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Fertilizer from the Library

Producing a hazard-free fertilizer from urine is a new concept. Initial experience is being gained at the Basel-Landschaft Cantonal Library in Liestal, which is fitted exclusively with NoMix toilets. The urine collected at this institution is processed to yield a liquid fertilizer. But before the product can be applied, a number of obstacles need to be overcome. Similar challenges also face pilot projects in other countries.

One of the goals of urine source separation is to recycle nitrogen, phosphorus and potassium to agriculture. These nutrients excreted by humans derive from foodstuffs. The increasing scarcity of nutrients makes it essential for substances used as fertilizers to be sustainably managed – especially in the case of phosphorus since, at current rates of extraction, natural reserves of this mineral will be exhausted in 50–100 years. Existing practice – whereby nutrients are released via wastewater treatment plants into receiving waters, air and sludge and thus irretrievably "disposed of" – needs to be transformed, with the aim of reusing valuable nutrients as comprehensively as possible; this would reflect the age-old use of animal excreta. However, from today's perspective, a wide variety of obstacles will first have to be surmounted. If the idea is to be implemented in practice, it must be shown to be politically, technically, environmentally and economically compelling.

The urine-based product Urevit is applied to a maize field.

Photos: Martin Koller, FiBL

Elimination of Micropollutants from Urine-based Fertilizer. According to our studies, society is essentially open to the NoMix technology. A majority of the public is prepared to accept urine-diverting toilets [1], and Swiss farmers can envisage using a fertilizer produced from urine [2] (see the article by Judit Lienert on p. 8). The product would, however, have to be of high quality, inexpensive, hygienically safe and free of micropollutants such as pharmaceuticals and hormones. Agricultural regulators also expect a urine-based fertilizer to meet stringent requirements. The approval procedure established by the authorities calls not only for proof of effectiveness, but also for experimental evidence of the absence of micropollutants. Experience from the debate on the quality of sewage sludge shows that, politically, the use of untreated urine in Switzerland would not be feasible. The removal of hazardous micropollutants is thus a prerequisite, even if this substantially increases the technical complexity of urine processing.

Breaking New Ground in Process Engineering. To initiate the approval process and to demonstrate that it is technically possible to produce a safe fertilizer from urine, Eawag launched a urine treatment pilot project at the Birs I wastewater treatment plant (WWTP) in Birsfelden (Canton Basel-Landschaft). Here, engineering processes developed at Eawag are used to produce a liquid fertilizer from urine under real-world conditions. The urine used comes from the newly built Cantonal Library in Liestal, which – thanks to the favourable attitude of Basel's policymakers and the authorities responsible – is fitted throughout with NoMix toilets and water-free urinals. Since the opening of the building in June 2005, urine from up to approx. 4000 library users per week has been available for fertilizer production at the Birs I WWTP.

When urine is processed to produce a fertilizer, the achievement of four goals needs to be assured:

- The nutrients nitrogen, phosphorus and potassium are to be concentrated.
- Micropollutants such as hormones and pharmaceuticals are to be largely eliminated.

Location	No. of NoMix toilets	No. of water-free urinals	Urine volume arising (l/week)	Urine tank size (m^3)	Urine treatment	Application, reuse
GTZ Eschborn D	56	25	8000	10	Struvite precipitation, NH_3-stripping	Effectiveness testing, field trials
Huber D	13	10	550	0.9	Struvite precipitation, ammonium sulphate precipitation	Crop fertilizers
Lambertsmühle D	4	2	60	4	None	Agriculture
Linz A Apartments School	 88 18	12	 approx. 2500 approx. 1500	 16 6	None	Sewer system
Gebers S	25	0	approx. 700	3x3.5	Storage for 6 months	Agriculture
Understenshöjden S	50	0	approx. 1000		Storage for 6 months	Agriculture
Basel-Landschaft Cantonal Library CH	10	2	100	1.7	Electrodialysis, ozonation	Effectiveness testing
Eawag CH	39	7	250	1 in each case (men + women)	Biological methods	Research: development of additional treatment methods

Tab. 1: National and international urine source separation projects.

- The product must be hygienically acceptable.
- The urine is to be stored in a stable form as a urea or ammonium solution.

From the wide variety of – in most cases – technically demanding processes available [3] (see also the article by Max Maurer on p. 14), a combination of electrodialysis and ozonation was chosen for the urine treatment plant at the Birs I WWTP. Both of these methods – neither of which has previously been applied in municipal wastewater treatment – were developed to the point of technical maturity at the Eawag laboratories and are now being tested on a large scale for the first time in our pilot project. Details of the functioning and operation of the pilot plant are given in the article by Wouter Pronk on p. 20 [4]. The main aim of this pilot study is to provide an example of how possible technical options for closing nutrient cycles can be put into practice and, in a real-life test to demonstrate the potential of nutrient recovery from urine both to the experts and authorities concerned and to interested members of the public. The results achieved to date are encouraging and should pave the way for the adoption of alternative wastewater management processes.

Urine Separation in Other Countries. From an international viewpoint, Eawag is not alone in its efforts to remodel nutrient cycles in developed areas. For some years, numerous activities have been under way, notably in Sweden, Germany, Austria and the Netherlands (Tab. 1). These include a number of projects described in detail in the literature, involving use of the NoMix technology on a large scale. Initially, the solutions adopted – often designed for rural areas – assumed that there were no grounds for concern with regard to urine quality, which meant that the urine could be used simply and directly. In the meantime, however, the issue of micropollutants in urine has been widely discussed. For example, recent tests with unpurified, concentrated urine applied as a fertilizer in high doses showed that the unwanted substances accumulate in the soil and in plants, inhibiting crop growth [5]. The hazard posed by micropollutants should therefore not be underestimated and is currently shaping development efforts in the area of urine storage and treatment. Likewise, research is increasingly focusing on the quality of the different types of product arising, with regard to fertilizer properties in agriculture.

Various projects in Sweden have shown that utilization of the urine collected is a crucial factor motivating the installation and continued use of urine-diverting toilets. For example, the NoMix toilets originally installed in the ecovillage of Björnsbyn in 1995 have since been replaced by conventional toilets. This was due to technical defects and the lack of a scheme for hazard-free recycling of nutrients to agriculture.

From Urine to Fertilizer. The fertilizer produced in the urine treatment plant at the Birs I WWTP (Urevit) is a nutrient solution that differs substantially from the urine on which it is based (Tab. 2). The liquid fertilizer is characterized by a fourfold higher concentration of nitrogen, phosphorus, potassium and other salts, the absence of micropollutants, bacteria and viruses, and a slightly lower content of organic components.

In Switzerland, as in most European countries, a product licence is required for fertilizers, with various classes being distinguished by the Swiss Fertilizer Marketing Ordinance (DüBV) of 2001 [6]. Mineral nutrient and urea fertilizers are considered to be unproblematic and can be applied without an approval procedure. Approval is, however, required for organic and farmyard fertilizers (e.g. slurry and silage effluents), and fertilizers based on meat-, bone- and bloodmeal are prohibited altogether. For all other fertilizers not explicitly mentioned in the list, an application has to be submitted for licensing based on an approval procedure. This also applies to human urine and urine products. For approval to be

granted, it has to be demonstrated that use of the product is not harmful to humans, animals or the environment, and that there are no adverse impacts on the foodstuffs produced.

Urevit has now received a provisional licence from the Federal Office for Agriculture. At the same time, efforts are being made to secure general approval and fundamental regulations for additional urine-based fertilizer products. The conditions specified cover the following points:

- Comparison of effectiveness with conventional fertilizers in field trials (including conditions for use in organic farming).
- Designation and chemical composition of the product.
- Instructions for application of the product.
- Proof of hygienic acceptability.
- Proof of absence of micropollutants (below the detection limit).

The Research Institute of Organic Agriculture (FiBL) in Frick investigated the effectiveness of Urevit as a fertilizer on fodder maize. These studies showed that Urevit is essentially suitable for use as a fertilizer. Whether crops were treated with ammonium nitrate or Urevit, plant growth achieved the maximum level in both cases and was significantly higher than with cattle slurry. However, the total yield was 13% greater with ammonium nitrate than with Urevit. Ammonium is probably lost to the air during the application of Urevit. Such losses could be prevented by alternative spreading methods, and yields could then be expected to equal those obtained with the use of ammonium nitrate.

Making Good Use of the Time Available. The pilot experiments on urine treatment in Basel-Landschaft are initially restricted to a period of six years. Within this time frame, Eawag intends to develop further processes for urine treatment on a laboratory scale. One promising process is phosphate recovery using biological methods or with the aid of magnesium ammonium phosphate (MAP). Urine for these experiments is collected by Eawag at its new headquarters, the Forum Chriesbach building, which – like the Cantonal Library in Liestal – has been fitted exclusively with NoMix toilets.

On the international front, too, research efforts concerning alternative wastewater management and new urine treatment processes are likely to be stepped up in the coming years. This trend is encouraging, for ultimately the more experience is accumulated, the better the prospects for the widespread adoption of the new concepts and technologies. ○ ○ ○

Is Urevit an effective fertilizer? The leaf colour of the plant (in this case fodder maize) is one of the assessment criteria.

Tab. 2: Composition of untreated urine and Urevit, the liquid fertilizer produced in the urine treatment plant (initial data).

Parameter	Untreated urine	Urevit
pH	8.7	9.1
Conductivity (µS)	–	150
Dissolved organic carbon DOC (g/l)	1.2	3.0–3.5
Chemical oxygen demand COD (g O_2/l)	3.6	10
Total nitrogen (g/l)	3.0	12
Ammonium (g/l)	2.9	11
Total phosphorus (g/l)	0.18	0.65
Potassium (g/l)	1.4	5.7
Magnesium (g/l)	–	0.008
Calcium (g/l)	–	0.020
Sodium (g/l)	1.6	6.5
Chloride (g/l)	3.0	15
Sulphate (g/l)	0.7	2.5

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