Source Separation and Treatment of Anthropogenic Urine

To address future demands of wastewater treatment (e.g., contaminants of emerging concern, more stringent phosphorus regulations, increased population, water quality impairments associated with combined or sanitary sewer overflows, etc.), improvements to conventional, end-of-pipe treatment can be made, and/or source separation of wastewater streams can be implemented. Of these options, source separation has emerged as an innovative option for addressing aging infrastructure with great potential for meeting sustainability criteria defined by the U.S. EPA.

A Roediger NoMixToilet. Reprinted with permission from Roevac.

Anthropogenic urine comprises only 1% of domestic wastewater, but contributes 75-80% of the nitrogen, 50-55% of the phosphorus, and a substantial portion of the pharmaceuticals/hormones and subsequent metabolites. As a result, research to date (largely conducted in Europe) has focused on the potential for urine diversion to reduce the environmental impact of these contaminants, decrease the energy and cost requirements of wastewater treatment, and provide a means to close the anthropogenic nutrient cycle either through nutrient recovery or direct urine reuse. This research can identify gaps in current knowledge on areas requiring further research for development of waste source separation technology.

The Current State of Technology

Urine diversion toilets (NoMix toilets) and waterless urinals have been developed by several manufacturers and have been improved through European pilot project feedback. Additionally, urine treatment technologies have been developed to the point of inclusion into small and mid-scale pilot projects (Table 1). User feedback has been a crucial part of the development of urine diversion, as toilet use is a sensitive topic. Urine diversion has been tested at the pilot scale in several locations, particularly in Europe (Table 2). A review of European pilot projects indicates that 80% of users like the idea of urine diversion, 75-85% were satisfied with design, hygiene, and seating comfort of NoMix toilets, 85% thought that urine-based fertilizer was a good idea (50% of farmers), and 70% would purchase food grown with urine-based fertilizer. However, 60% of users also encountered problems, indicating that NoMix toilets require further development.

Recommendations

Urine diversion technology is developed to the point that, with proper operation and maintenance, mid- to large-scale pilot projects are possible. The most probable method of implementation of urine diversion in the U.S. would be at the neighborhood scale, in apartments, or in commercial or institutional buildings (offices, hospitals, educational institutions, etc.) where a complete decentralized approach to wastewater management is employed including graywater use for nonpotable purposes and anaerobic digestion of blackwater.

In addition to necessary improvements or adaptations to urine diversion toilets, several knowledge gaps exist which may hinder the progress of urine diversion in the U.S. Specifically, whole life costs of urine diversion on several scales and life cycle assessments with energy, contaminant, and water balances may be necessary to justify further research. These assessments may take into account other decentralized wastewater treatment scenarios, and should account for the potential to address aging and deteriorating U.S. wastewater infrastructure in a sustainable manner. Pilot projects and social surveys, although extensively conducted in Europe, are lacking in the U.S. These may be conducted either after a simplified set of life cycle and cost assessments is executed, or during the development of more thorough assessments.

BENEFITS

- Describes the current global status of urine source separation and treatment technologies, pilot projects, and research groups.
- Shows that urine treatment can result in a safe, nutrient-rich, micropollutant-free fertilizer.
- Illustrates that urine diversion toilets and storage tanks have been developed for urban water management to the point that inclusion into larger pilot projects is feasible with proper oversight.
- Assesses the potential for urine diversion to reduce the energy requirements in wastewater treatment plants, and to improve water quality by allowing for more efficient removal of nutrients and micropollutants.
- Suggests a path forward in the development of urine source separation and treatment in the U.S.

AVAILABLE FORMAT

Online PDF

TO ORDER

Contact WERF at 571-384-2100 or visit www.werf.org and click on Search Research Publications & Tools.

WERF Subscribers: Download unlimited free PDFs at www.werf.org.

Non-Subscribers: Charges apply to some products. Visit www.werf.org for more information.

Refer to: **STOCK NO. INFR4SG09b**

For more information, log on to **www.werf.org**.

Table 1. Technologies Available for Primary Urine Treatment Goals.

Treatment Goal	Proposed Technologies (that have at least advanced to lab-scale experiments)	Technologies Implemented in Urine Diversion Pilot Projects
Sterilization	Storage	Storage
Stabilization	Acidification, Partial Nitrification	
Volume Reduction to Concentrate Nutrients	Evaporation, Freeze-Thaw, Reverse Osmosis	Evaporation
Nutrient Removal	Annamox (N removal), Electrocoagulation (P removal)	
Phosphorus Recovery	Struvite Precipitation	Struvite Precipitation
Nitrogen Recovery	Ammonia Stripping, Ion Exchange, IBDU Precipitation, Struvite Precipitation	Struvite Precipitation
Removal of Micropollutants	Ozonation, Electrodialysis, Nanofiltration	
Creating a Fertilizer Free of Micropollutants	Struvite Precipitation, Electrodialysis and Ozonation	Struvite Precipitation, Electrodialysis and Ozonation
Optimizing Nitrogen and Phosphorus Recovery	Struvite Precipitation with Zeolite Adsorption	

Table 2. Summary of Select Pilot Projects.

Location	Number of UD Toilets	Number of Waterless Urinals	Urine Volume (L/week)	Urine Tank Size (m^3)	Urine Treatment	Application or Reuse	Technical Feedback Available	Social Feedback Available
GTZ headquarters, Eschborn, Germany: office building	56	25	8000	10	Struvite precipitation	Field studies	Limited; additional feedback available in 2011	Yes
Basel-Landshcaft Cantonal Library, Switzerland	10	2	100	1.7	Electrodialysis and ozonation	Field studies	Limited	Yes
SolarCity, Linz, Austria: apartment	88	12	Approx. 2500	16	None	Sewer system, treatment/ reuse to be initiated	Yes	Yes
SolarCity, Linz, Austria: school	18		Approx.1500	6	None	Sewer system, treatment/ reuse to be initiated	Yes	Yes
Kinglake West, Sydney, Australia: individual households	N/A	N/A	N/A	N/A	None	Trial application at turf farm	No	Projected to be available in 2011

CONTRACTORS

Sybil Sharvelle, Ph.D.
Larry A. Roesner, Ph.D., P.E.
Colorado State University – Department of Civil and Environmental Engineering

RESEARCH TEAM

Kimberly LeMonde Fewless
Colorado State University – Department of Civil and Environmental Engineering

PROJECT SUBCOMMITTEE

Michael Borst
U.S. Environmental Protection Agency

Richard Field, P.E.
U.S. Environmental Protection Agency

Thomas O'Connor
U.S. Environmental Protection Agency

Mary Stinson
U.S. Environmental Protection Agency (retired)

Daniel Murray
U.S. Environmental Protection Agency

Swarna Muthukrishnan, Ph.D.
American Water

Jian Yang, Ph.D., P.E.
American Water

The research on which this report is based was funded in part by the U.S. Environmental Protection Agency (U.S. EPA) through Cooperative Agreement No. CR-83419201-0 with the Water Environment Research Foundation (WERF). Unless an U.S. EPA logo appears on the cover, this report is a publication of WERF, not U.S. EPA. Funds awarded under the agreement cited above were not used for editorial services, reproduction, printing, or distribution.