Beyond end-of-pipe solutions: There are alternatives to wastewater treatment plants for pollution control (Photo Abwasserverband Altenrhein)

Green isn't always beneficial: The NoMix technology could rapidly help to resolve nutrient overload issues in coastal waters (Photo Keystone)

Introduction

Research background

(Tove A. Larsen, Judit Lienert)

Urine source separation is based on a simple insight: most of the nutrients in wastewater – about 80 % of the nitrogen and 50 % of the phosphorus – derive from urine, which itself accounts for less than 1 % of the total volume of wastewater. In the twentieth century, wastewater treatment plants in Europe were expanded specifically to deal with these nutrients, as they produced toxic effects (e.g. ammonium in rivers) or excessive algal growth (e.g. phosphorus in lakes). At treatment plants, major efforts were undertaken to precipitate phosphorus, to convert ammonium to nitrate and to then eliminate the latter.

The "NoMix technology" concept is also simple: urine is collected in the front compartment of specially designed toilets and drained, with a little flushing water or even undiluted, into a local storage tank. The back compartment of these toilets operates on the same principle as conventional models; the waste matter collected is flushed into the sewers with water. One of the Novaquatis research topics was how urine is to be subsequently managed: the nutrients nitrogen and phosphorus are used to produce a fertilizer – or are removed by processes similar to those applied at wastewater treatment plants.

Separating urine from wastewater would offer various advantages: wastewater treatment plants could again be built on a smaller scale, and at the same time waterbodies could be more effectively protected from nitrogen and phosphorus inputs. The nutrients could be recycled to agriculture, and the micropollutants in urine – hormones and pharmaceutical residues – could be removed without being mixed with wastewater. Urine source separation would thus clearly increase the flexibility of wastewater treatment. In the face of global water scarcity, the NoMix technology also represents an excellent way of improving the quality of reused water.

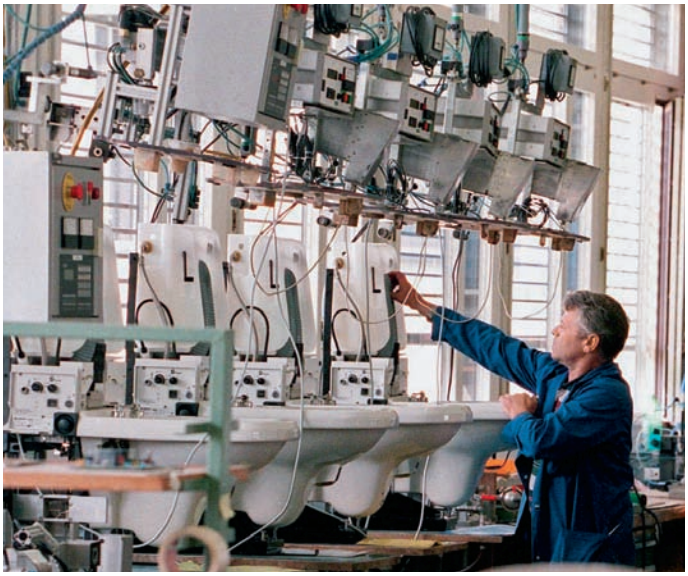
The NoMix technology has major potential. However, the costs need to be competitive with conventional technologies, since problems of water pollution control and phosphorus recycling to agriculture can often also be addressed using conventional methods.

In Novaquatis, we studied whether, in what form and in what circumstances the NoMix technology is a viable option. As a wide range of questions are involved, the projects were organized into work packages reflecting the stages of a possible nutrient cycle. An overview is given on pp. 2–3, and further details can be found in the individual Novaquatis publications (see pp. 26–28).

Results and synthesis

Gratifyingly, the NoMix technology meets with a high level of approval among the public. All the people surveyed in Novaquatis were familiar with and had used the still-immature technology. Although they recognized the drawbacks of today's NoMix toilets, the overwhelming majority found the basic idea convincing (Nova 1). Practitioners also show considerable interest: in Canton Basel-Landschaft, for example, large-scale pilot projects were successfully conducted (Nova PP). With regard to conservation of resources, the NoMix technology also performs well: it has the potential to make a major contribution to water pollution control in an energy-efficient manner. In addition, in areas of nutrient scarcity, urine represents a local nutrient resource (Nova 7).

The difficulties are in the detail, and urine transport proved to be the most problematic point. Installing new pipes or transporting urine by tanker from basement storage tanks for centralized treatment would be a complex and costly undertaking. In Novaquatis, we elaborated low-cost solutions for transporting urine via the existing sewer system (Nova 3). However, despite their potential, they failed to convince the project partners from the sanitary technology industry. These approaches are too closely tailored to Swiss conditions and are also only suitable for relatively small catchment areas. The sanitary industry therefore considers the market potential to be too low to justify investments in the NoMix



Major potential: Urine source separation could spell big business for the sanitary industry (Photo Keystone)

Problem or opportunity? Nutrients from urine are unwelcome in waterbodies, but useful as fertilizers (Photo Andri Bryner)

technology (Nova 2). Improved sanitary technology is, however, indispensable; although pilot projects can be carried out with today's NoMix toilets – larger-scale demonstration projects are not feasible (Nova PP). The objections raised by the sanitary industry will thus have a decisive influence on future developments.

At the same time, literature studies (Nova 7) indicated the huge potential of the NoMix technology from a global perspective. Coastal waters in particular are severely threatened by nutrient overload. As a result of explosive population growth in these regions, the problems associated with nutrients from wastewater are becoming increasingly prominent on the global agenda. Greater elimination of nutrients is required – which is at present being carried out almost exclusively in industrialized countries. In areas currently lacking a fully developed infrastructure, the NoMix technology can protect water resources more rapidly and effectively than the expansion of sewers and treatment plants. The potential of the NoMix technology in cases where acute population pressures give rise to intractable water pollution control problems was impressively demonstrated by the example of China (Nova 8).

Ultimately, the key issues are cost-effectiveness and the technical and organizational possibilities of urine source separation. If urine could be readily transported, centralized urine treatment would be the option of choice. Methods already exist (Nova 4), and processes such as phosphorus precipitation and biological nitrogen elimination can be applied much more cheaply and energy-efficiently to concentrated urine than to wastewater. Great potential also attaches to methods for the recovery of nitrogen and elimination of micropollutants – pharmaceuticals and hormones excreted by humans and detectable in waterbodies. Urine in wastewater accounts for an estimated 50 % of the ecotoxicological hazard posed by these substances (Nova 5).

Given the difficulties and/or cost of transport, the potential and cost-effectiveness of decentralized processes need to be considered. Urine treatment on site appears to be an attractive option. However, it was not possible within the Novaquatis project to study decentralized processes in detail. Here, too, the combination of phosphorus precipitation and biological nitrogen elimination would certainly be a promising approach. We are confident that mass production could make decentralized processes economically attractive for the sanitary and other industries. More problematic, in our view, is the stability of decentralized technologies and the level of maintenance required, especially in the case of biological processes. To facilitate the adoption of the NoMix technology, the two types of solution could be pursued in parallel. In view of Eawag's scientific expertise, we are better qualified to develop stable biological processes and solutions for the organizational problems of decentralized treatment than to identify new options for urine transport.

Conclusions

The Novaquatis research showed that the NoMix technology could represent a valuable alternative to nutrient elimination as practised today – provided that one of the two fundamental problems is solved: either an attractive, widely applicable and low-cost solution needs to be found for urine transport, or stable and cost-effective technologies need to be developed for decentralized treatment.

Water pollution due to nutrient emissions is an increasingly serious problem worldwide, and we are convinced that it is worth seeking solutions. However, to be competitive, innovations require large markets. It may therefore be advisable initially to develop technologies for fast-growing urban areas where nutrient elimination at wastewater treatment plants is inadequate or non-existent. In this way, the NoMix technology could rapidly and effectively help to resolve global water pollution issues. This would require the development of attractive and economic technologies – e. g. by Swiss companies, which increasingly operate in global markets. As solutions of this kind also represent a realistic option for industrialized countries, implementation of the NoMix technology in demonstration projects would make sense here, too. In the long term, Swiss waterbodies would also benefit from the widespread application of this system.