix toilets and drained into the storage tank. Household measurements revealed that the urine yield was only 60–75 % of the amount expected, thus showing where practical improvements to the NoMix toilets are possible. In the institutional setting, e.g. at Eawag, considerably more urine was collected with the NoMix toilets. However, the potential for improvement can only be estimated for the women's toilets, since the men use the urinals in most cases. Further measurements indicated that in 55–60 % of flushes, the low water volume button was pressed. In certain households,

Gone but not forgotten: The date and time of each flush are recorded by a digital counter at Eawag (Photo Ruedi Keller)

Community-level toilet usage: Precise data on housing, employment and recreation are required for the microsimulation model (Photo Karin Güdel)

however, the low-flush option was hardly ever used; in the institutional setting, the proportions varied widely. The frequency of flushing in households clearly demonstrated the reason for the "morning peak" in nitrogen levels at wastewater treatment plants: not only is morning urine more concentrated, but flushing is more frequent at this time of day. In addition, marked differences were observed for households between weekdays and the weekend. This coincides precisely with the results of measurements at wastewater treatment plants. The detailed data can be used to help design urine storage tanks for future pilot projects, thereby avoiding the construction of units that are too large – and costly – or too small.

Nova 3-3: Microsimulation model (formerly Nova 7-1)

(Christian Spörri, Peter Reichert, Irene Peters, Tove A. Larsen)

A new computer model based on microsimulation was used to evaluate the effects of different strategies for the management of urine tanks [7]. The test region was the catchment of the Ergolz 1 wastewater treatment plant in the canton of Basel-Landschaft. The model is based on census data concerning residents, their workplaces and residential and commercial buildings. It represents people's movements to work, recreational activities and service enterprises. Medical data provided the basis for simulating people's urination patterns and, hence, urine production in individual toilets. Rain forecasts and precipitation data from the region were used to identify optimum tank management strategies, with the aim of achieving the goals defined in Nova 3-1 – levelling out nitrogen loads at the wastewater treatment plant and avoiding urine releases from combined sewer overflows. With a random distribution of NoMix toilets in only 30 % of the apartments and workplaces and a tank capacity of 10 litres, the model generates the following predictions: the peak load entering the wastewater treatment plant is reduced by 20 %, and at the same time urine concentrations in the sewer system during rainfall are lowered by 22 %. More elaborate modelling thus makes it possible to identify better control strategies than the one applied in Nova 3-1, which assumes universal distribution of NoMix toilets.

Conclusions

The key problem for the NoMix technology is how to transport urine from the NoMix toilet to a central treatment plant. Nova 3 shows that a good interim solution can at least be found for urine transport, which optimizes the capacity of wastewater treatment plants – i. e. transport via the existing sewer system, with urine streams distributed over 24 hours. In principle, it would also be possible to discharge concentrated urine through the sewer network in a wave. However, the feasibility of this approach would have to be demonstrated by experience from a large-scale practical project. Implementation of the interim solution would permit such experiments. As an alternative to the difficulties of transport, urine could be treated locally in accordance with the findings of Nova 4.

Practical experience from the pilot projects shows that there is room for improvement in the efficiency of urine source separation in NoMix toilets – a finding that is of particular relevance for the further development of the NoMix appliances.