

# NoMix Technology: How Good is the Acceptability?

**The successful implementation of an innovative technology depends on many factors. Apart from its technical superiority compared to traditional solutions, the needs of the stakeholders play a vital role. We were interested to know whether the market is ready for the NoMix technology, a sanitary concept for urine source separation, which would revolutionize our current system of wastewater management. Surveys showed that consumers and farmers have a positive attitude, given that the NoMix technology is adequate, inexpensive, and safe. Sanitary firms are confident that they can further develop NoMix toilets, but they demand strong commitment from wastewater professionals who will, therefore, play a deciding role in putting the NoMix technology into practice.**

Originally, the urban wastewater system was designed as a transport system. The underlying principle has hardly changed over the past hundred years. More and more, wastewater professionals realize that it is difficult to meet modern requirements of water pollution control with these old structures. On the one hand, the urban wastewater system still has gaps, e.g. houses that are not connected to the sewer

system or leaky sewers and combined sewer overflows which discharge untreated waste water directly into surface waters or into the ground water. On the other hand, wastewater treatment plants have to meet increasing demands; e.g. it is still unknown whether micropollutants such as pharmaceuticals and synthetic or natural hormones, which are mainly excreted via urine, can be efficiently eliminated in treatment

plants. Measures at source – such as urine separation – could help solving such problems. Additionally, although only 0.5% of the waste water from households is urine, this fraction is responsible for most of the nutrients arriving at wastewater treatment plants. Urine, therefore, significantly contributes to the charge of the treatment plants. The separate collection and treatment of urine, thus, offers entirely new possibilities to increase the efficiency of wastewater treatment [1].

## Urine Source Separation via NoMix Technology

The NoMix technology consists of specifically designed toilets for the separate collection of urine. The urine is stored in urine tanks and can then be transported to the treatment plant at favorable times, either via the existing sewer system or by special trucks. Additionally, the urine could be treated in special urine processing plants (Tab. 1). These would offer the advantage of an easier elimination of micropollutants. The raw urine could also be processed into a fertilizer product, which could partially replace artificial mineral fertilizers. Technology version A – separate collection and use of stored urine as fertilizer – is already being practiced. Versions B and C, however, are new, but they could easily be integrated into the existing sewer system and have advantages for the treatment plants (Tab. 1). Thus, introducing the NoMix technology could increase the efficiency of treatment plants, improve water pollution control and close nutrient cycles. At EAWAG, the interdisciplinary research project NOVAQUATIS deals with the NoMix technology [2]. Issues addressed are in addition to sanitary technology, storage, transport and processing of urine, production of fertilizer also the question whether this technology can win the necessary acceptance of stakeholders. Traditionally, new technologies in wastewater management were developed by professionals without participation of the public. This is not appropriate for urine separation



Would you buy these vegetables if you knew they were produced with an urine fertilizer?

in households. Therefore, already at an early stage of the research, NOVAQUATIS integrates users of NoMix toilets, farmers applying urine-based fertilizer, the sanitary industry, as well as wastewater professionals who will have to apply and promote this new technology. In this article, we present the results of several surveys and a theoretical analysis.

### Positive Response of Consumers and Farmers

Consumer attitudes towards the NoMix technology were explored in several focus groups [3]. Focus groups are moderated group discussions with informed citizens

on a well-defined topic. The 44 participants were informed by a computer based information system [4] and visited a NoMix toilet. 71% of the men and 89% of the women thought the NoMix toilet is a good or very good idea. With 88%, most of the men would move into an apartment with NoMix technology, but only 42% would buy a NoMix toilet. Similarly, 79% of the women could imagine living in a flat with NoMix technology and even 63% were willing to buy a NoMix toilet. Consumers stressed the importance that the new technology would equal today's level of comfort and cost. Interestingly, only 16% of the men stated that they do not sit down for urinating, which is necessary for the functioning of the NoMix toilets available today. With 72%, the majority of the interviewed persons would also buy food grown with the help of a urine-based fertilizer and even 80% prefer urine-based fertilizer to artificial mineral fertilizer. However, the participants emphasized that any risk concerning hygiene and micropollutants would have to be excluded.

A mail survey among 467 farmers in the German speaking part of Switzerland showed similar results [5]. Unfortunately,

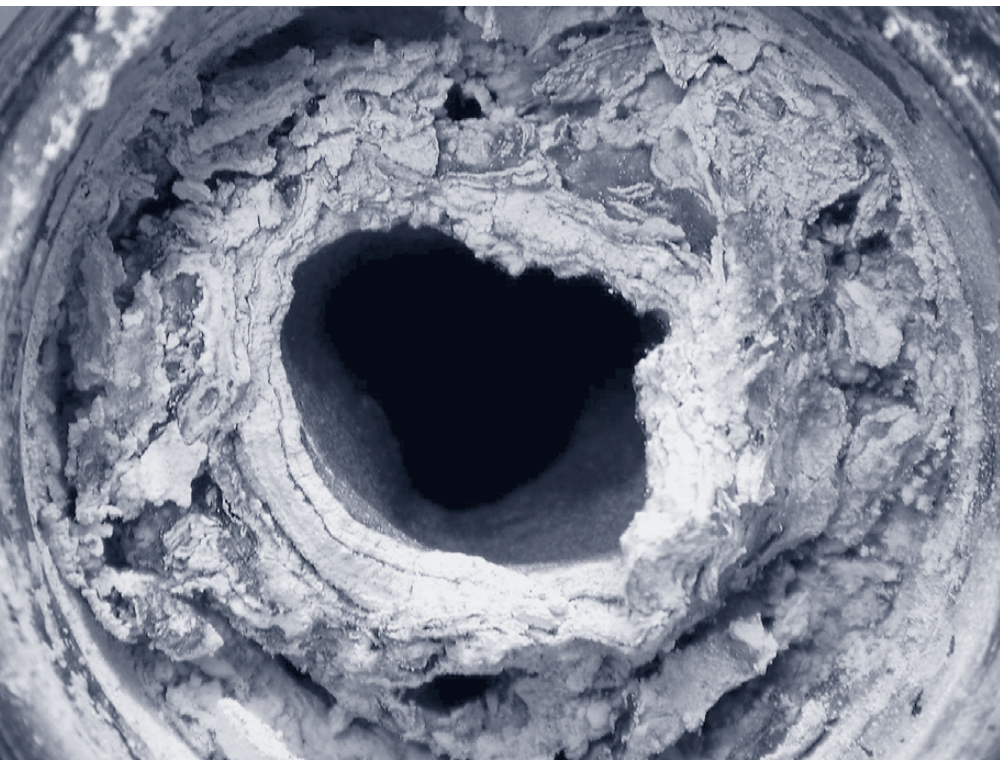
this survey cannot be regarded as representative: first, because only 27% of the questionnaires were returned and second, because the answers of IP- (integrated production) and organic farmers differed significantly. Nevertheless, the survey gave some important indications: 57% of the farmers regard urine source separation as a good or very good idea and 42% would purchase a urine-based fertilizer product. The chances of opening a market for a urine-based fertilizer are presumably high in those cases where additional fertilizer is purchased anyway, i.e. especially for IP- and vegetable production. Farmers also demand a product without risk: 30% mentioned concerns that the fertilizer might contain micropollutants. The preferred type of fertilizer would be a grainy and odorless nitrogen fertilizer. From these first surveys, we conclude that the NoMix technology could be accepted, given it is cheap, safe, and at least as comfortable as the current technology.

### Sanitary Industry: Market for NoMix Does not yet Exist

Urine source separation is a technology that has been applied for several millennia. Thirty years ago, this tradition was again

	NoMix technology version		
	A	B	C
<b>Duration of storage</b>	6 months Local storage of urine for hygienization	3–7 days Short-term local storage of urine	1–2 days NoMix toilet with integrated urine tank
<b>Transport</b>	Trucks	Sewer system Central control of urine drainage via existing sewer system during nights without rainfall (i.e. while minimal amounts of other waste water is drained via the system) Before reaching the general treatment plant, urine is led to a special processing plant	Sewer system Central control of urine drainage via existing sewer system (see version B)
<b>Urine processing</b>	No	Yes In central urine processing plants Removal of micropollutants and processing into a fertilizer product	Yes Together with waste water in existing treatment plants
<b>Nutrient recycling</b>	Yes Direct use of stored urine as fertilizer in agriculture	Yes Fertilizer product for agriculture (maybe industry)	No
<b>Main intention</b>	Nutrient recycling Improved water pollution control with simpler wastewater treatment plants	Nutrient recycling Improved water pollution control with simpler wastewater treatment plants	Transition scenario “Peak-shaving” of nutrient load in treatment plants, thus increasing capacities Less urine in combined sewer overflows, where untreated waste water is directly discharged to surface waters
<b>Literature</b>	Johansson, 2001 [6]	Larsen and Gujer, 1996 [1]	Rauch et al., 2003 [12]

Tab. 1: Attributes of the three NoMix technology versions [7]. All three versions consist of a NoMix toilet and a urine collection tank.



K. Ullert, EAWAG

A urine conducting pipe clogged by urine precipitates.

taken up in Scandinavia and from 1990 on, modern NoMix toilets were produced in Sweden. Between 1992 and 1996, about 3000 NoMix toilets were installed in more

than 15 pilot projects [6, 7]. A technologically refined and attractive NoMix toilet is available today [8]. However, it is essential to further improve the sanitary technology,

Definition of attributes (according to Rogers, 1983 [10])	Possible attitude of wastewater professionals
The <b>relative advantage</b> is the degree to which an innovation is perceived as being better than the idea it supersedes ( often expressed as economic advantage, status giving etc.).	Large uncertainties: <ul style="list-style-type: none"> <li>Benefit for ecology is significant, but difficult to quantify</li> <li>Costs are unknown in initial stage</li> </ul>
<b>Compatibility</b> is the degree to which an innovation is perceived as consistent with the existing values, past experience, and needs of potential adopters.	<ul style="list-style-type: none"> <li>NoMix technology has to prove its superiority in practice</li> <li>Paradigm shift from central wastewater treatment in treatment plants to a decentralized system "at source" is necessary</li> <li>Contradictory to traditional approaches of problem solving</li> </ul>
<b>Complexity</b> is the degree to which an innovation is perceived as difficult to understand and use (not to be confounded with the notion of complexity in natural sciences).	Separation of liquid wastes: <ul style="list-style-type: none"> <li>Possibly difficult to understand (yet well known from solid wastes)</li> <li>Technological challenge</li> </ul>
<b>Trialability</b> is the degree to which an innovation may be experimented with on a limited basis.	Limited trialability, especially of technology version B and C (Tab.1)
<b>Observability</b> is the degree to which the results of an innovation are visible to others.	Limited observability, because of <ul style="list-style-type: none"> <li>Preventive measures</li> <li>Long periods of time</li> <li>Abstract concepts</li> </ul>

Tab. 2: The five attributes, often of prime importance for the diffusion rate of an innovation [10], and their application on the possible attitude of wastewater professionals towards the NoMix technology [7].

since some problems are still unsolved such as the precipitation of urine which leads to a clogging of the urine conducting pipes and to the development of unpleasant odors [9]. Since beginning of the project, NOVAQUATIS has kept in close contact with the sanitary industry. The larger companies are convinced that the development of modern NoMix installations is possible. Unfortunately, the market for NoMix technology is not yet visible. Therefore, the sanitary industry is still hesitant to invest on a large scale.

## Wastewater Professionals Holding the Key Position

How can the NoMix technology gain broader acceptance and wider diffusion? Presumably, the attitude of the wastewater professionals is the most critical factor for the development of the NoMix technology. In order to understand the attitudes of wastewater professionals and to identify the crucial factors, we used the classical diffusion theory. Rogers [10] defined five main attributes, which are relevant for the diffusion rate of an innovation – i.e., relative advantage, compatibility, complexity, observability, and trialability (definitions see Tab. 2). Moreover, according to the diffusion theory, the acceptance of an innovation over time normally follows an s-shaped curve. After a rather slow start, a successful innovation "takes off" and adoption occurs rapidly (Fig. 1). It seems that wastewater professionals re-

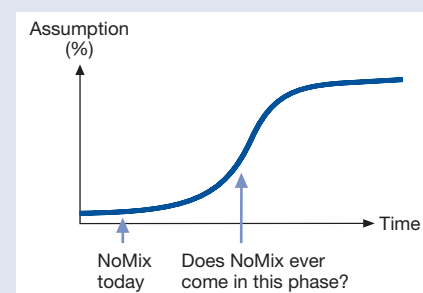


Fig. 1: Diffusion of innovations [10]. After a rather slow start, a successful innovation suddenly "takes off".

gard the NoMix technology as disadvantageous in most of the five attributes (Tab. 2) [7]. In the following, two of the most relevant attributes are discussed in more detail:

■ The **relevant advantage** of an innovation compared to the existing technology is often assessed by a cost-benefit-analysis, e.g. by comparison of ecological advantage and monetary expenses. This kind of analysis is difficult to perform in the case of the NoMix technology, because of numerous uncertainties, especially concerning the costs, which exist in the initial stage. Therefore, a relatively cheap technology such as version C (Tab. 1), which allows depreciating investments already made in the existing system, will have better chances.

■ The **compatibility** of NoMix with an existing technology is perceived as low. Especially wastewater professionals are – with good reason – convinced that the existing system is very successful concerning hygiene and comfort. A new technology will have to prove its equality. Another obstacle for the implementation of the NoMix technology is the necessity of a paradigm shift leading away from a central wastewater treatment in treatment plants to a decentralized collection and processing of urine. Yet, presumably many wastewater professionals do not see any urgency to give up the current system. Up to now, it was possible to solve new wastewater problems in a single step within the treatment plant. Thus, from a traditional point of view, searching for radically new approaches in order to solve many problems simultaneously is unfamiliar. Hence, the technology versions which can easily be integrated in the existing structures are probably more successful.

This first analysis [7] might explain why the diffusion of NoMix technology among wastewater professionals is rather slow. Further studies are needed in order to better identify those factors, which might cause a breakthrough for the NoMix technology. This is why pilot projects demonstrating a successful implementation play a very important role [11].

### First Pilot Building with NoMix Technology: Cantonal Library in Liestal

For the first time in Switzerland, the NoMix technology will be fully implemented in the cantonal library of Basel-Landschaft in Liestal. The installations for urine source separation consist of NoMix toilets, a urine collection tank and a computer-controlled release of the urine from the storage tanks. The pilot building is expected to be finished in 2005. It offers ideal conditions to test the innovative sanitary technology, because the toilets will be visited by a mixed and interested public with a diverse socio-cultural background. Based on the experiences made here, guidelines for future construction purposes shall be defined [11].

On a smaller scale, the NoMix technology is already being tested in a series of other projects: four apartments in a Swiss city were equipped with NoMix toilets, and EAWAG and the University of Applied Sciences Basel (FHBB) are also testing different types of NoMix toilets. These projects are very important in order to identify the flaws of the new technology and to explore user attitudes with the help of questionnaire surveys. The experiences will lead to recommendations for the further develop-

ment of the NoMix technology by the sanitary industry.

In conclusion, society seems to be open for the new, unconventional NoMix technology and the sanitary industry seems to be willing to advance the technology. Therefore, the crucial factor for a successful diffusion of the NoMix technology is presumably its acceptance by wastewater professionals. Transition scenarios that can easily be integrated into the existing system (version C, Tab. 1) have good chances of being accepted by all stakeholders – including wastewater professionals.



Judit Lienert, biologist, is coordinating the project NOVAQUATIS as deputy project manager. She is interested in interdisciplinary and transdisciplinary research and the intersection of science and practical application.



Tove A. Larsen, chemical engineer and project manager of NOVAQUATIS. She examines possibilities of introducing a sustainable urban wastewater management.

Further information: [www.novaquatis.eawag.ch](http://www.novaquatis.eawag.ch)

- [1] Larsen T.A., Gujer W. (1996): Separate management of anthropogenic nutrient solutions (human urine). *Water Science and Technology* 34, 87–94.
- [2] Lienert J., Larsen T.A. (2002): Urinseparierung – eine Alternative für die schweizerische Siedlungswasserwirtschaft? *gwa – Gas Wasser Abwasser* 11, 819–826.
- [3] Pahl-Wostl C., Schönborn A., Willi N., Muncke J., Larsen T.A. (2003): Investigating consumer attitudes towards the new technology of urine separation. *Water Science and Technology* 48, 57–65.
- [4] [http://www.novaquatis.eawag.ch/english/NoMixtool\\_e.html](http://www.novaquatis.eawag.ch/english/NoMixtool_e.html)
- [5] Lienert J., Haller M., Berner A., Stauffacher M., Larsen T.A. (2003): How farmers in Switzerland perceive fertilizers from recycled anthropogenic nutrients (urine). *Water Science and Technology* 48, 47–56.
- [6] Johansson M. (2001): Urine separation – closing the nutrient cycle. Final report on the R&D project “Source-separated human urine – a future source of fertilizer for agriculture in the Stockholm region?” Stockholm Water Company, Stockholm, 40 p.
- [7] Larsen T.A., Lienert J. (2002): Societal implications of re-engineering the toilet. Proceedings of the IWA Leading Edge Conference Series “Sustainability in the Water Sector”, Venice, p. 29. *Water Intelligence Online*, submitted.
- [8] [www.roevac.com](http://www.roevac.com)
- [9] Udert K., Larsen T.A., Gujer W. (2003): Estimating the precipitation potential in urine-collecting systems. *Water Research* 37, 2571–2582.
- [10] Rogers E.M. (1983): *Diffusion of Innovations*. Collier Macmillan Publishers, London, 453 p.
- [11] Kühni M., Koch G., Ott E. (2002): Zukunftsweisende Sanitär- und Abwassertechnik – Erstes Pilotprojekt der Schweiz für Urinseparierung, -speicherung und -steuerung im technischen Massstab. *gwa – Gas Wasser Abwasser* 11, 827–835.
- [12] Rauch W., Brockmann D., Peters I., Larsen T.A., Gujer W. (2003): Combining urine separation with waste design: an analysis using a stochastic model for urine production. *Water Research* 37, 681–689.