Closing the nutrient cycle

Summary from a unique research project in Sweden

by Mats Johansson and Mirjam Nykvist

Mats and Mirjam are both systems ecologists and are working in VERNA Ecology with new techniques for wastewater treatment.

Malmgårdsv. 14
SE-116 38 Stockholm
SWEDEN
Tel.:+46 8 641 75 00
Fax:+46 8 702 12 80
e-mail: verna@verna.se

VERNA Ecology is a member of the network Swedenviro Consulting-group
Info: http:www.swedenviro.com

Abstract

The method to separate human urine to use as fertilizer is now tested on a fullscale in Sweden.

In 1995, the Understenshöjden housing estate was built in the Stockholm suburb of Björkhagen. Shortly afterwards, the conversion of the Palsternackan estate in Enskede was completed. Urine-separating toilets were installed in both these estates.

The Stockholm Water Company initiated a dialogue with the two housing companies, HSB National Federation and AB Stockholmshem. The three partners agreed to launch a four year research and development project.

Some of the mian findings and conclusions of this project were summarised in a report: "Urine separation — closing the nutrient cycle" which was published in June 2000. (see end of article for more info). This presents the state of knowledge in Sweden on urine-separating toilets and systems for the recirculation of urine as an agricultural fertilizer.

Figure 1: Ecovillage Understenhöjden, Sweden - one of the project sites

Background

The history of urine separation in Sweden

In the 1970s several products and toilets were developed, including urine-separating insets, with a focus on holiday houses.

In the early 1990s the first urine-separating toilets in sanitary porcelain were produced.

The number of different urine-separating toilets is increasing. There are now three different manufacturers of urine-separating toilets with a dual-flushing system on the swedish market:

- The Dubletten toilet from BB Innovation & Co AB
- The DS toilet, Wost Man Ecology AB
- The Nordic 393U from Gustavsberg

In addition there is one single flush urine-separating toilet from Wost Man Ecology

In total, approximately 3-4'000 urine-separating toilets have been sold in Sweden over the last five to ten years. Most of them are used in single family households or holiday houses.

Separating human urine

Most of the nutrients that are essential in agriculture (N, P, K) are found in human urine. Faeces contain a smaller percentage of these substances, while the quantities in greywater are insignificant espescially if non-phospate detergents are used.

Separating the urine, which only accounts for about 1 % of the total wastewater flow, and using it as fertilizer makes it possible to utilize most of the nutrient content of wastewater

It must be kept in mind that greywater represents by far the largest volume of wastewater and must still be treated. Consequently, urine separation cannot replace other treatment methods but is a complement that provides a possibility to recycle a larger proportion of the nutrients in wastewater.

Essential requirements for the recirculation of urine

When closing nutrient cycles, one has to be careful not to establish a "cycle" of infectious matter, which will increase hygienic risks and recirculate an inferior nutrient fraction (due to the presence of environmentally harmful substances and undesired products).

Neither residents nor farmers will accept exposure to increased hygienic risks, and farmers are obviously not interested in fertilizers with low nutrient content or high levels of environmentally harmful substances.

Important conclusions from the project

- Urine separation can improve the recirculation of nutrients such as nitrogen (N), phosphorus (P) and potassium (K), originating from wastewater.
- Urine is a complete fertilizer for farmland.
- Urine separating systems often presents less environmental impact than conventional wastewater systems.
- The hygienic risks are negligible if the urine is handled properly.
- If the residents are motivated the overall function of the system will improve.

What has been achieved during the four years of the project?

In addition to developing a system for transportation, storage and reuse of human urine extensive research has been undertaken. Some of the problem areas that were identified at an early stage and studied within the project framework were:

The spread of infection and hygienic risks:

- Survival of pathogenic microorganisms in urine.
- Quantifying and measuring the fecal contamination of urine.
- This research was carried out by the Swedish Institute for Disease Control.

Environmental impact and resource management:

- Discharges of nutrients and BOD after the separation of human urine.
- Amount of water saved by urine-separating toilets.
- Quantities of nitrogen, phosphorus, potassium, sulphur and other plant nutrients that can be recirculated to agriculture as a result of urine separation in a housing estate.
- How source separated human urine can be used as fertilizer.
- Energy consumption in urine separation systems compared with conventional systems.
- This research was carried out by The Swedish Institute of Agricultural Sciences, Department of Agricultural Engineering and The Swedish Institute for Agricultural and Environmental Engineering.

Technical and social aspects:

- Size and function of urine tanks and piping networks in the residential area.
- Practical experience of the function of urine separatign systems.
- Residents attitudes to urine-separating toilets.
- This research was carried out by The Swedish Institute of Agricultural Sciences, Department of Agricultural Engineering.

FAQ's Frequently asked questions and answers about urine separation

By summarizing the conclusions from the project a number of frequently asked questions have been addressed in the report. The answers correspond to the Swedish environment and the conclusions may not always be adequate if directly transferred to situations in other countries.

Does urine separation involve any hygienic risks?

If the workers handling the urine are careful and the recommendations for storage and risk minimazation are followed, it is considered that the hygienic risks of urine separation are negligible. When it comes to hygienic risks it should, however, be pointed out that nothing is completely risk-free.

Does medicine residue represent a risk in human urine?

Almost all substances that occur in medicines are degradable by the microorganisms that are naturally present in the soil and absorption by the plants is probably negligible.

What effect does source-separated urine have on nutrient discharges?

When a urine separating system is introduced, nitrogen discharge into water is reduced by about 60% irrespective of the type of treatment. In the case of phosphorus, the reduction depends on the type of treatment of the wastewater as a whole. Where the treatment plant ensures efficient phosphorus removal the reduction is marginal, but where the plant does not provide phosphorus removal the reduction may be almost 50%.

How much water does urine separation save?

The amount of water saved may vary between 5 — 40 litres per person per day depending on individual habits and the toilet with which the comparison is made.

How much plant nutrients is recirculated to farmland when a urine separating system is used?

Assuming that residents spend an average about 15 hours at home every day, about 1,6 kg of nitrogen and 0,2 kg of phosphorus is recirculated per person per year. In the case of highly motivated residents, it may be as much as 2-2,5 kg of nitrogen and 0,25 kg of phosphorus per person per year.

How does energy consumption in a urine separating system compare with that in a conventional system?

In an efficient urine separating system located less than 30-40 km from the farmland, the fertilizer value of the urine in itself represents a saving in energy compared with transportation and application.

How much nitrogen is lost in a urine separating system from toilet to field?

Where the system is properly designed nitrogen losses are very small, less than 1 % from the toilet, via collection tanks, transportation and storage to application. The losses associated with application are less than 10 % and may, if the best available technology is used, be as low as 1 — 2 %.

What effect does human urine have as a fertilizer?

The effect of urine applied to a spring crop corresponds to 80-90% of the effect with the same amount of nitrogen in the form of mineral fertilizer. Human urine can be applied in growing crop with good results.

What should the capacity of the urine tank be when urine separation is introduced in a housing area?

On average, the amount of liquid produced by the Dubbletten model is 1.5 litres per person per day, while the Wost Man Ecology DS model produces 2.5 litres.

What is the greatest environmental advantage of urine separation today?

In the short term the urine separation systems are most useful as a complement to

individual sewage treatment systems.

More information about the report "Urine separation — closing the nutrient cycle" can be provided by:

The Stockholm Water Company
Stockholm Vatten AB
SE-106 36 Stockholm
Sweden
Phone: +46 8 522 120 00
Fax: +46 8 522 120 02

From september 2001 the report will be available on their web-page: http://www.stockholmvatten.se as an Acrobat reader document.

Contact information for other members of the project group:

Swedish Institute for Disease Control

- Caroline Schönning, caroline.schonning@smi.ki.se
- Thor-Axel Stenström thor-axel-stenstrom@smi.ki.se
- Info: http://www.smi.ki.se

The Swedish Institute of Agricultural Sciences, Department of Agricultural Engineering

- Håkan Jönsson, hakan.jonsson@lt.slu.se
- Info: http://www.lt.slu.se

The Swedish Institute for Agricultural and Environmental Engineering

- Lena Rodhe, lena.rodhe@jti.slu.se
- Info: http://www.jti.slu.se

--> *To table of contents*