Going to Scale with Urine Diversion in Sweden – From Individual Households to Municipal Systems in 15 Years

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Abstract
The development from small-scale reuse to municipal systems for transport, storage and reuse of source separated human urine is covered in the paper. Discussions on the lessons learned and examples of systems in use are presented as well as a discussion of the key aspects and critical factors for urine diversion to go to scale in Sweden.

Keywords
Urine diversion, Swedish legislation, up-scaling, municipal systems,

INTRODUCTION

The Swedish development of "modern" urine diverting systems have been of interest also in an international context. This paper tries to describe this development as four sub-sequent phases with examples of UD systems in use. The paper discusses key aspects and critical factors for urine diversion to go to scale in Sweden as well as the lessons learned.

Urine diversion is a sanitation technology that facilitates reuse of nutrients found in human excreta. In Sweden, urine diversion (UD) systems have been piloted and developed for more than 15 years. An estimate from 2006 states that there are more than 10,000 porcelain UD toilets installed in Sweden and that there are at least 10-15 larger systems for reuse of human urine in Sweden, most of these are managed by municipalities. General pros and cons of urine diversion from a Swedish perspective are displayed in Box 1.

Box 1: Pros and cons of urine diversion in a Swedish perspective
Pros:
- Facilitation of nutrient recycling
- The urine holds very high quality with regards to heavy metals and organic pollutants, compared to other wastewater fractions (e.g. sludge, treated wastewater, greywater etc), since the urine contains only what has been processed through food intake
- Less nutrient load to the wastewater which reduce the number of processes necessary for the wastewater treatment both for on-site sanitation and also for centralized systems, should UD be applied in central systems
- Visibility of the wastewater system - makes the users more aware of an otherwise quite invisible part of our daily lives

Cons:
- Visibility also leads to more engagement - visibility is good for the understanding of ones actions and its effects on the environment but it will also demand some more from the user of the system, in this case e.g. adaptation to a new toilet type
- There has been toilet types on the market which have been less user friendly and thus more difficult to use
- Urine piping and storage tanks increase housing construction costs
- An extra fraction for the municipality to handle, demands a municipal system for collection, treatment and reuse

THE INSTITUTIONAL SETTING IN SWEDEN CONCERNING URINE DIVERSION

The Swedish legislation is embracing the idea of nutrient reuse and includes sustainability and protection of the environment in different pieces of legislation and policies. The Environmental Code, dating from 1998, contains several opportunities for the implementation of closed nutrient loop oriented sanitation technologies for on-site sanitation in rural areas in Sweden. Recycling and efficient use of natural resources are integral objectives of the Code as is the precautionary principle; the polluter pays principle and the concept of "Best Available Technology". These principles are, however, not always used by the local environmental authorities when specifying the requirements for on-site sanitation system. In accordance with the Environmental Code, urine is considered as a household waste fraction and should therefore be managed by the municipality. This fact has made the municipal departments responsible for solid waste in Sweden look closer into their responsibility for urine and the implications of urine collection and reuse. The Planning and Building Act gives the municipalities the faculty to single-handedly decide on the spatial planning and infrastructure development in the local situation but this is hardly never used to enable closed-loop approaches for wastewater systems. The Planning and Building Act was revised in 2005 and it was proposed that all new houses shall have space available for sorted waste fractions within its premises. In accordance with the Environmental Code, urine is considered as a sorted waste fraction and shall thus be managed by the municipality. The Planning and Building Act could be used as a tool for municipalities for strategic sanitation planning but that is seldomly the case today.

In parallel to the Environmental Code, National Environmental Quality Objectives were established in 1999. Sweden's environment policy is based on these sixteen environmental quality objectives for different areas. These objectives describe what quality and state of the environment should be to be sustainable in the long term. Recirculation of natural resources (including nutrients) is part of the National Environmental Quality Objectives and one of the targets is stating that at by 2015 at least 60% of phosphorus compounds present in wastewater will be recovered for use on productive land. At least half of this amount should be returned to arable land[1]. Another example of this mainstreaming of nutrient recycling is the revision of the agricultural use of sludge statutes, issued by the Swedish Environmental Protection Agency, which also will regulate the use of human urine in agriculture as well as other wastewater fractions. The proposal is expected to be decided upon in 2010. The background to the statutes proposal and also the background to the target of 60% P recovery are described in Kvarnström et al (2002).

In Sweden on-site sanitation regulation has undergone a remake over the last ten years. The local environmental authorities, being responsible for on-site sanitation permits, used to give permits only to either sand filter, infiltration beds or compact wastewater treatment plants, following national guidelines, from 1987, for on-site sanitation. The guidelines were technology-prescriptive and basically only allowed these two different technical solutions for on-site wastewater treatment. The Environmental Protection Agency published new national guidelines on on-site sanitation in 2006, where the focus is not on sanitation technology per se but the function of the sanitation technology instead. The Swedish EPA thereby guides the local authorities on what kind of demands they should pose on the house owner, to guarantee that the

[1] http://www.miljomal.nu/Environmental-Objectives-Portal/

2nd chapter of Environmental Code is complied to. The national guidelines are especially emphasizing the need to reduce the phosphorus loads to the recipients and the importance of nutrients recycling.

Sweden is a member of the European Union and is therefore governed by the EG Water Framework Directive, now being implemented throughout the EU. There are also many EU-related laws and regulations that are applicable to agricultural activities. Swedish organic agriculture is governed by the EU regulation (EEG) 2092/91 which applies to all certified European organic agriculture. The regulation is interpreted by the certification authorities in each member country. The EU regulation regulates all inputs allowed in organic agriculture. Human urine is at present not included in the EU regulation which makes it difficult for organic farmers to use human urine even if the Swedish organic farmers union and the Swedish organic agriculture certifying organization, KRAV, have nothing against it per se as a fertilizer. According to KRAV standards septic tank sludge and urine originating from an organic farm can be re-used at the same farm. This standard has been applied to a village in Sweden where the farm and the households in the vicinity of the farm are considered as part of a quite closed nutrient system, since the surrounding households are buying products from the organic farm. Thus, urine from the surrounding households has been used at the organic farm, as part of a pilot study, to generate experience which might in the long run also lead to proposals for new regulations for organic farming.

The above is showing that there is a relatively enabling legislative environment for recycling and reuse of nutrients from sanitation systems in Sweden. What might be missing are economic incentives that possibly could unleash the on-site sanitation market and the integration of reuse aspects in the strategic municipal planning.

THE FOUR PHASES OF MODERN URINE DIVERSION IN SWEDEN

UD is nothing new in Sweden. By the turn of the 20th century there were many different models of dry and dry urine diverting toilets in use in Sweden. Most famous was the Marino toilet which looks very much like modern Swedish UDDT[2]. In this paper we focus on the development of the modern urine diverting systems that were introduced in the early 1990s.

Characteristics	- Criticism of conventional sanitation - Ideological promotion of alternative wwt	- Politically driven initiatives - R&D	- Little political interest - Housing areas to solve reuse themselves - Criticism from. WSS-professionals	- Locally driven - Communication between actors - Reuse as part of sustainable sanitation

[2] Johansson, M, Jönsson, H, Höglund, C, Richert Stintzing, A & Rodhe, L. 2000.

Phase	**1 – Ecovillages** **1990 - 1995**	**2 – From rural to urban settings** **1995 - 2000**	**3 – Backlash** **2000-2005**	**4 – On-site sanitation and municipal organization** **2005 -**
Drivers	Agenda 21, Sustainable development, Closing the loop	National Environmental Objectives. Renovation of suburbs	Little municipal support Not cost-saving in urban settings	New guidelines for on-site sanitation Good examples
Actors	Local groups/ecovillages, innovators and interested farmers	Housing companies, Researchers, politicians	A few researchers, housing areas and municipalities	Municipalities Farming organizations

Figure 1: UD in Sweden at a glance and the content is explained below.

Phase 1: Urine diversion in Ecovillages

The first phase of modern urine diverting toilets took off in the early 1990s targeting single households and summer houses and more than 10 ecovillages. The fact is that one major environmental feature of many ecovillages was their sanitation system. The urine from these installations was either reused or disposed of on the premises or used by a nearby farmer. Municipalities and authorities were most oftenly not involved in the collection and reuse of the urine. This phase is characterized by individual "sanitation champions" on grass root level and the first generation UD toilets which were technically immature.

Box 2: The ecovillage of Smeden in Jönköping

Smeden ecovillage is located in the south of Sweden. It was inhabitated in 1993 and it consists of 24 households (appr 70 people). The sanitation system consists of water-flushed urine diversion toilets (with liquid-solid separation of the blackwater by use of Aquatron) and with separate treatment of greywater. Smeden ecovillage was the first multiple household development in Sweden to install urine diversion. The urine is reused by a farmer nearby without involvement of the municipality, the composted solids from the blackwater is reused locally and the treated greywater can be reused from a reservoir/pond system when there is a need for watering gardens. The system has had its challenges, but a survey made in 1997-1998 showed that ¾ of the respondents to the questionnaire used made a point of listing their wastewater system as one of the most successful measures in the ecovillage. Read more at www.ekoby.org

Phase 2 - from rural ecovillage to urban settings

The second phase, by the mid 1990s, was characterized by a high political will for ecological sustainability and visions of the future green society of Sweden, leading towards the adoption of the National Environmental Quality Objectives among other things. Huge investments were made in different environmental projects on municipal level, within a national ”Local Investment Program” for sustainable buildings and projects. In parallel to this investment program a few multi-storey buildings and projects in urban settings were constructed with UD during this period. For some of these projects systems for reuse were established and municipal actors were involved, e.g. in Stockholm. R&D has been undertaken on these systems including numerous aspects ranging from household perceptions, reuse on individual to industrial agriculture level, to

technical, hygienic aspects and socio-economic aspects. Many of these findings were published in Johansson et al (2000).

A driving factor, for the multi-storey UD constructions, was ideas in the National Environmental Objectives on building sustainable urban settlements and the parallel need to renovate "the million program houses" i.e. suburbs with high-risers built in the 1960s. Housing companies piloted "sustainable buildings "to learn more. In some of these projects they used urine diverting dual-flush-toilets of the first generation. The common belief at this time was that UD was a mature and easily adoptable system at this stage. However, very few were thinking about the reuse aspects of the collected urine; only one or two projects developed systems for using the urine in agriculture. Hence, many of these projects lacked the base for becoming good examples.

Box 3: Understenshöjden – Urban settlement with urine diversion
Understenshöjden is an urban ecovillage, located only 5 km from the city center of Stockholm. It consists of 44 households (approximately 130 people). This urban ecovillage was inhabitated in 1995. The sanitation system is characterized by water-flushed UD toilets, urine collection and on-site treatment for the combined greywater and blackwater. Today the wastewater is, however, led to the nearby municipal sewers and the urine is still transported to farmers outside Stockholm (www.ekoby.org, Johansson et al , 2000).

As a result of the major investment program focusing on the implementation of sustainable technologies in the municipalities at the end of the 1990s, 10-15 municipalities used this to promote nutrient reuse sanitation technologies, mainly UD-toilets, for on-site sanitation and started to organize and to organize systems for transporting, storage and reuse of urine.

Phase 3 - Backlash for urine diversion
The political will and grass root enthusiasm characterizing phase 1 and 2 of UD development was not followed by the necessary economical incentives to create a sanitation market, nor with a maturation speed of the UD technology necessary to really harness the political will existing during the late 1990's. Initial problems from the pilot-installations was spread. The stagnant trend in installations and the relatively small volumes of fertilizer available made it less interesting for farmers to invest in storage tanks etc. needed to facilitate reuse, which in turn led to a message spreading that the farmers were not interested in urine as a fertilizer. Which they were, they just were not willing to pay for taking care of the urine.

All mentioned above led to (i) the closing down of a few UD systems were reuse actually existed and (ii) replacement of UD toilets at different locations where there was no reuse system organized. One reason for replacement of the UD toilets in some housing areas has been poorly functioning toilet models, where the UD model used, mainly first generation UD toilets, has not been replaced with better performing UD toilets on the market but rather with normal WC's. Another critical factor also discouraging the use of UD in individual household is if there is no municipal system for collection and reuse of the urine. The households and housing companies see little use of the UD system as such if the urine is not collected and reused.

As mentioned above a few municipal systems have also been closed down, this mainly due to poor organization of the system, where the system's resulting robustness has been too weak or where roles of the different institutions have not been clearly set.

Thus the anticipated up-scaling of UD and other nutrient recycling sanitation technologies in the beginning of the 21th century never happened for a variety of reasons, some mentioned above. Moreover, little or no money was available for organizing and building more demos and municipal systems, funding for R&D ceased due to changes in the national funding organizations and there were no economic or legal incentives available to speed up the installation of UD. The development was also hampered by the non-enabling regulatory framework guiding on-site sanitation decisions on local level (see legal framework section above). The foreseen large-scale enforcement of poor on-site-systems towards on source-separating did not happen and the interest for urban UD-installations disappeared.

Phase 4: Municipal organization for reuse and growing interest for UD in on-site sanitation
Today we see a fourth phase developing, in the enabling, but not enforcing, legislative environment we do have in Sweden for nutrient recycling. The recognition of the environmental quality objectives is gaining ground, the possibilities for authorities to use the legislation towards reuse of nutrients given by the physical planning and environmental legislation regarding are being discussed on municipal level. Quite a few Swedish municipalities are developing sanitation policies that encourage reuse of wastewater fractions and this will in the long run lead to increased source separation and reuse in agriculture.

Today there is indisputable that the responsibility to organize systems for collection, treatment and reuse of nutrients lies with the municipalities. This, together with the increasing knowledge of the negative effect poorly functioning on-site systems has on surface and groundwater, has lead to the development of strategic decisions and policies for on-site sanitation in many municipalities. The number of municipalities that are actively discussing organization for reuse of urine diversion and source separation are rapidly increasing.

Box 4: Kullön
Kullön is located on an island in the municipality of Vaxholm, not far from Stockholm. The residential area is the largest UD equipped housing area in Sweden with its 250 houses. The sanitation system is comprised of water-flushed UD toilets, where the urine is collected in tanks on neighborhood level. The combined blackwater and greywater is treated tertially in a decentralized wastewater treatment plant. It took eight years from the construction of the first house until reuse in agriculture of the collected urine was achieved. The municipality did initially not want to be involved in the transport, storage and use of urine, but requested the householders to organize this themselves. This lead to a situation where the urine was neither collected nor reused between 2001 to 2007. After a political process within the municipality and a slow but steady progress towards reuse an organization for the reuse has been established and the urine collection on neighborhood level started again in 2008.

Urine diversion emerged as a bottom-up, ”alternative” technology in the 1990s in Sweden, promoted by enthusiasts and politicians. It was believed to be a mature technology and a self-organizing system that could be rapidly built into urban settings, which it was not at the time. The first two phases of the modern urine diversion development in Sweden and the research conducted however showed the potential of the UD and helped developing both the technology and the institutional aspects of UD. The backlash that followed slowed down the progress and not until new guidelines for on-site sanitation was launched urine diversion came back as an interesting technology that makes it possible to protect the environment and reuse the nutrients at the same time, which is something that traditional end-of-pipe techniques fail to deliver.

In spite of the backlashes on UD experienced we clearly see that the experiences gained through the urine diversion since the beginning of the 90's have paved the way for nutrient recycling sanitation systems in general in the Swedish context. What we foresee in the future is new urine diversion systems, with a mature technology, some economical incentives creating the recycling market and also the use of other nutrient reuse-oriented sanitation systems such as black water systems. There are examples of municipalities organizing blackwater collection, treatment and reuse systems, e.g. by engaging in anaerobic digesters for mixtures of organic household waste, black water and farming residues. These initiatives are expected to mushroom in areas where the centralized systems are to expensive or inappropriate to build.

CRITICAL FACTORS FOR URINE DIVERSION TO GO TO SCALE IN SWEDEN

The most critical factors for scaling up urine diversion in Sweden are:

- That municipal authorities exerts their legal mandate to force households with on-site sanitation to comply to the new strict criteria for on-site sanitation and that they also actively promote sanitation systems facilitating nutrient recycling
- the creation of incentives
    - for households to adopt UD-systems, incentives
    - for the municipalities organizing reuse systems between households and agriculture
    - for farmers to demand nutrient-rich wastewater fractions, such as urine and to engage in nutrient reuse systems
- National level strategy for nutrient reuse
- The exchange of experiences between the 15 -20 most involved and experienced municipalities. This will help speeding up the development and also to help the active promoters in their day-to-day work.

CONCLUSIONS

The institutional development in Sweden – legislation, national goals on recycling of nutrients and cooperation at the local level – may not yet be described as a success story, but there are lessons to be learned on what to do and in which order things need to be done to secure a success. A number of critical factors and key aspects have been developed during the last 15 years of capacity and knowledge development in Sweden – and hopefully some of this can be of use for other countries and actors striving for sustainable sanitation systems including reuse of nutrients.

There is an enabling legislative environment in Sweden that with increased knowledge exchange and increased capacity among involved authorities and other actors may lead to a rapid development of reuse of urine and other wastewater fractions in Sweden.

The idea of urine diversion and the UD-toilets are widely spread and the advantages are commonly known among both authorities, farmers and also many households. The challenge is to create a market for manufacturers of toilets and large enough volumes of urine to interest farmers

Some of the lessons learned from 15 years of urine diversion are that:

- Timing is of great importance to make synergies between political will and interest in a question and the technological development and the anchoring among key actors. It may not be the best alternative to use political will and interest to rocket-launch a technology if all

necessary pillars are not in place. It might be more strategic to use this kind of momentum to look closer at the regulatory framework, build demos, develop knowledge and capacity among stakeholders and not to forget initiate R&D on the systems built.

- The institutional landscape must be described as early as possible as a starting point for designing and using incentives for all involved actors.
- It takes time to implement new technology. Knowledge and capacity in key stakeholders, mature technologies, local markets, legal and economical incentives must be in place for new technologies to take off. This was not the case when urine diversion became the hip thing in the mid 1990s. Both the technology and the institutional levels needed to mature and develop before it could be scaled up.

Following the fourth phase of urine diversion where urine from on-site systems are being reused we also imagine that UD will be considered as one option within centralized systems, to reduce nutrient loads to existing wastewater treatment plants for smaller cities and villages and enable reuse of nutrients where the sludge is not accepted by farmers. This to achieve the goals set in recycling policies and maybe also to reduce medical residues going into and out from the wastewater treatment plants.

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