


Sanitation and Reuse

Experiences world-wide on reuse of different sanitation flowstreams

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Acronyms

BWSSB	Bengaluru Water Supply and Wastewater Board
CREPA	Centre Régional d'Eau et Assainissement à faible coût
EWS	eThekwini Water and Sanitation
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
ONEA	Office National d'Eau et Assainissement
UDDT	Urine-diverting dry toilet
UKZN	University of Kwa-Zulu Natal

Front page photos: Linus Dagerskog, CREPA, VERNA and SARAR-T.

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1. Introduction

Wastewater from a household is a mixture of three distinct and different flowstreams: (i) greywater from kitchen, laundry and showers, (ii) urine, and (iii) feces, Figure 1. As can be seen in this picture *greywater by far represents the highest volume* (100 to 1000 times higher than the feces produced daily), that the *urine by far has the highest content of nutrients* and that the *feces fraction has by far the highest pathogen content*. These three flowstreams thus have very distinct and different qualities. Using the same logic that has made several cities around the world abandon combined sewers for duplicate ones to take away the stormwater, which is high in volume and very different in composition to wastewater, and the same logic that has made solid waste collection entities in many European countries to go for source separation of organic waste, and other fractions such as glass, paper, metal etc. it is of interest to look at separate collection and treatment of the flowstreams in Figure 1 to optimize treatment and to maximize the reuse potential of both water and nutrients.

This report presents a number of different cases with such separate collection and treatment, where the actors have taken the strategic decision for an up-stream source diversion of flowstreams and separate treatment for different reasons, ranging from practical and logistical reasons in e.g. South Africa, through reduction of eutrophication of lakes in Sweden, to water conservation in Bolivia and access to quick-acting N fertilizers in Niger. Interesting projects under planning, where “triplicate”[1] wastewater systems are investigated and are under planning are also presented towards the end of the report.

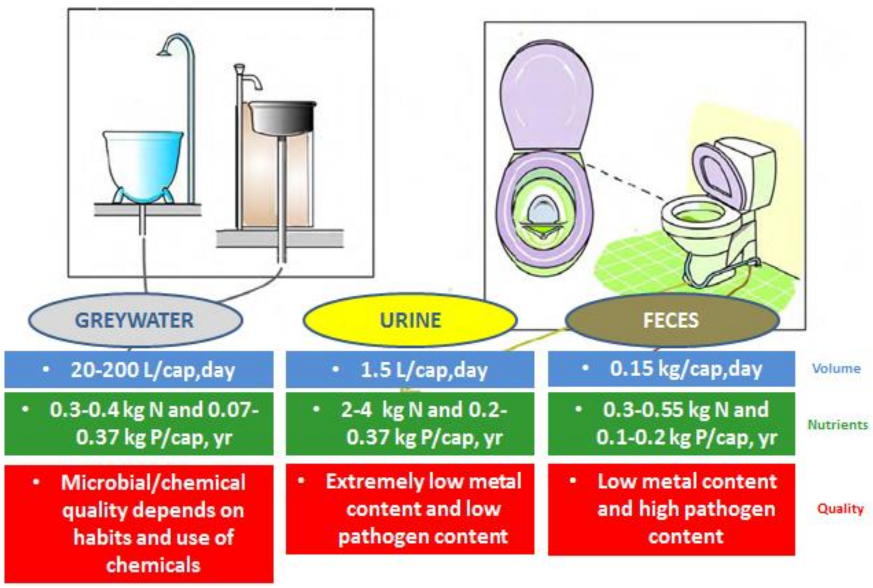

Figure 1: Characteristics of the different wastewater flowstreams from a household: greywater, urine and feces. The blue boxes represents the volume produced per capita per day, the green the nutrients “produced” per capita per year and the red boxes represent the microbial and chemical quality of the different flowstreams[2].

[1] The next generation wastewater systems after duplicate ones: separate collection of (i) stormwater, (ii) a plant-nutrient rich flowstream and (iii) the remaining wastewater, often greywater only.

[2] The picture is adapted from Kvarnström, E., Emilsson, K., Richert Stintzing, A., Johansson, M., Jönsson, H.,af Ptersens, E., Schönning, C., Christensen, J., Hellström, D., Qvarnström, L., Ridderstolpe, P., Drangert, J.O. 2006. Urine diversion – one

1.1 More on the characteristics of different wastewater flowstreams

Urine and feces

We ingest plant nutrients daily through our food intake, and the plant nutrients are also excreted on a daily basis. For a full-grown person *all plant nutrients ingested are also excreted – what we eat we also excrete*. *The nutrient content of our excreta* can thus be calculated based on the average dietary intake for different countries[3]. The pollutant level of our excreta is low, given that it contains only residues from what we have decided has good enough quality to eat in the first place[4]. The exception here is for pharmaceutical residues which we ingest when ill and subsequently excrete through urine and feces. In conventional wastewater systems the pharmaceutical residues gets conveyed to wastewater treatment plants, where they do not get efficiently removed and they have shown detrimental effects on aquatic life in recipients of wastewater, which may lead to future pharmaceutical treatment demands on wastewater treatment plants. Soils, on the other hand, are more apt to break down pharmaceutical residues, since 1 m^3 of soils contains the same amount of microorganisms apt at attacking pharmaceutical residues as 1 km^3 of water[5] . It is therefore reasonable to believe that pharmaceutical residues represent less of a risk when they are exposed to soils in agricultural reuse than when discharged into water courses.

The *microbial quality* of urine is high, since very few pathogens are excreted through the urinary tract. The feces are the main excretion route for pathogens and is therefore the flowstream with the highest pathogen content.

Blackwater is the mixture of urine and feces and thus has both a high nutrient and pathogen content and good chemical quality.

It can be concluded that urine, feces and blackwater have good properties for agricultural reuse, given their high content of nutrients, provided that both feces and blackwater are treated to improve the microbial quality. Numerous scientific field trials of urine have proven that urine is as effective an N fertilizer as chemical ammonia-based fertilizers, and guidelines for its agricultural use exists[6]. The value of its fertilizing effect has been calculated to USD 80[7] per year for an average family of nine in Niger, which, for a small-holder farmer with little access to chemical fertilizer and who is struggling to get by, represents a real asset.

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step towards sustainable sanitation, downloadable in English, Portuguese, Russian and Spanish at http://www.ecosanres.org/publications.htm

[3] Jönsson, H., Richert Stintzing, A., Vinnerås, B., Salomon, E. 2004. Guidelines on the use of urine and faeces in crop production. EcoSanRes Series 2004:2.Downloadable in English, Spanish, Portuguese, Russian and French from http://www.ecosanres.org/publications.htm

[5](http://www.landsbygdsnatverket.se/download/18.e01569712f24e2ca09800011443/Lst+Stockholm_Milj%C3%B6_S%C3%B6dert%C3%A4ljemodellen.pdf

[6] Jönsson, H., Richert Stintzing, A., Vinnerås, B., Salomon, E. 2004. Guidelines on the use of urine and faeces in crop production. EcoSanRes Series 2004:2.Downloadable in English, Spanish, Portuguese, Russian and French from http://www.ecosanres.org/publications.htm and Richert Stintzing, A., Gensch, R., Jönsson, H., Stenström, T.A., and Dagerskog, L. 2010. Practical guidance on the use of urine in crop production. Downloadable at http://www.susana.org/lang-en/library?view=ccbktypeitem&type=2&id=757

[7] http://www.worldwaterweek.org/documents/WWW_PDF/2012/Thur/No-Food-and-Nutrition/Linus-Dagerskog-Moussa-Bonzi.pdf

Greywater

The quality of greywater is strongly related to the habits of the household and to the products available on the market. The nutrient content is especially dependent on the use of detergents. EU has put a limitation on the phosphate use in household laundry and automatic dishwasher detergents[8] and other European countries, e.g. Norway and Switzerland have banned phosphate-based detergents all together. Such legislation, enforced, has an effect on the greywater content of P. It has been shown that greywater from a normal household can contain up to 900 different xenobiotic pollutants, resulting from our daily use of body products, detergents, cleaning agents etc[9]. The microbial quality of greywater is dependent on habits, if e.g. diapers are washed within the household.

Greywater is less interesting for reuse from an agricultural perspective (less nutrients and complex chemical composition), but can be interesting for irrigation and groundwater recharge, after appropriate treatment.

Fecal sludge from pit latrines and septic tanks

Pit latrines and septic tanks often receive a mixture of human excreta and greywater with liquids being soaked away and a fecal sludge is accumulated in the pit/septic tank. The fecal sludge thus contains high levels of pathogens, but quite low levels of nutrients compared to what the pits/septic tanks receive through the blackwater. Mass balance calculations from fecal sludge collected from pits in Bangladesh[10] showed that only about 6% of the P, 1% of the N and less than 1% of the K a pit receives is retained in the sludge after 1 year of undisturbed storage[11]. Hence, the absolute bulk of the nutrients are soaked away. However, use of fecal sludge for crop production, a common practice e.g. in Northern Ghana and in India, has shown that the sludge is improving crop yields[12] so whatever nutrients and organic matter that is present in the fecal sludge has an agricultural value. Fecal sludge contains pathogens and will need sanitization before agricultural use.

1.2 Technical information

A number of good sources exist for the design and implementation of sanitation systems with separate treatment of different flowstreams.

- The planning process is crucial for any sanitation upgrade/expansion. Good planning approaches are found in
    - IWA's Sanitation 21, downloadable from http://www.iwahq.org/contentsuite/upload/iwa/Document/Sanitation21.pdf
    - Tayler, K., Parkinson, J., Colin, J. 2003. Urban Sanitation – A Guide to Strategic Planning.

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[8] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:094:0016:0021:en:PDF

[9] Eriksson, E., Auffarth, K.P.S., Henze, M. and Ledin, A. (2002). Characteristics of grey wastewater. Urban Wastewater. 4(1): 85 – 104.

[10] BRAC – unpublished data.

[11] BRAC- unpublished data

[12] Kvarnström, E., Verhagen, J., Nilsson, M., Srikantaiah, V., Ramachandan, S., Singh, K. 2012. The business of the honey-suckers in Bengaluru (India): The potentials and limitations of commercial faecal sludge recycling – an explorative study. Occasional paper 48. The Hague:IRC International Water and Sanitation Centre. Available at http://www.irc.nl/op48 and BRAC – unpublished data.

- Community-Led Urban Environmental Sanitation from SANDEC, downloadable from http://www.eawag.ch/forschung/sandec/gruppen/SESP/projects_sesp/clues/index_EN
- SANDEC has published a concise compendium presenting, in a structured form, a large amount of information on tried and tested technologies, thus providing a useful planning tool for making more informed decisions. Downloadable in English, Spanish and Nepali from http://www.eawag.ch/forschung/sandec/publikationen/compendium_e/index_EN
- SEI has published a microbial and health assessment in sanitation, guidelines for use of treated urine and feces in crop production and a document on urine diversion, all downloadable from http://www.ecosanres.org/index.htm
- WHO Guidelines for the safe use of human excreta and greywater in agriculture can be downloaded from http://www.who.int/water_sanitation_health/wastewater/gsuweg4/en/index.html
- The 2013 Stockholm World Water Week Water Prize Laureate, Dr Peter Morgan has worked extensively with low-cost, rural solutions for both water, sanitation, school sanitation, menstrual hygiene, gardens and recycling, all available at his organization's web page http://www.aquamor.info/
- The Sustainable Sanitation Alliance, SuSanA, has a web page with case studies and other resource material, downloadable from http://www.susana.org/
- The Swiss NGO seecon, together with sector colleagues world-wide, have pulled together a toolbox for sustainable water and sanitation management, see http://www.sswm.info/home

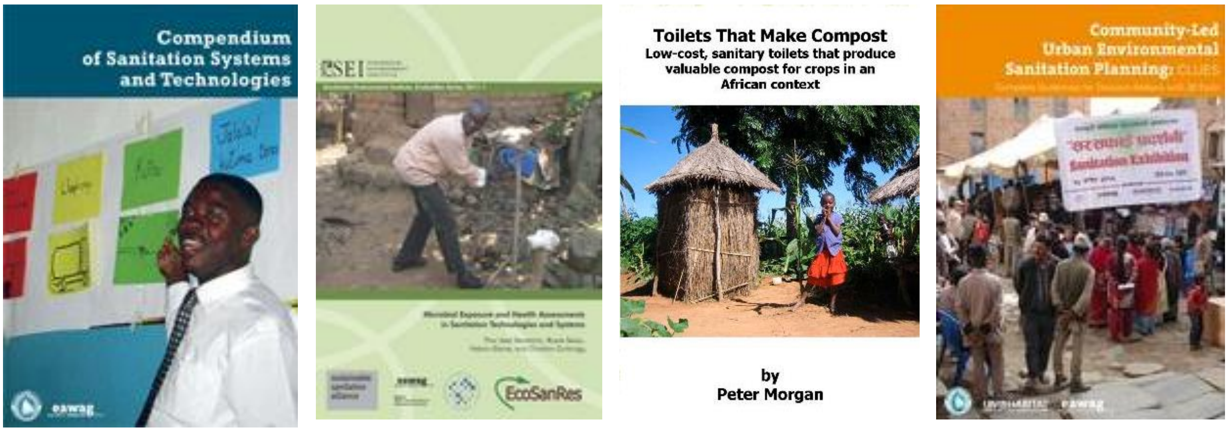

Figure 2: Examples of publications available on-line.

2. Cases

We have chosen to divide the case studies into three different contexts, Figure 3.

Context 1 – *on-site sanitation with relatively high population density* - represents a relevant context world-wide. The urban population is estimated to increase to 4.2 billion out of a projected global population of 7.7 billion people in 2020[13]. Much of this increase will take place in rapidly growing small and medium-sized towns[14], which already today are stretched in terms of infrastructure and capacity to deliver services to its citizens. In many African cities, less than 15% of urban dwellers benefit from the centralized collection of wastewater[15]. One of the greatest challenges to meet the sanitation MDG, and more so, to reach beyond the sanitation MDGs in terms to also achieve collection, treatment and reuse and not only containment, lies within this context. Four examples are presented within this context, one from Bolivia, one from Burkina Faso, one from India and one from Mexico.

Context 2 – *on-site sanitation with a low population density* – is where about 90% of the world's open defecators are found. In fact, 72% of the world's population without access to improved sanitation lives in rural areas[16]. Access to improved sanitation in rural areas is definitely a challenge also for LAC. The JMP progress report from 2012 reported that Bolivia, Brazil, Peru and Paraguay are among those countries where more than 50% of its rural population does not have access to improved sanitation. Cases from South Africa, Niger, Sweden and Mexico are presented.

Context 3 – *separate flowstream collection within an existing wastewater jurisdiction* – can be highly interesting for cities with resources and capacity for centralized collection and treatment of wastewater and who want to do so keeping the different wastewater flowstreams separate, with the same logic that many municipalities in Europe today collect solid waste in separate fractions. Reasons for keeping the flowstreams separate are to (i) meet more stringent effluent quality demands, (ii) mimimize eutrophication by keeping the nutrients on land and not discharged to water, (ii) good quality fertilizers, (iii) minimize water use, (iv) tailored treatment possible to each flowstream. For this context we have no large-scale cases to present but smaller cases from Sweden, Brazil and the Netherlands and we will also give some hints of potential developments in the area.

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[13] Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, World Population
Prospects: The 2006 Revision and 2007 revision - http://esa.un.org/unup/ accessed on September 19, 2011.

[14] UN Habitat, 2009. *Planning Sustainable Cities: Policy Directions. Global Report on Human Settlements 2009*. [online] Nairobi: UN Habitat. Available at: http://www.unhabitat.org/downloads/docs/GRHS2009Abridged.pdf

[15] Schaub-Jones, D., 2005. *Sanitation Partnerships: Beyond Storage: On-Site Sanitation as an UrbanSystem*. [online] London: Building Partnerships for Development in Water and Sanitation. Available at: http://www.bpd-waterandsanitation.org/web/w/www_127_en.aspx

[16] http://www.wssinfo.org/fileadmin/user_upload/resources/JMP-report-2012-en.pdf

Figure 3: The three contexts used to present the case studies in this report. Image: F. Kvarnström

2.1 Context 1 – On-site water and sanitation, or no sanitation at all, with a high population density

2.1.1 El Alto, Bolivia[17]

El Alto is located at 4,050 m elevation above sea level on a plateau just south-west of La Paz. The city is the result of urban sprawl from La Paz and got its city rights in 1982. Its estimated population in 2009 was around 900,000 inhabitants, with a growth rate of 5.1% per year.

Both El Alto and La Paz depends on groundwater and melt water from glaciers and the snow-covered mountains for their water supply. An accelerated melting and retreat of the glaciers has been documented in recent years, causing concerns in the cities about the effects of climate change on the future water availability in the cities. Simultaneously the water demand has increased, and now exceeds the supply leading to water shortages and rationing for those served. In the meantime not all are served today and it has been estimated that 51% of the population of El Alto do not have access to water and sanitation. An expansion of the existing, but limited, centralized water and wastewater services is planned, but given the very high costs involved in such expansions, coupled with the water scarcity, and the grass-root demand for quick improvement of the water and sanitation services for non-served in El Alto form the backdrop for the project described in this case study.

[17] Most information for this case has been extracted from Suntura, C. and Sandoval, B. 2012. Large-scale ecological sanitation in a peri-urban area in El Alto, Bolivia. Case studies of sustainable sanitation projects, downloadable at http://www.susana.org/lang-en/library/library?view=ccbktypeitem&type=2&id=1583

Fundación Sumaj Huasi, a Bolivian NGO with long-standing experience of dry sanitation projects, responded to a call for proposals to improve the sanitation situation in District 7 of El Alto (27,000 inhabitants, mainly Aymara indigenous farmers immigrated from the Lake Titicaca area), issued in 2005 by the Superintendence of Water and Sanitation Services together with WHO. After preparatory studies and surveys to understand the context, and to design an appropriate system the implementation of the first phase started in the beginning of 2008. Today, after the completion of four phases, 4,500 of the citizens of District 7 in El Alto are served with simple greywater systems, dry, urine diverting toilets, and a collection service that takes care of the flowstreams, or wastewater fractions, from the dry toilet. The dry toilets consume less water and are also robust, in terms of its functionality irrespective of water shortages etc. Cornerstones in Sumaj Huasi's work have been (i) a continuous identification of lessons learned and the corresponding improvements phase after phase, (ii) the educational component, and (iii) the involvement of the citizens. Sumaj Huasi has also contributed with its knowledge to other dry sanitation projects across the country.

The technical system

An outline of the technologies used and the responsibilities for the El Alto system is shown in Figure 4.

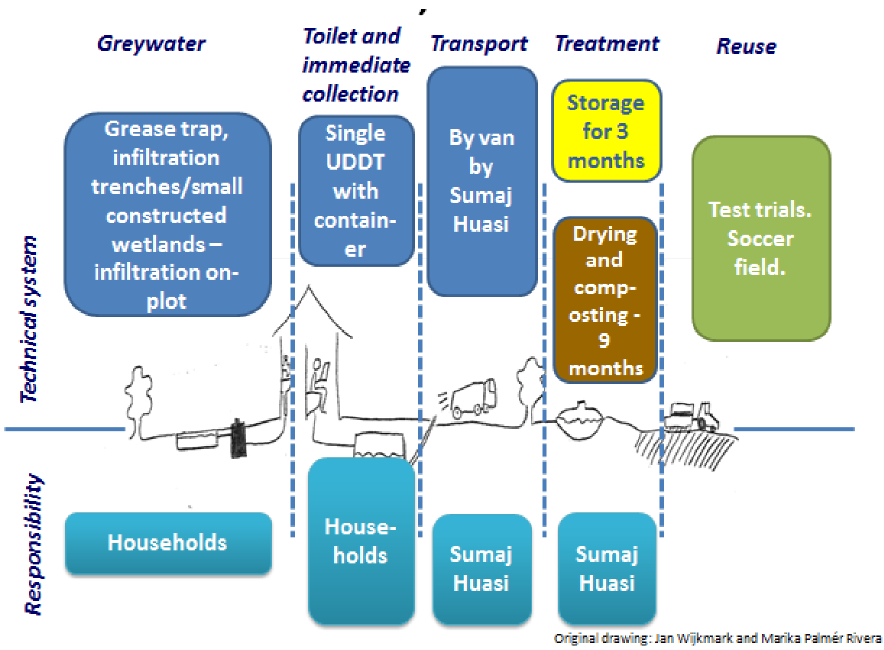

Figure 4: El Alto technologies and responsibilities.

<u>The household system</u> provided consists of a single-vault dry, urine-diverting toilet, urinal for men and a shower, constructed close to the house, and access to the toilet is through built-in steps to facilitate the user accessibility to the toilet. A hand-washing basin, which is big enough to allow for washing of clothes, is located outside the toilet/shower, see Figure 5. Each unit is constructed by a mason with the help of the household. The household contributes with their labor and with material such as sand, stone, water, soil and bricks. The household is also involved in the interior design, and can provide accessories such as tiles and decorations but also more profound improvements to the toilet such as electricity, which is not covered under the project. The urine-diversion pedestal and the urinal are made of fiberglass and are equipped with odor traps made of rubber membranes. The urine is collected in 20L jerry cans. A jerry can typically fills up in one week. The feces are collected in

100L containers and it will need emptying once every 1-2 months. A small volume of sawdust is added to the toilet after each defecation and a very small volume of water is added to the urine bowl after each urination.

The greywater from the showers and the hand-washing basin is treated on-site either with a grease trap connected to infiltration trenches, or through a little wetland in the backyard of the houses where ornamental or edible plants are grown.

Figure 5: The toilet with shower and hand-washing basin from the exterior (photo: K. Andersson) and a drawing of the toilet with shower (source: C. Suntura).

Figure 6: The toilet and shower.Photos: K. Andersson.

The *urine and feces are collected from the households for treatment at a compost center*. The compost center, 1.6 ha large, is strategically located in District 9 close to the served households in District 7, and it is designed to also provide opportunities for learning and demonstration. The community members of District 9 contributed with the land to the compost center and benefit from the project by being able to access capacity development at the center, and through the profits from produce grown at the center.

The urine is stored at the composting center in 5,000L tanks for three months to allow sanitization, see Figure 7.

The feces are vermi-composted for 8 to 9 months with red California worms, see Figure 7. The process takes place in 24 shallow trenches with L 8m x W 2.2m X D 0.8m, with covers. The worms degrade the organic matter, from the bottom to the top, while producing humus. The humidity is measured and adjusted throughout the composting process.

Figure 7: Composting trenches and urine storage at the compost center. Photos: K. Andersson.

Reuse

The collected urine is currently used in crop cultivation experiments and will be used for establishment of a soccer field in the area.

The compost resulting from the vermi-composting is bagged and given away for free to farmers in the area. Sumaj Huasi has undertaken a number of studies that concludes that the compost has a good microbiological quality and that it meets the WHO guidelines for a safe fertilizer for food production. Laboratory analyses of food produced with the compost and urine also show that they are safe for human consumption. However, microbiological research undertaken on the vermi-compost[18], using a risk assessment approach, indicated that the vermi-composting itself *will not accelerate* the inactivation of Ascaris ova. The researcher recommended that policies should be put in place, restricting the application of the vermi-compost to crops only eaten cooked and to avoid using it as soil conditioner in public places where children can accidently ingest it. This is also in line with the WHO Guidelines for safe use of excreta in agriculture, which recommends a multi-barrier approach to minimize risks in relation to food production and consumption with excreta-based fertilizers.

[18] Collender. P. 2013. *Ascaris* viability and assessment of risk for a vermicomposting ecological sanitation system in El Alto, Bolivia. MSc thesis, EMORY University, USA. Downoladable from http://www.anesbvi-nssd-bolivia.org/sites/default/files/collender_dissertation.pdf

Sumaj Huasi has undertaken some demonstration trials with e.g. potato cultivation where the urine and vermi-compost treated plots yielded twice as much as the control plot that received cow dung.

Figure 8: Vegetable cultivation at the compost center and bags of vermi-compost.

Organization

Roles and responsibilities

The households are responsible for the immediate maintenance of their toilets and also of moving the containers of urine and feces out to the street on the established collection days. Sawdust is needed for covering the feces after each defecation and is easily accessible in the area.

Sumaj Huasi is responsible for the collection and treatment of the urine and feces. It has two teams with defined routes which collect the urine jerry cans once a week and the feces once every 1 to 1.5 months. The collection teams have noted that 1.5 months between emptying render the containers too heavy to handle, so a shorter time between collection events is preferable. Two agronomists work at the compost center for handling the treatment and trials of the fertilizers.

Economy

The identified costs for the system are shown in Figure 9.

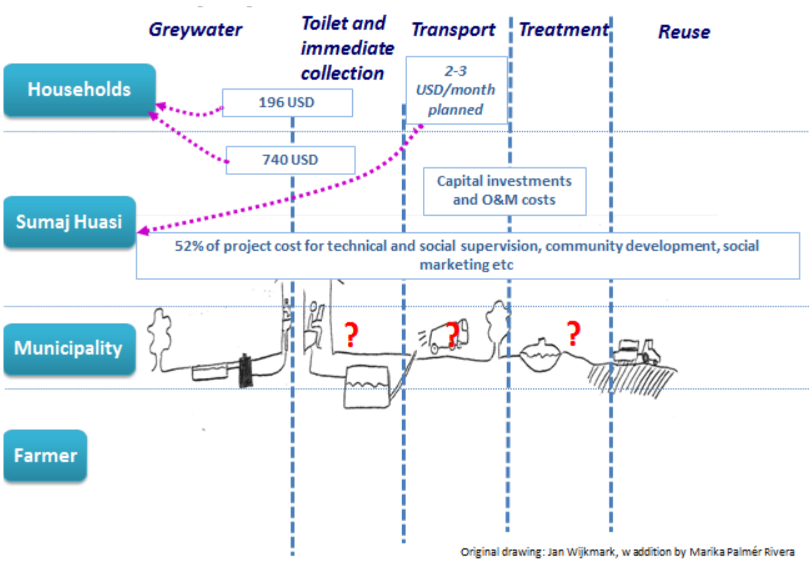

Figure 9: Costs for the El Alto system.

As can be seen in Figure 9, the system is heavily subsidized today and its sustainability, once the project runs out, is questionable. Even with a fee and with a sell of the produced fertilizers it may be difficult to get costs covered. It would be interesting to see to which extent the city of El Alto is subsidizing its centralized system and how the municipality/utility could take an equal responsibility of the system in District 7.

Conclusions and lessons learned

The El Alto project is innovative and quite unique in the world, where experiences on running a sanitation project with separate collection and treatment of urine, feces and greywater have been generated on the scale of service delivery to 4,500 people. The survival of the system is dependent on it being equally treated, in terms of budget allocations, as the centralized sewer system serving parts of El Alto, and also on the introduction of a collection fee for the households.

Surveys have shown that about 70% of the toilet/shower systems are currently in use. The more the households have participated with design improvements, the higher the usage rate. The households' participation level was highly correlated to whether the family had permanent residency in the house or not.

A number of developments to the technical approach were identified and changed during the project, in terms of what works material-wise, increased visibility of the urine jerry can to avoid over-flowing cans, integration of shower and toilet in the same room, to reduce costs, and to collect the feces in containers to reduce the space needed for the vaults.

Dialogue, capacity development and the demonstration of the effectiveness of the treated urine and the compost, as well as the microbial testing of the compost and produce were very important to create trust for the produced fertilizers.

The project worked closely with national stakeholders such as the Bolivian Ministry of Environment and Water, the Vice Ministry of Potable Water and Basic Sanitation and the project contributed to national aims of improving the quality of life and food security of the Bolivian citizens.

Further reading on El Alto:

- Suntura, C. and Sandoval, B. 2012. Large-scale ecological sanitation in a peri-urban area in El Alto, Bolivia. Case studies of sustainable sanitation projects, downloadable at http://www.susana.org/lang-en/library/library?view=ccbktypeitem&type=2&id=1583
- Collender. P. 2013. *Ascaris* viability and assessment of risk for a vermicomposting ecological sanitation system in El Alto, Bolivia. MSc thesis, EMORY University, USA. Downoladable from http://www.anesbvi-nssd-bolivia.org/sites/default/files/collender_dissertation.pdf

Contacts for more information on El Alto:

- Carlos Suntura, Executive Director Sumaj Huasi: csuntura@sumaj.org.

2.1.2 Ouagadougou, Burkina Faso[19]

Ouagadougou is the capital of Burkina Faso, a landlocked country in West Africa. Ouagadougou is an outstretched city with about 1.47 million inhabitants (2006). Its improved sanitation coverage in 2006 was 19%[20] and the number of connections to the centralized sewer system is 200[21]. Water scarcity, the outstretched city layout and lack of funds are three challenges for expansion of the sewer system within the city.

An alternative to the VIPs promoted by the water utility for non-served within the city boundaries and also as an alternative to expansion of the sewer collection and treatment has been implemented in Ouagadougou. Between 2006 and 2009 ONEA, Office National d'Eau et Assainissement – the water utility, together with CREPA (Centre Regional d'Eau et Assainissement à faible coût[22], with its headquarter in Ouagadougou and the executing agency for the project) and GIZ ran an EU-financed project under which *922 urine diverting dry toilets (UDDTs)* of different types we constructed on household level, and where *eco-stations* were put up to handle the collected urine and dried feces. Eleven public places, such as prisons and community centers also got urine diverting dry toilets installed. *800 farmers were trained* under the project on the use of the liquid and solid fertilizers produced from the collected urine and feces at the eco-stations, as one important component to get a demand for the products going[23].

The project constructed toilets in four different sectors of Ouagadougou, see Figure 10, and in each sector *an eco-station* was set up. The four different eco-stations were, and are still, run by four CBOs[24].

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[19] Technical details for the Ouagadougou case study are to a large degree obtained from von Muench, E. (editor). 2012. Compilation of 25 case studies on sustainable sanitation projects in Africa. Sustainable Sanitation Alliance, downloadable at http://www.susana.org/lang-en/case-studies?view=ccbktypeitem&type=2&id=1623

[20] von Muench, E. (editor). 2012. Compilation of 25 case studies on sustainable sanitation projects in Africa. Sustainable Sanitation Alliance, downloadable at http://www.susana.org/lang-en/case-studies?view=ccbktypeitem&type=2&id=1623

[21] http://www.wsp.org/sites/wsp.org/files/publications/Ecosan_Report.pdf

[22] CREPA has changed name to Water and Sanitation for Africa, http://www.wsafrica.org/.

[23] von Muench, E. (editor). 2012. Compilation of 25 case studies on sustainable sanitation projects in Africa. Sustainable Sanitation Alliance, downloadable at http://www.susana.org/lang-en/case-studies?view=ccbktypeitem&type=2&id=1623

[24] Dagerskog, L. and Makaya, J. 2012. Overview of the current state of the ecological sanitation system in Ouagadougou. International Water Management Institute/Stockholm Environment Institute – unpublished data.

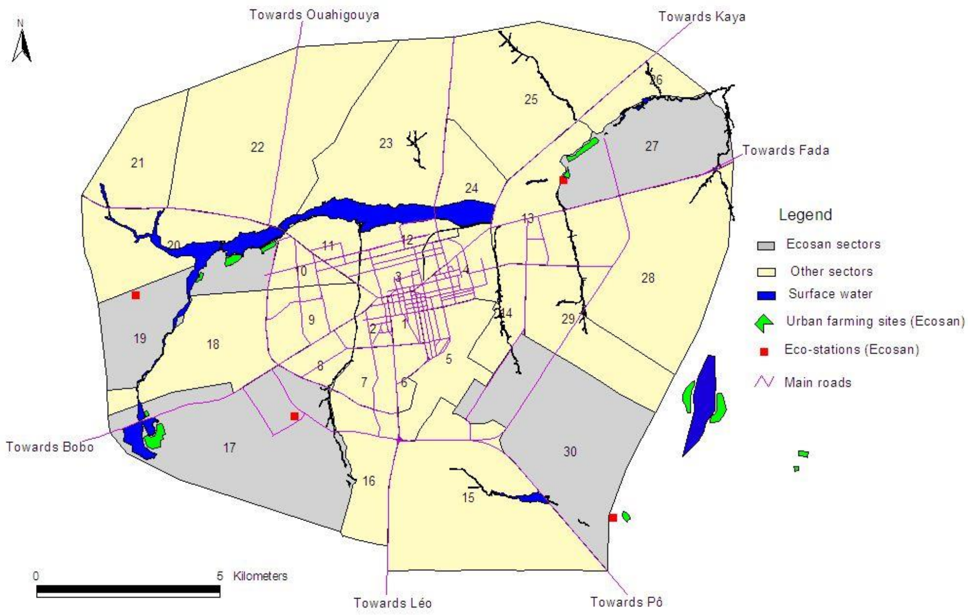

Figure 10: Map of Ouagadougou. Sectors with dry urine-diverting toilets and eco-stations are grey[25].

A schematic overview of the technical system and responsibilities is shown in Figure 11.

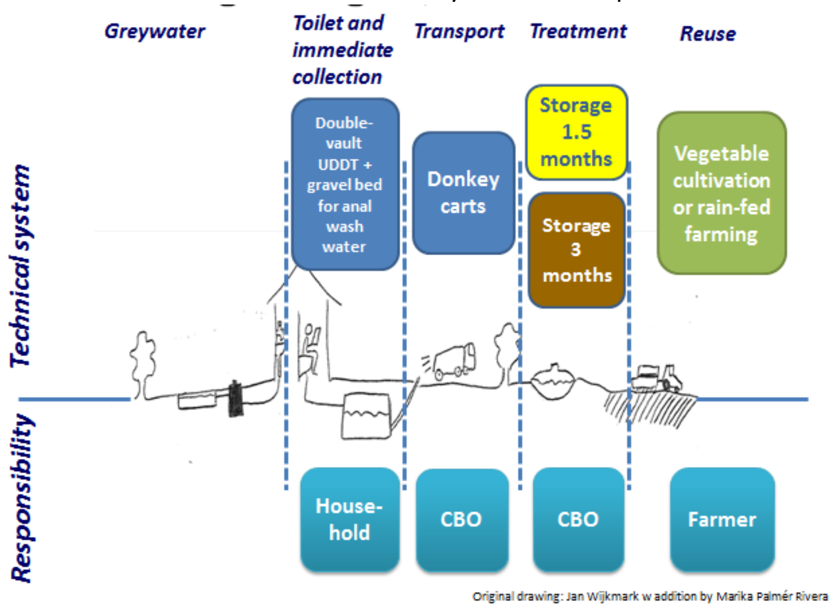

Figure 11: Schematic overview of the Ouagadougou system.

Technical system design

Three types of *urine diversion dehydration toilets* (UDDTs) were initially used for the collection of faeces and urine: (i) double-vault toilets, (ii) single-vault toilets and (iii) "box toilets" for informal areas. However, during the project implementation the second and third options were abandoned due to difficulty to handle the fecal material from the single-vault toilets and due to poor quality of the "box toilet". Efforts to reduce the cost by using adobe super-structures were also abandoned, due to poor durability of the adobe-based super structures. *Anal wash water* is led

[25] von Muench, E. (editor). 2012. Compilation of 25 case studies on sustainable sanitation projects in Africa. Sustainable Sanitation Alliance, downloadable at http://www.susana.org/lang-en/case-studies?view=ccbktypeitem&type=2&id=1623

separately to a gravel bed for infiltration. *Urine* is collected separately in 20 L jerry cans outside the toilet, see Figure 13. *Feces* are collected dry and separately in a vault, see Figure 13. The vault's size is about H 0.65m x W 1.45m x L 1.30m, and it is constructed above ground to facilitate emptying. Thus, there is a need for steps or an inclined "path" to get up to the toilet. In a single-vault toilet the feces are collected in 50L plastic bins placed in the vault and lined with a recycled plastic bag. Once a bag is full, it is placed in a barrel, painted black and stored on-site until it is picked up by the collection service. In the double-vault systems, one vault is used at a time. When one vault is full, the pan is sealed/seat is moved to the adjacent vault. One vault will fill in about 6-8 months in a family of 6-8 people. When the second vault is full it is time to empty the first vault, see Figure 14.

One cup of ash is added to the vault after each defecation event to reduce the moisture and to increase the pH of the feces/ash mixture[26].

Figure 12: Double-vault, urine diverting toilet with squatting pan in Ouagadougou. Photos: CREPA.

Figure 13: Urine-diverting toilet with urinal inside a house. To the right yellow jerry cans used for urine collection can be seen as well as the entry into the feces vault. Photo: A. Fall.

The *urine and feces/ash mixture are collected, sector-wise, by a CBO engaged to provide collection, transport and treatment of the urine and feces*. The CBO charges the households the equivalent of USD 0.67/month for this service and they pick up the urine-filled jerry cans (see Figure 13) and replace them with empty ones. They also pick up the plastic bags from the single vault toilets and empty the double-vault feces/ash mixtures, see Figure 14. The jerry cans and bags with feces/ash mixtures are transported to *the eco-stations* by means of donkey carts, Figure 15.

[26] Other cover materials can also be used, like dry soil, but that will not promote an increase in pH.

Figure 14: Emptying of a double-vault toilet. Note the dryness of the feces. Photo: L. Dagerskog.

The eco-stations are four in total, see Figure 10. They were strategically located either close to collection points of municipal waste or close to markets/garden centers where there is a high concentration of urban farmers. The eco-stations are equipped with plastic tanks (storage capacity varying between 1 to 6 m^3 depending on eco-station and size of sector it is serving) for urine storage and pits where the collected feces/ashes mixtures are stored, a hangar for working material and space for donkey and cart maintenance.

Figure 15: The CBO in action and urine storage at the eco station. A donkey cart filled with yellow urine-filled jerry cans picked up from the households and another donkey cart filed with green jerry cans filled with "birg-koom". Photo: L. Dagerskog and A. Fall.

At the eco-station the urine is stored for an additional 30 days to allow for a period of undisturbed sanitization. After the storage the sanitized urine is poured into green jerry cans, labeled birg-koom, mòoré for liquid fertilizer, Figure 15.

Storage space for the urine at the eco-station is an issue, except at the eco-station where the CBO has invested in extra storage capacity. When all tanks and jerry cans are full, the collection stops at household level which of course puts the households in a very difficult situation, since their available jerry cans will fill up quite quickly. The coping strategies of the associations have been to wait for a big client to come and free up capacity, give away urine for free, to request help from the municipality to take some for greening of public places, and coordination with the other eco-stations to see if there is a demand for birg-koom with their customers[27].

The double-vault feces/ashes mixture is stored separately for an additional 2 months in a separate chamber. The feces/ashes mixtures collected from single-vault toilets and box toilets are also stored separately in a chamber for an additional 6-8 months of storage. No composting takes place, sanitization is expected to take place through addition of ashes initially and then due to storage time. After the end of the storage time, bags are filled with the dry mixture and labeled birg-koenga, which is mòoré for solid fertilizer.

The WHO Guidelines for excreta and greywater use in agriculture[28] states that undisturbed storage of feces for at least one year at a temperature of 20-35°C should be enough to allow for substantial to total inactivation of viruses, bacteria and protozoa plus substantial inactivation of e.g. Ascaris eggs. The guidelines also recommend that urine be stored for 6 months undisturbed before use on all crops. CREPA conducted a quite extensive research program on dry, urine-diverting toilets, sanitization of flowstreams and reuse during 2002-2005. During this time they found that 21 days of storage, in the case of West Africa, was enough to minimize health risks with urine and an undisturbed storage time of 6 months for the feces minimized health risks with the feces fraction[29]. Thus, the eco-stations are respecting West-African adaptations of the WHO guidelines, which were also confirmed during the life-time of the project with tests both on the birg-koom and birg-koenga and crops cultivated with these fertilizers. However, post-project there is no budget for regular microbiological testing.

During a follow-up study of the system it was found that only a fraction of the excreta generated by a family found its way back to the eco-stations[30]. Relatively more feces than urine were collected, implying that people may not use the toilets for all their sanitary needs. In order to increase the amount of urine collectable per household it has been recommended to[31]:

- Having a urinal for men to avoid squatting when urinating (most men probably do not use the toilet when only urinating);
- Improve the design of the urine collection part of the squatting pan to make it very user friendly (avoid splashing, material that does not promote odors etc.), to stimulate use by women.
- Improve slope and diameter of urine and anal washing pipes to reduce clogging problems.

[27] Dagerskog, L. and Makaya, J. 2012. Overview of the current state of the ecological sanitation system in Ouagadougou. International Water Management Institute/Stockholm Environment Institute – unpublished data.
[28] http://www.who.int/water_sanitation_health/wastewater/gsuweg4/en/index.html
[29] http://conference2005.ecosan.org/presentations/klutse.pdf
[30] Dagerskog, L. and Makaya, J. 2012. Overview of the current state of the ecological sanitation system in Ouagadougou. International Water Management Institute/Stockholm Environment Institute – unpublished data.
[31] Dagerskog, L. 2012. Analysis of the reuse business opportunities in the Ouagadougou ecosan system. International Water Management Institute/Stockholm Environment Institute – unpublished data.

- A better system for urine storage at household level that avoids the need for household members to change container. This could either be through a larger urine tank or a more frequent collection service.

Reuse

The EU project contained a strong reuse component, with dedicated work with farmers to generate understanding, acceptance and demand for birg-koom and birg-koenga. The re-naming of the sanitized urine and feces was one measure taken to decrease stigma and also to focus on the actual purpose and use of the products after sanitization: their fertilizing qualities. Other measures included training, demonstration plots to show the effectiveness of the fertilizers etc. The birg-koom is promoted as a fast-acting nitrogen fertilizer to be used as any other fast-acting N fertilizer during the crop growth. Birg-koenga is promoted as a phosphorus-rich base-fertilizer.

The project's work with the reuse component generated a certain demand for fertilizers among the urban farmers in Ouaga. Birg-koom is sold today at USD0.20/20L (a jerry can) and the birg-koenga is sold at USD 5.1/50 kg bag. A recent follow-up of the project[32] showed that the CBOs manage to sell 74% of the birg-koom, and 48% of the birg-koenga produced. Volume-wise more birg-koom is produced than birg-koenga so one explanation to the difference in sold product between the two is that the project activities were mostly focused on urine collection and reuse, since it represents more of a challenge volume-wise.

Interviews[33] with the CBOs in 2012 revealed that one CBO had experienced an increase in demand for the products after the end of the EU project, one a decrease and two had the same demand as during the project. The CBO who had experienced a decrease in demand had lost two big customers of their products due to bad publicity of the products and stigmatization of the product users. The CBO who experienced an increase in demand had worked a lot with sensitization and working with secured customers. Other obstacles mentioned in terms of product demand were transport difficulties – to get the fertilizers to the villages - and odors[34]. The main clients seem to be urban farmers and nurseries, but there are some clients who buy larger quantities for their plantations/fields outside Ouagadougou.

Interviews with four farmers using birg-koom and birg-koenga revealed that all agreed that the fertilizers give good yields. Their views on reasons for limited demand for birg-koom and birg-koenga among their peers is (i) strong odors during application, (ii) cumbersome transportation of the voluminous birg-koom, (iii) doubt of hygienic quality, (iv) bad publicity of the fertilizers. Their recommendations to increase the demand is to work with (i) sensitization, (ii) use good protective gear, (iii) laboratory analyses to reassure quality, (iv) collaborate with transporters.

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[32] Dagerskog, L. and Makaya, J. 2012. Overview of the current state of the ecological sanitation system in Ouagadougou. International Water Management Institute/Stockholm Environment Institute – unpublished data.

[33] Dagerskog, L. and Makaya, J. 2012. Overview of the current state of the ecological sanitation system in Ouagadougou. International Water Management Institute/Stockholm Environment Institute – unpublished data.

[34] Stored urine has a strong ammonia smell and is equal to other organic fertilizers in that respect. The dry feces do NOT smell unpleasantly.

Figure 16: Farmers in Ouagadougou using birg-koenga in their production. Photo: A. Fall.

The number of urban farmers, areal and water available for urban farming in Ouagadougou can cater for birg-koom and birg-koenga produced from about 54000 people[35] , counting on 3 crop yields per year and an available areal for urban farming of 201 ha. Thus, any up-scale above 54000 citizens served will have to involve the hinterlands of Ouagadougou and farmers practicing rain-fed farming. If all of Ouagadougou's citizens' excreta were collected all farmland within a radius width of 7 km outside Ouagadougou would have to be engaged[36]. Technically it would demand a much larger storage capacity of the CBOs and more efficient transport means than the donkey carts used today.

Organization

Roles and responsibilities

The roles and responsibilities are outlined in the schematic overview in Figure 11. The *household* has *the responsibility to maintain the household installations*, and they contributed to a varying degree to the construction costs of the toilets. The bulk investment into the on-site toilets was made by the EU project. A recent survey[37] estimated that about 60% of the toilets were in use 2.5 years after the completion of the project. Reasons given to this drastic decrease are that some toilets were broken, non-functional and thus abandoned. Also, toilets constructed in local material[38] early on in the project have been destroyed by rains and inundations and thus non-functional. Some households were upset over the collection fee, claiming that they had not been informed about this prior to the building of the toilet.

Interviews with 10 households using the toilets revealed that the main advantages of the systems are that the toilets in general have little to no odor and flies, that the monthly collection fee (USD0.67) is cheaper and easier to handle than having a pit or VIP emptying which can cost up to USD40 per emptying, and that the above-ground toilets are less susceptible to inundation during the rainy season. Main disadvantages are that the toilets have stairs to enter, can be difficult for elderly and

[35] Dagerskog, L. 2012. Analysis of the reuse business opportunities in the Ouagadougou ecosan system. International Water Management Institute/Stockholm Environment Institute – unpublished data.
[36] Dagerskog, L. 2012. Analysis of the reuse business opportunities in the Ouagadougou ecosan system. International Water Management Institute/Stockholm Environment Institute – unpublished data.
[37] Dagerskog, L. and Makaya, J. 2012. Overview of the current state of the ecological sanitation system in Ouagadougou. International Water Management Institute/Stockholm Environment Institute – unpublished data.
[38] Attempts were made to reduce the investment costs by building superstructures in e.g. adobe, but this approach was abandoned later in the project since the durability of the superstructures was seriously impaired with the cheaper materials.

sick, younger children have problems to use the toilets correctly, and that they need good use and maintenance to function well.

The *CBOs are responsible for the collection, transport and treatment* of the urine and feces. The eco-stations they operate were initially set up under the EU project.

The *municipality supports the CBOs*. A decree was taken to create a municipal ecosan committee with a focal point together with a municipal budget line has been set up to support the CBOs after the end of the EU project. The focal point conducts regular visits to the eco-stations but no regular lab analyses are made of the birg-koom and birg-koenga. There are no local by-laws to guide the collection/reuse of these organic fertilizers.

ONEA is the national water and sanitation utility with water and sanitation jurisdiction in Ouagadougou. ONEA was involved in the EU project, and ONEA was going to include UDDTs in their portfolio of toilets/latrines for a further up-scaling of the UDDTs in the four sectors and elsewhere in Ouagadougou[39]. According to the municipality's focal point there is no up-scaling planned and ONEA has not been involved since the end of the EU project. Any up-scaling would need to be made in coordination with ONEA. Possibilities for CBOs to provide services within the wastewater jurisdiction and to be contracted by ONEA need to be investigated.

Economy

A simplification of the **financial flows** in the system is shown in Figure 17. In spite of the relatively high costs for the toilets, they are cheaper than the double-vault VIPs promoted by ONEA[40].

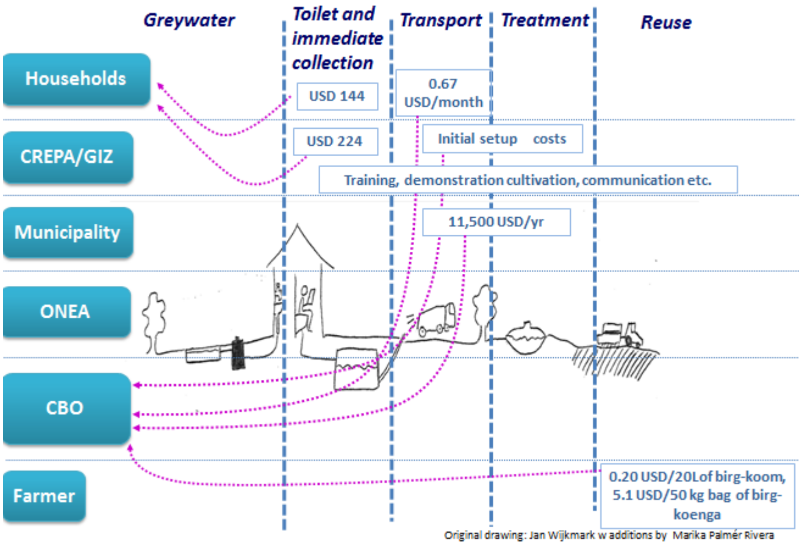

Figure 17: Costs in the Ouagadougou project.

The CBOs generate incomes from two different sets of customers in their two-sided business model with incomes generated from their primary market, the households, and then also from the secondary market, the farmers to whom they sell the birg-koom and birg-koenga. However, the

[39] von Muench, E. (editor). 2012. Compilation of 25 case studies on sustainable sanitation projects in Africa. Sustainable Sanitation Alliance, downloadable at http://www.susana.org/lang-en/case-studies?view=ccbktypeitem&type=2&id=1623

[40] http://www.wsp.org/sites/wsp.org/files/publications/Ecosan_Report.pdf

incomes generated today from emptying fees and payments for the fertilizer do not cover their O&M and depreciation costs. The municipality has, however, committed to the project, and a budget line has been created for the CBO support in the municipal budget. This is seen as a solution workable at this size of the project but unsustainable for an up-scaling[41]. Today 59 to 74% of the CBOs' income is composed of the subsidy from the municipality.

Ways to increase the profitability of the CBOs' work is to combine an increased fee[42] (for the fee to be on par with the monthly fee for solid waste collection) and to also combine that with an increased collected volume. Given the low per household collected volume today[43], there is a potential to increase the volume both through actively working with the customers today, to get more pee and poo where it belongs, and also through an increase in number of households with similar toilets. Such an upscale does demand an involvement of the national water and sanitation authority, ONEA, who has not been involved since the end of the EU project[44].

It has been suggested that the CBOs, as one way of increasing their incomes, start farming themselves since the real gain in the use of the birg-koom and birg-koenga comes for those who use it in crop cultivation. The CBOs would need to access land for cultivation, which it is reasonable that the municipality provides as safe recycling of nutrients is also a public interest. If the CBOs were in charge also of cultivation the system as a whole would be more robust, with a more predictable demand for the fertilizers[45].

There are, however, two other paths to explore in terms of increasing the incomes for the CBOs. It may seem outrageous that the service delivery through the CBOs may be as much as 74% subsidized. However, whether that is unreasonably high in the Ouagadougou context or not can only be known when knowing to which degree ONEA is subsidizing its customers, especially its 200 customers on the centralized sewer systems. There is a need to better understand how much of the costs of the utility's customers are covered through paid fees, and to look at business models involving ONEA. One also needs to remember that the business model described in this case study makes sure that the nutrients in the human excreta go back to agricultural land with a minimum of pollutants, something that is very difficult for a centralized sewer system to achieve without highly sophisticated unit processes to reduce organic pollutants, heavy metals etc. in the wastewater.

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[41] Dagerskog, L. 2012. Analysis of the reuse business opportunities in the Ouagadougou ecosan system. International Water Management Institute/Stockholm Environment Institute – unpublished data.

[42] Only possible if the service provided becomes more reliable. In the interview with households half of the interviewees expressed that the CBOs came by too seldom, forcing them to sometimes pour out the urine to free up jerry cans. The CBOs on the other hand were not completely satisfied with the payment frequency of their customers either, so a need for improvement also on payment reliability. Dagerskog, L. and Makaya, J. 2012. Overview of the current state of the ecological sanitation system in Ouagadougou. International Water Management Institute/Stockholm Environment Institute – unpublished data.

[43] The volume collected per household is much less than what should be generated per household, indicating that the systems are not used optimally and fully. Dagerskog, L. and Makaya, J. 2012. Overview of the current state of the ecological sanitation system in Ouagadougou. International Water Management Institute/Stockholm Environment Institute – unpublished data.

[44] l Dagerskog, L. 2012. Analysis of the reuse business opportunities in the Ouagadougou ecosan system. International Water Management Institute/Stockholm Environment Institute – unpublished data..

[45] Ibid.

It is also important to look at other subsidy policies in Burkina Faso. Chemical fertilizers are subsidized in Burkina Faso, which is understandable from a crop production perspective in a country where smallholder farmers may produce at as little as less than 15% of the crop yield potential of a field[46]. However, it also means that the price of NPK fertilizers and urea, is 25% lower than the world market price in Burkina Faso. It would be most interesting to investigate whether the CBOs, as fertilizer producers, could qualify for the same type of subsidies for their organically and locally produced fertilizers.

An increased demand for the birg-koom and birg-koenga would also increase the profitability for the CBOs. Some suggestions on how the demand for the fertilizers can be increased are:[47]

- Increased prices of chemical fertilizers would make alternatives more interesting.
- Extended research and testing of the fertilizers to show their hygienic and agronomic quality and strong public awareness campaigns that deliver this message
- If it would be possible to eco-label produce that have been fertilized with fertilizers, and these products could be sold at higher price
- Transformation of urine into a more desirable product (reducing volume and/or reducing odors)
- Policy and regulation that would encourage/enforce reuse of sanitation products. If reuse was mandatory but there was not enough demand in the private market, one could think of public management of the excreta for fertilization of rain-fed agricultural land around the capital.

Conclusions and lessons learned

Overall, the EU project is considered to have generated encouraging results both on household, CBO and farming level. The municipal authorities have embraced the concept and the Ministry of Agriculture has spoken favorably about the approach which is tackling two main challenges for Burkina Faso simultaneously: access to sanitation and improvement of food security to reduce the number of people suffering from malnutrition in Burkina Faso. The EU investments are still, to a fairly large degree, providing services 2.5 years after the handover of the project to the municipality, in spite of all different difficulties along the sanitation service delivery chain, from collection to reuse. This is to a large degree contributed to the various stakeholders involved who are true pioneers in the quest of a sustainable sanitation system.

The project has managed to demonstrate that it is possible to organize sanitation service delivery in urban areas, which can generate income from processing the excreta to produce fertilizers, even if the incomes at this point do not cover its costs. However, in most settings, centralized sewer systems with wastewater treatment do not generate enough income to cover their investment or O&M costs either, which is important to remember which in this case is the relevant alternative to compare with. The sanitation service delivery system in Ouagadougou is not optimally organized, and a number of improvements in the organization, improvement of volumes collected, improvement in

[46] http://www.worldwaterweek.org/documents/WWW_PDF/2012/Thur/No-Food-and-Nutrition/Linus-Dagerskog-Moussa-Bonzi.pdf

[47] Dagerskog, L. and Makaya, J. 2012. Overview of the current state of the ecological sanitation system in Ouagadougou. International Water Management Institute/Stockholm Environment Institute – unpublished data.

reliability of services, sensitization, looking closer at the relationship with ONEA and different types of subsidy schemes, expansion of the CBO activities towards farming could all help to improve the profitability of the CBOs. However, it should not be forgotten that the CBOs are providing the society with a huge environmental service when collecting the nutrients and converting them into fertilizers with low organic pollutant and heavy metal content, which is difficult for any utility in the world to actually match today.

One interesting lesson learned for the EU project is that the only "public" place where the UDDTs really work as intended is the prison. The prisoners at the MACO prison is in charge of the management of the whole system, O&M of the toilets, treatment of the collected excreta as well as the agricultural reuse of the fertilizers on their own fields in the prison. As with any public toilet, a rigorous O&M mechanism must be in place to ensure the cleanliness and function of the toilets which did not happen at the other public places.

Further reading on Ouagadougou:

- Dagerskog, L. and Makaya, J. 2012. Overview of the current state of the ecological sanitation system in Ouagadougou. International Water Management Institute/Stockholm Environment Institute – unpublished data.
- Dagerskog, L. 2012. Analysis of the reuse business opportunities in the Ouagadougou ecosan system. International Water Management Institute/Stockholm Environment Institute – unpublished data.
- Dagerskog, L., Coulibaly, C. and Ouandaogo, I. 2010. The Emerging Market of Treated Human Excreta in Ouagadougou. Urban Agriculture Magazine, No. 23, April 2010. Downloadable at http://www.ruaf.org/node/2217
- Dagerskog, L. and Bonzi, M. 2010. Opening minds and closing loops. Sustainable Sanitation Practice, Issue 3, 2010. Downloadable at http://www.ecosan.at/ssp/issue-03-use-of-urine/issue-03
- von Muench, E. (editor). 2012. Compilation of 25 case studies on sustainable sanitation projects in Africa. Sustainable Sanitation Alliance, downloadable at http://www.susana.org/lang-en/case-studies?view=ccbktypeitem&type=2&id=1623
- WSP. 2009. Study for financial and economic analysis of ecological sanitation in Sub-Saharan Africa. Downloadable at http://www.wsp.org/sites/wsp.org/files/publications/Ecosan_Report.pdf

Contacts for more information on Ouagadougou:

- Mr Sienou, focal point for the Ouagadougou project on municipal leve, phone: +226-70243642

2.1.3 Bengaluru, India[48]

Bengaluru is a fast-growing city in South-West India with a population of around 8.5 million people according to the 2011 census. The authority responsible for the management of wastewater in the city is the Bengaluru Water Supply and Sewerage Board (BWSSB). It has been estimated that approximately 60%, or about 5.1 million, of the citizens of Bengaluru rely on on-site sanitation systems or no systems at all. The soak pits and septic tanks are to the most degree emptied by private operators, the number of operators in Bengaluru has been estimated to at least 300.

The private operators of on-site systems have for a long time been working in an institutionally grey zone, with little or no official recognition, difficulties to obtain credit in the formal financial sector, higher cost than entrepreneurs in the formal sector, being subject to paying bribes, no monitoring etc. In recent years this has started to change. Certain state government recognition of the necessity to engage with on-site sanitation service delivery, not the least as a mean to abandon manual scavenging, has emerged lately through a program where e.g. Karnataka state is providing 210 of its cities with at least one tanker truck. This may not be seen as an improvement of the situation by the private tanker truck operators, but it is a sign that the State Government is taking steps towards a more official recognition of the situation.

In Bengaluru BWSSB has also increased its involvement in on-site service delivery with two new fecal sludge drying plants installed. Emptying at these facilities is connected to a cost per load for the tanker truck operators. Uncontrolled fecal sludge dumping in the environment and on vacant lots around the city still happen, partly due to dumping fee at the sludge drying plants but also as a mean to save fuel. Agricultural reuse of the fecal sludge frequently occurs around Bengaluru, since a number of the tanker truck operators empty their truckloads on farmland close to the city rather than on vacant lots. This case study describes this uncontrolled fecal sludge reuse.

The technical system

An overview of the technical system and responsibilities are shown in Figure 18.

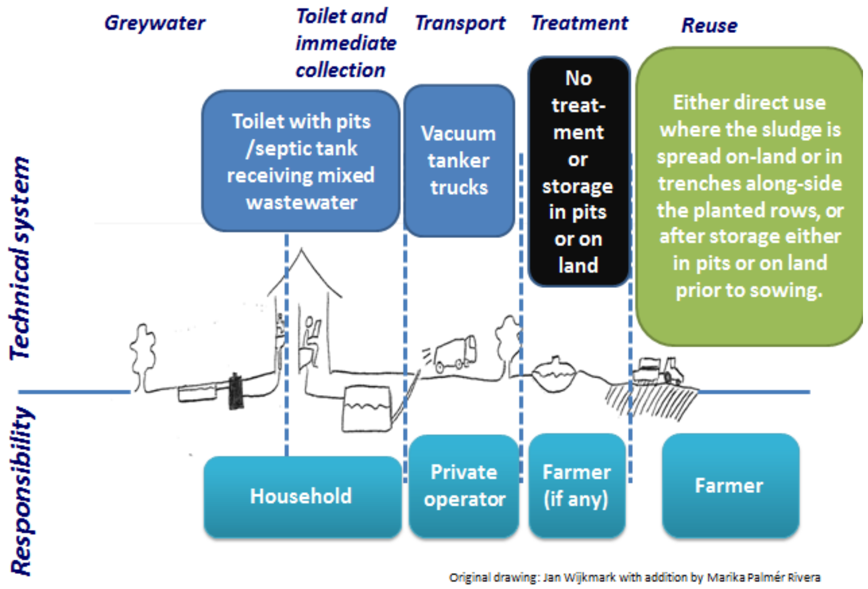

Figure 18: PPT with technical system and responsibilities.

[48] Most data for this case study comes from Kvarnström, E., Verhagen, J., Srikantaiah, V., Ramachandran, S. and Singh, K. 2012. The business of the honeysuckers in Bengaluru, India: The potentials and limitations of commercial fecal sludge recycling – an explorative case study. IRC International Water and Sanitation Centre, downloadable at www.irc.nl/op48/

The existing *on-site systems on household level* typically consist of soak pits, septic tanks or holding tanks receiving mixed wastewater, located outside the house and close to the street. Size, type and material depend on size of household and level of sophistication of the system. It is noteworthy that the construction of holding tanks has developed into a separate industry with small-scale contractors that have specialized in the construction of circular holding tanks, with a depth of 6 meters, and a diameter of 1.8 m. In turn, these holding tank constructors are served by small-scale companies that produce concrete rings.

Newer apartment buildings consuming more than 50,000 L/day have requirements of decentralized sewage treatment, systems that also generate fecal sludge.

The on-site systems are served by private tanker truck operators, Figure 19, running small businesses with one or a few tankers each. The customer can reach the tanker operators through formal (yellow pages etc.) or informal channels (by word of mouth, calling cell # found on passing tanker trucks etc.).

Figure 19: A private operator emptying a soak pit from a hostel building. Photo: V. Srikantaiah.

The *treatment of the fecal sludge*, when provided by farmers, consists of storage, either on-land that is left uncultivated for a period of time or in pits or trenches, see Figure 20.

Figure 20: Storage and dewatering in a pit and on uncultivated land. Photo: V. Srikantaiah.

Reuse

The tanker truck operators often, as explained above, dump their truck loads on vacant lots, in the environment or on farmland within or close to the city boundaries. This is an easy way for the tanker truck operators to empty their trucks at no cost, or even, in some cases, to get paid for their truck load by the farmer[49].

From the farmers' point of view, the reuse of fecal sludge decreases their costs as fecal sludge replaces farmyard manure and/ or chemical fertilizers. Interviews with five farmers in Bengaluru showed that yearly financial gains from the use of fecal sludge can be estimated to be between USD 129 to 2,700. One farmer had made good business out of fecal sludge, by drying it and then selling it further to other farmers at a yearly gain of about USD 7,300. Four out of the five farmers mentioned that their yield had increased with the use of fecal sludge as a fertilizer. In general, all of them were content with the fertilizing value of fecal sludge. None of the farmers registered any reluctance in using fecal sludge for their crops, nor did they mention that their direct clients – the wholesalers – were not willing to buy their produce. Some farmers did raise concerns over laborers experiencing skin problems especially with the use of fresh fecal sludge, or refusing to handle sludge[50].

Figure 21: Sludge for reuse and the crops. Photo: V. Srikantaiah.

Organization

Roles and responsibilities

The roles and responsibilities are outlined in Figure 18. The model has come into place without any direct involvement of BWSSB or the local or state authorities. The roles and responsibilities are thus divided between the household responsible for the technical installations on the household level, the private operators provides the emptying services to their primary set of customers, the households, and then provides nutrients to their second set of customers, the farmers. The farmers take care of the reuse.

[49] Through interviews with tanker truck operators it was found that one of them, occasionally, got INR100 for his truck load at a farmer. Kvarnström, E., Verhagen, J., Srikantaiah, V., Ramachandran, S. and Singh, K. 2012. The business of the honeysuckers in Bengaluru, India: The potentials and limitations of commercial fecal sludge recycling – an explorative case study. IRC International Water and Sanitation Centre, downloadable at www.irc.nl/op48/

[50] Kvarnström, E., Verhagen, J., Srikantaiah, V., Ramachandran, S. and Singh, K. 2012. The business of the honeysuckers in Bengaluru, India: The potentials and limitations of commercial fecal sludge recycling – an explorative case study. IRC International Water and Sanitation Centre, downloadable at www.irc.nl/op48/

This model largely lacks institutional support today. An institutional embedding of the current practices, tweaked to increase safety both for farmers and consumers, would be a model largely suitable for on-site sanitation service delivery for many Indian cities and a viable alternative to centralized collection and treatment of wastewater. This would be most applicable if the utilities responsible for urban sanitation would consider the services that are already operating (within a non-networked area), and use these as the basis for improving service delivery, rather than automatically seeking to expand sewer networks. For this to happen it is important to better understand the necessary sanitization needed to reduce health risks associated with the reuse of fecal sludge and to develop regionalized guidelines and legal framework for the handling, transport, treatment and application of nutrients from fecal sludge.

Other necessary institutional changes include (i) the incorporation of sewage disposal systems in building plan approvals, (ii) land use plans to earmark space for solid and liquid waste treatment, (iii) separate systems for blackwater from toilets and greywater, (iv) understanding the interaction between soak pits/holding tanks and the groundwater and design for non-pollution[51].

Economy

The financial flows, as estimated, are shown in Figure 22. The tanker truck businesses are viable financially today, given that they exist without any external support. Overall, the model seems to be providing satisfactory services, at least to middle-class households not connected to the main sewerage network. Fecal sludge use by farmers have added benefits in terms of costs savings, potentially serving as an added income-generating activity, and increasing crop yield. From an environmental perspective, fecal sludge reuse also seems to have reduced the burden and pressures on the environment (fecal sludge on a vacant lot or in a water course represents an environmental problem which is larger than fecal sludge on an agricultural field).

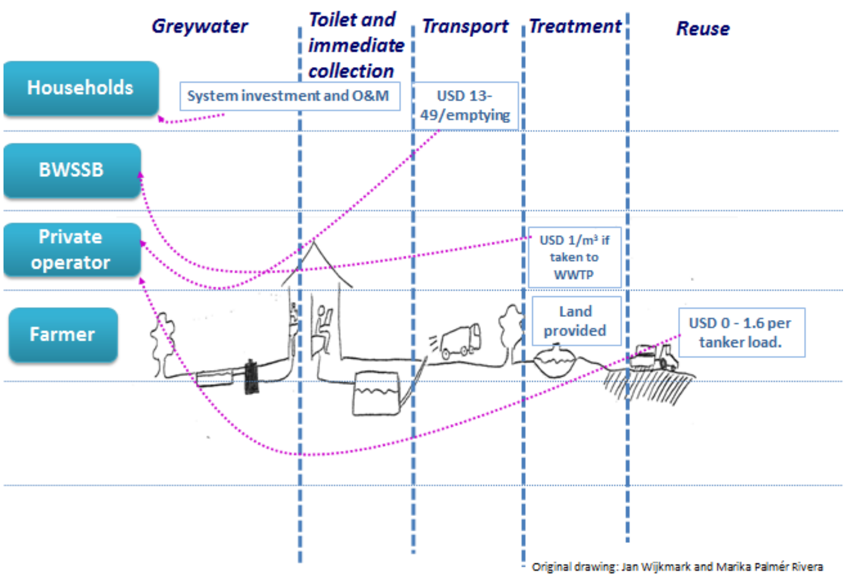

Figure 22: Costs in Bengaluru.

However, the financial challenge is to fit *__improved treatment and sanitization__*, with a starting point in current practices, within the profitability of the tanker truck operators and farmers' activities, which

51 http://www.slideshare.net/zenrainman/honeysuckers-sanitation-solution-from-the-informal-sector?from_search=3

is of utmost importance in order to reduce the health risks associated to an uncontrolled use of fecal sludge.

Conclusions and lessons learned

It can be concluded that the private operator provided fecal sludge emptying services with agricultural reuse in Bengaluru is a financially viable model, but they operate in an institutionally grey area, without monitoring or fecal sludge treatment. Improved treatment and sanitization, with a starting point in current practices, within the profitability of the tanker truck operators and farmers' activities, is of utmost importance in order to reduce the health risks associated to an uncontrolled use of fecal sludge. An institutional embedding of the current practices, tweaked to increase safety both for farmers and consumers, would be a model largely suitable for on-site sanitation service delivery for many Indian cities and a viable alternative to centralized collection and treatment of wastewater.

Further reading on Bengaluru:

- Kvarnström, E., Verhagen, J., Srikantaiah, V., Ramachandran, S. and Singh, K. 2012. The business of the honeysuckers in Bengaluru, India: The potentials and limitations of commercial fecal sludge recycling – an explorative case study. IRC International Water and Sanitation Centre, downloadable at www.irc.nl/op48/
- Video on fecal sludge reuse in Bengaluru: http://vimeo.com/23587361
- Presentation on slide share: http://www.slideshare.net/zenrainman/honeysuckers-sanitation-solution-from-the-informal-sector?from_search=3

Contact for more information on Bengaluru:

- Vishnawath Srikantaiah, Director of Biome Environmental Solutions Pvt, Ltd (http://www.biome-solutions.com/index.php), email: zenrainman@gmail.com

2.1.4 Centro de compostero, Tepoztlan, Mexico

Antecedentes

En el contexto del Proyecto Piloto de Saneamiento Ecológico, Proyecto TepozEco, 2003-2006, en Tepoztlán, Morelos, México, financiado por el gobierno de Suecia a través del Instituto de Medio ambiente de Estocolmo (SEI) y su programa Ecological Sanitation Research (EcoSanRes), se realizaron diversas actividades para el acopio, investigación y uso/disposición de orina, en la búsqueda del cierre de ciclo de nutrientes en actividades de saneamiento ecológico. Entre las actividades realizadas para el acopio de orina se colocaron mingitorios secos en la oficina y la oficina del ayuntamiento, en establecimientos comerciales, en escuelas y a nivel doméstico y se constituyó una microempresa) para dar servicio de mingitorios portátiles en las fiestas del pueblo (carnaval, fiestas de barrio en Tepoztlán y eventos públicos). La orina acopiada se utilizó para el establecimiento de pruebas de campo en manejo y uso de orina como fertilizante (en cultivos de maíz, nopal y aguacate) y en la utilización de ésta en proceso de composteo.

Durante el proyecto TepozEco fue establecido un centro de composteo para Tepoztlán en el cuál se procesaban las podas de jardín provenientes de los jardines y vías públicas. Previo al establecimiento de este centro las podas se disponían sin ningún tratamiento en el basurero municipal, ocupando grandes volúmenes del mismo y creando problemas de descomposición al interior de las capas de basura. Una vez establecido el proyecto del Centro de Composteo, todas las podas de jardín se empezaron a utilizar para la producción de compostas. Como forma de mejorar la calidad de las compostas, ya que eran ricas en carbono y pobres en nitrógeno, se comenzó con la aplicación de orina acopiada.

Technical system design

La orina utilizada en el Centro de Composteo Municipal de Tepoztlán, fue acopiada en contenedores de 20, 40, 200 y 1100 lts en las oficinas del Proyecto TepozEco. Para trasladarla al Centro de Composteo, se utilizó una camioneta con un contenedor de 1100 lts. La orina era bombeada de los contendores en donde estaba almacenada hacia a el contenedor sobre la camioneta. Una vez en el centro de composteo, la camioneta se colocaba en una parte alta del terreno y desde ahí, con el uso de una manguera y por medio de gravedad , se canalizaba la orina hacia las compostas. La forma de aplicación de la orina fue haciendo agujeros en las compostas aplicando la orina en los agujeros. Después de la aplicación se solicitaba que una semana después se trapaleara la composta.

El traspaleo de las compostas era llevado a cabo por un tractor agrícola con pala, que prestaba el ayuntamiento.

Paralelamente se montó un experimento en pequeñas cajas de madera para valorar el uso de la orina y dosis en las compostas. El análisis monitoreo de este experimente se realizó a través del registro del pH, y cromatografía al final del proceso. No se observaron diferencias significativas en estos registros, ni en factores físicos y velocidad de descomposición del material, se piensa que esto fue debido a lo largo del proceso de composteo de podas de jardín (10 meses), al tamaño de las muestras experimentales y a los registros utilizados, hubiera sido de gran valor realizar pruebas de utilización del producto para la producción vegetal.

Organization

El centro de composteo tuvo la participación de 4 organizaciones: El Comisariado Ejidal (dueños del basurero municipal), La Autoridad Municipal, El Proyecto TepozEco y la organización Valle Sagrado. Cada uno de los actores aportaba diferentes cosas: El municipio proveía el agua para las compostas, la gasolina para la picadora y 2 trabajadores de tiempo completo, el Ejido proveía el espacio para el centro de composteo, la picadora, la herramienta y la supervisión por parte de ellos; El proyecto TepozEco (Sarar Transformación) la asesoría técnica (2 veces por semana) y Valle Sagrado vería por el cumplimiento de los acuerdos, sobre todo cuando hubiera cambios de administración en El Ejido o el Ayuntamiento.

Conclusiones y Lecciones aprendidas

- No obstante no se hayan encontrado resultados significativos con el uso de orina en las compostas, dado el alto contenido de carbono en el material y bajo contenido de nitrógeno, consideramos que la orina puede ser un mejorador del proceso de composteo y calidad final del material.
- El centro de composteo representa una excelente opción para la disposición de grandes volúmenes de orina y transformación de materia orgánica a abono y con esto ayudar al cierre

de ciclo de nutrientes, a través de la producción de un material (composta) de fácil manejo y utilización/ disposición.

- El centro de composteo aportó diferentes beneficios: permitió retirar grandes volúmenes de poda de jardín (aprox 1000 m^3) del basurero municipal, se aplicaron 1800 lts de orina acopiada durante el Proyecto TepozEco, se produjeron 270 m^3 aprox de composta y representaba un gran potencial para la producción de abono y canalización de la orina proveniente de las actividades de saneamiento ecológico. Sin embargo faltó más diálogo y reuniones entre los actores involucrados (Ejidatarios, Autoridades municipales y Proyecto TepozEco) de manera de ir construyendo una visión conjunta del proyecto. Por demasiada carga de trabajo entre las autoridades y posteriormente el cambio de autoridad municipal, empezaron a haber desacuerdos entre los ejidatarios y la nueva administración con lo que se interrumpió la comunicación en relación al Centro de composteo. Los ejidatarios sentían que ellos estaban financiando al ayuntamiento, por otros favores que le hacían independientemente del centro de composteo y el ayuntamiento sentía que estaba aportando demasiado. La falta de una visión común y la falta de comunicación, ocasionó la caída del proyecto.

- El manejo adecuado de los residuos orgánicos representa grandes beneficios ambientales (no considerados económicamente), por lo que las actividades realizadas para alcanzarlo deberían ser consideradas como un servicio ambiental y por ende recibir de apoyos cuando son necesarios.

- La comunicación entre los actores así como el contar con una figura institucional que permita la permanencia del proyecto independientemente de los cambios de administración/personal de las instituciones, puede ser clave para la permanencia y avance de este tipo de proyectos.

- El proyecto TepozEco aportó un análisis de costos del proyecto así como sugerencias para la optimización en el funcionamiento de centro de composteo y de esta manera buscar la sostenibilidad financiera del proyecto, sin embargo, la falta de una visión común no permitió llevarlos a cabo.

Contact for more information:

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- Magdalena Bulnes, SARAR-Transformación: maidabulnes@sarar-t.org.

2.2 Context 2 - On-site water and sanitation (or no sanitation at all) with low population density (rural to urban edge)

2.2.1 Durban, South Africa[52]

Through a municipal amalgamation in 2000 eThekwini Water and Sanitation's jurisdiction grew from covering about 1 million people with water and wastewater connections to about 3.5 million people, where the substantial part of the new customers lived outside the waterborne sanitation edge. Hence, EWS had to start service delivery both on existing on-site systems (mainly VIPs) and also to expand the services to those without services in rural areas, alongside with service delivery within the sanitation waterborne edge for a number of cities and towns. Outside the waterborne edge EWS took the strategic decision to meet the national policy stipulation of free basic services on sanitation with the use of urine diverting toilets instead of expansion of VIPs or other types of on-site systems. The main reason for this strategic decision was the high cost associated to VIP emptying (USD 250 per VIP emptying) and that many of the non-served communities in the hills around Durban are relatively inaccessible. The emptying of a fecal vault of a double-vault urine diverting toilet, after one year of undisturbed storage, is much less cumbersome, costly and repulsive than the emptying of VIP latrines. Moreover, the emptying can be done by the house owners themselves when accompanied by the correct training.

Box A: eThekwini Water and Sanitation in figures today

- 3.6 million people
- 646 000 properties
- Supply of 860 ML/day of water from 9 water treatment works
- Treatment of 500 ML/day of wastewater
- 263 water reservoirs
- 27 wastewater treatment works
- 7000 km of sewer mains
- 11 300 km of water mains
- 475 000 water connections
- Around 36,000 VIPs within and outside the waterborne edge
- 500 informal settlements served by ablution blocks with toilets, showers, an area for laundry and sometimes in connection to a community center.
- Around 80,000 dry urine diverting toilets outside the waterborne edge of the municipality

[52] The information on this case is an amalgamation from personal communication with EWS staff, personal observations and from von Muench, E. (editor). 2012. Compilation of 25 case studies on sustainable sanitation projects in Africa. Sustainable Sanitation Alliance, downloadable at http://www.susana.org/lang-en/case-studies?view=ccbktypeitem&type=2&id=1623 and EWS Factsheet on urine collection – unpublished document.

There are about 80,000 urine diverting toilets now installed in Durban in rural areas, serving over 500,000 people. The EWS urine diversion toilet program entails many components, varying from house visits, training, street theatre as well as the actual construction. The program is unique in South Africa as it integrates water services (yard tanks, allowing 300 L/family, day), sanitation as well as household hygiene education and O&M training (each and every household gets visited five times) as a single package.

In order to make the services sustainable EWS recognized from the start that every intervention needs to be accompanied by education of the customers and that the customer education program cannot have a specific end date, since the messages need to be sustained in the communities over a long time. To formulate a pertinent program to address the objectives for the *rural sanitation* above a perception survey was undertaken to gauge attitudes, opinions and knowledge levels among the customers. An education program, taking into account the results from the survey, was then developed, and used in combination with other tools.

The education program makes use of tools such as leaflets and posters, working models, and manuals both for how to train facilitators and a curriculum guide for educators and facilitators. The education program was rolled out in cooperation with the Council's Health Department and implemented both at clinics, community halls, schools and in homes. The facilitators use, among other things, street theatre, Fig 23, to approach difficult subjects with humor in a non-threatening way with a high message retention level. Participation at street theatre events is encouraged through competitions and lucky draws.

EWS' educational campaigns have gained international recognition through the UN-Habitat certificate on best practices and the Impumelelo Award for Excellent Innovation.

Figure 23: Street theatre group in Durban. Source: eThekwini Water and Sanitation.

The technical system

The technical system components and the responsibility division are shown in Figure 24. A model of *the household UD toilet* can be seen in Figure 25. A unit consists of two vaults, a super structure, one seat and a urinal. One vault is at use at a time. When the first vault is full, after about a year, the seat is moved to the adjacent hole/vault. The content in the first vault is then allowed to rest undisturbed until the second vault is full. The system is odor-free as long as the vaults' ventilation pipes are functional and as long as there is no urine, or other liquid entering into the vault in excess amounts. EWS has noted that there is a bit of difficulty in aligning the urine pipe to the infiltration device when switching the seat from one hole to the other, which may lead to urine entering into the vault and subsequent odor problems. After each defecation some soil or ash is added to the vault to cover and dry out the surface. The UD systems were initially not set up for urine reuse neither on-plot nor for collection and reuse off-site. The urine is therefore today infiltrated into the soil for most installations, see more below. The natural slope of the ground is used, when possible to avoid the use of steps in the design to the largest degree possible so as to facilitate the toilet access for elderly. One disadvantage of this design is that the front wall of the vault is located sub-surface which may negatively affect the drying of the feces in the vaults.

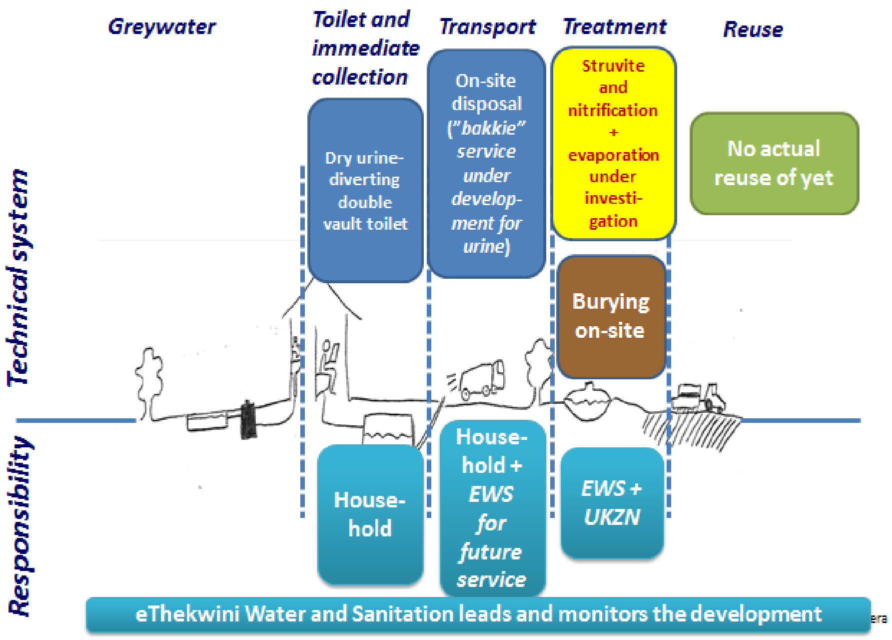

Figure 24: The technical system and the responsibility division, from PPT

Once the second vault is full, the first vault, which has been resting undisturbed during the time it has taken to fill the second vault, is emptied. The emptying responsibility lies with the household, who can either choose to do it themselves (the first emptying is accompanied by EWS staff), or they can pay a local contractor to do the service for them. Instructions from EWS on safe pit emptying includes use of protective gear, burying of the dried feces, planting a tree or grass over the covered feces and vigorous hand and tool washing after the emptying.

Figure 25: Model of dry urine diverting toilet in Durban, an interior of a UD toilet, emptying of a vault and the hilly terrains of eThekwini Municipality. Source: EWS.

The systems are designed to be managed on household level, without reuse. However, *EWS is looking into large-scale collection set-ups for the urine* and is currently running a collection service for about 700 households in so called control areas to collect urine for research and to test the service set-up. Municipal staff is serving the control areas with “bakkies” – South African expression for pick-up trucks, and collect urine from the households in the control areas, see Figure 26. Access to the households is facilitated through the use of locally employed facilitators and by keeping good relations with the councilors in the control areas.

Reuse

No reuse is taking place at the moment in the Durban system. The dried feces is buried on-site and on-plot reuse of urine has not been promoted by EWS, who has taken a more conservative approach towards reuse after urine storage only, a method used both in Sweden, Bolivia, Burkina Faso, Nepal, the Philippines to mention a few places. However, EWS is working on a large-scale collection and reuse system for the urine, which is currently under testing. Currently EWS, University of Kwa-Zulu Natal (UKZN) and the Swiss Federal Institute of Aquatic Science and Technology (EAWAG) are jointly carrying out a research program, funded by Bill and Melinda Gates Foundation, called “Valorisation of Urine Nutrients in Africa" (VUNA[53]), where low-cost struvite production from urine as well as nitrification and subsequent evaporation are investigated as methods to convert urine into solid fertilizers. It is worth mentioning that through struvite formation most nitrogen cannot be converted into a solid phase, whereas the nitrification and evaporation, albeit a more difficult process, is more promising in terms of capturing all nutrients in the urine into the solid phase. The VUNA project also looks into social acceptance, economic feasibility, incentive schemes, business/logistic models among other things.

Moreover, EWS is also working on *fertilizer pellet production from its VIP fecal sludge* through the use of a patented pelletizer, the LaDePa[54] machine.

Figure 26: Urine collection service and the urine fertilizer research facility at NewlandsMashu. Source: EWS.

Organization

Roles and responsibilities

EWS takes a responsibility of service delivery to all its customers, whether they are paying with full pressure water and wastewater connections or whether they are on the free basic services package. EWS is responsible for the construction of toilets, training and accompanying the families until they are capacitated to operate and maintain the toilets themselves. EWS is currently investigating a large-scale collection system for the urine in order to produce urine-based fertilizers, and is investigating models for how the collection and treatment system will look like. The outcome of the VUNA project briefly described above will help the decision makers to decide whether it is better to collect the urine by municipal staff in a highly optimized collection process or to even include an incentive scheme, reduce the work load and open up opportunities for local entrepreneurs. The final goal is to collect a maximum volume of urine for the least cost possible and to produce a valuable urine-based fertilizer. How that system looks like, and its responsibility division, is yet unclear.

Economy

A summary of costs is shown in Figure 27. According to the SA constitution all citizens have the right to free basic water and sanitation. EWS has chosen to tackle this with dry UD systems together with 300 L/family, day of drinking water for families living in houses worth less than R250,000. The

[53] Read more about the VUNA project here: http://www.eawag.ch/forschung/eng/gruppen/vuna/index_EN
[54] Read more about the LaDePa here: http://www.irc.nl/docsearch/title/180877.

program is mostly funded through the Municipal Infrastructure Grant (system construction costs) plus through tariff cross-subsidies for the extra 100L/day (outside the Free Basic Services) and for O&M. The per household costs for water, toilet and training has been estimated to USD 1,400, where the toilet costs is about USD 800.

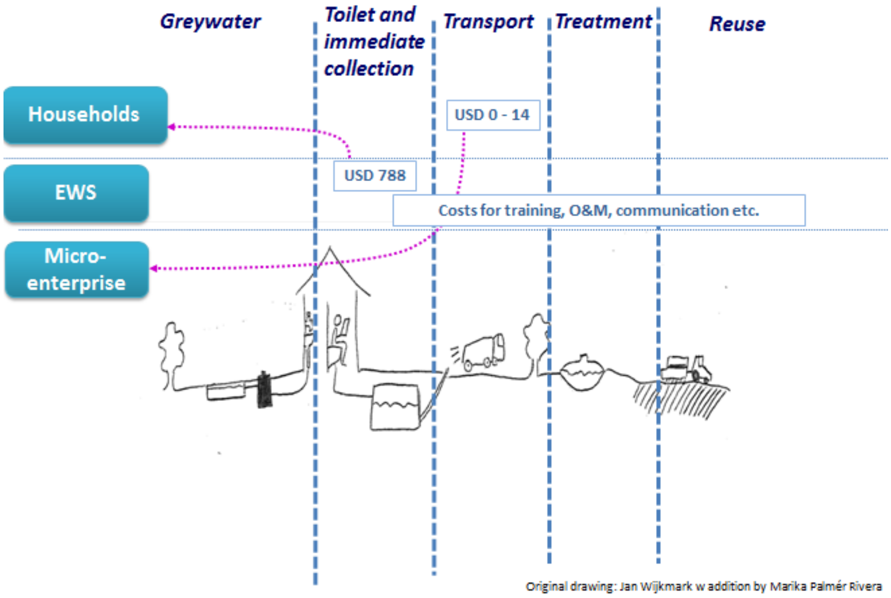

Figure 27: PPT on the costs in the system

The households can either empty their feces vaults every 6-12 months themselves, for free, or pay for a collection service, which costs between USD 7-14 per emptying event.

Conclusions and lessons learned

EWS is a utility who has managed to develop models for service delivery to its full range of customers, from those in high-end areas to informal settlements (EWS runs successful ablution blocks in 500 of its 500 informal settlements) to its rural customers formerly without any services. They are also providing emptying services for its customers with existing VIPs. EWS is thus a role model when it comes to service delivery irrespective of technology type. EWS also stands out in terms of its strong research ties with, among others, UKZN. EWS is currently involved in, among other things, the development of attractive waterless toilets where energy, food security, job creation and a clean environment are in focus. EWS also understands the crucial importance of customer relations, customer education and what trust between the utility and the customer means in terms of functionality of the service provided and payments in return. Listening to its customer base and take corrective actions in terms of program adaptation is fundamental to all EWS programs. EWS has transformed from being an engineering-driven utility in 2000 to a customer-oriented one in 2013, all the while pushing the knowledge boundary forward not the least within the field of sanitary engineering.

Further reading on Durban:

- von Muench, E. (editor). 2012. Compilation of 25 case studies on sustainable sanitation projects in Africa. Sustainable Sanitation Alliance, downloadable at http://www.susana.org/lang-en/case-studies?view=ccbktypeitem&type=2&id=1623
- EWS Factsheet on urine collection – unpublished document.
- 10 min video on the program: http://www.youtube.com/watch?v=WZjHnkapRgg
- WIN-SA's lessons series on the EWS experience: http://www.susana.org/lang-en/library?view=ccbktypeitem&type=2&id=1170
- Presentation made at WEDC conference 2006 on the EWS experience: http://www.susana.org/lang-en/library?view=ccbktypeitem&type=2&id=1277

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2.2.2 Aguié Province, Niger[55]

Niger is a land-locked country in Western Africa, with more than 80% of its land covered by the Sahara desert. Niger is consistently ranked low in the UN Human Development Index, 2012 it was positioned 186 out of 186 countries. Most of the population of about 17 million people lives in the South and South-West of the country. Aguié province, bordering to Nigeria in the south, is one of the most densely populated provinces in Niger.

Figure 28: Aguié province, Niger.

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[55] The information for Aguié can mostly be found in Dagerskog, L. 2010. Productive sanitation in Aguié, Niger – Testing a nutrient recycling system with a view to measure its potential for improving agricultural productivity. Technical Advisory Note to IFAD, downloadable at http://www.ecosanres.org/aguie/documents/TAN%20Niger%20Aguie%20Prod%20Sanitation%20CREPA%201049%20(4).pdf

A project to improve agricultural productivity to ensure an increased food security and health for smallholder farmers in Niger was implemented in Aguié province in 2009-2010, using productive sanitation systems[56] as the mean to increase the smallholders' access to fertilizers. The project was financed by the International Fund for Agricultural Development, IFAD, and implemented by a consortium of agricultural and sanitation actors: CREPA HQ together with CREPA Niger (these days Water and Sanitation for Africa), PPILDA[57], and Stockholm Environment Institute. The project's starting point in increased food security and then using sanitation as a mean, all financed with agricultural funds is a quite unique set-up. The project had three different components:

1. Introducing and gaining acceptance for productive sanitation systems in 11 villages in Aguié.
2. Conduct research on fertilizing effects of urine as well as on risks and low-cost technologies to facilitate the collection, treatment and reuse of human excreta.
3. Local, national and international outreach of the results

Before the onset of the project it was thought that the approach of productive sanitation and the reuse of treated human excreta would be very challenging due to cultural/religious aspects. However, the reality for smallholder farmers in Niger is very harsh, with the increasing land pressure and the unaffordability of chemical fertilizers, a situation which opens up for possibilities to circumvent taboos, when it can be shown that the circumvention of taboos improves the access to an efficient fertilizer. The project team managed to achieve this cultural turnaround using the PHAST/SARAR methodology, adapted for the purpose, and by using participative testing of urine as a liquid fertilizer on village level. One key message used in the PHAST/SARAR facilitation was that an average family of nine persons in Niger excretes the equivalent of 50 kg of urea and 50 kg of NPK per year, Figure 29, which represents a huge value for a smallholder family. Another "tool" used in the adapted PHAST/SARAR methodology was to build on local practices. The villagers all agreed to that there is a correlation between the fields with the best yields and where people traditionally go for open defecation (Figure 29), which has not hindered anyone from eating crops from those fields were reuse happens without treatment. Productive sanitation then becomes a conscious, safer and more efficient way to improve what is already taking place. As in Burkina Faso, the urine and feces, when sanitized, is named liquid and solid fertilizer in haussa: takin ruwa and takin bussashé, to focus on the function of the product rather than its origin.

Figure 29: PHAST/SARAR in action. Photo: L. Dagerskog, image: Aguié citizen.

[56] Productive sanitation systems are systems that allow for the safe reuse of the plant nutrients in human excreta for crop production.
[57] Projet de Promotion de l'Initiative Locale de Développement en Aguié under the Niger Ministry of Agriculture

1,100 families were equipped with simple urinals through the project and about 200 families with simple toilets. Three year after the end of the project more than 80% use the urinals and more than 70% use the toilets. The approach has spread widely in Niger[58] through the work by Water and Sanitation Africa (former CREPA):

- An EU and Care Denmark financed project in the Tarka valley (2011-2015) using the approach developed in the Aguié project. It has already constructed over 300 toilets (1,000 toilets will be constructed by the end of the project) and collected 25,000 L of urine which have been used, after sanitization through storage, on onions, tomatoes and millet in 23 villages.
- The DANIDA-funded PASEHA II in the Zinder and Diffa regions (2013-2015) will construct more than 1,000 toilets of the type used in Aguié.
- The Zinder region has another project, funded by EU and Water and Sanitation Africa, where the Aguié approach will be implemented in 30 villages.
- USAID and CLUSA-funded project on food security in the Filingué and Illéla districts have constructed 120 toilets of the Aguié type.
- An EU funded project to improve sustainable access to sanitation and hygiene in Niamey will construct 50 urine-diverting toilets in peri-urban Niamey.
- World Vision will also incorporate the approach in their project implementation.

The technical system

A schematic overview of the technical system and responsibilities is shown in Figure 30. Over 200 toilets were installed under the project and two different types were used. One toilet relies on composting and storage as treatment, for which the urine diversion is combined with a double-pit toilet where the feces, anal wash water and a bit of soil added after each defecation are all collected in the pit. The other type of toilet relies on drying and undisturbed storage for treatment, for which the urine diversion is combined with an above-ground, double-vault toilet where the anal wash water is diverted separately and a bit of ash is added after each defecation to improve the drying process. The toilets in Figure 31 are of the drying model. The super structure is either in straw or adobe. Simple urinals, jerry cans with a funnel and a ball-shaped odor blockage (can be a used light bulb or other similar object) are used by 1,100 families, Figure 31. The urinals are either dug down, to accommodate for a squatting position or posed on the ground. The toilets and urinals are extremely low-cost.

[58] Personal communication, Hamadou Kailou, WS Africa (formerly CREPA Niger).

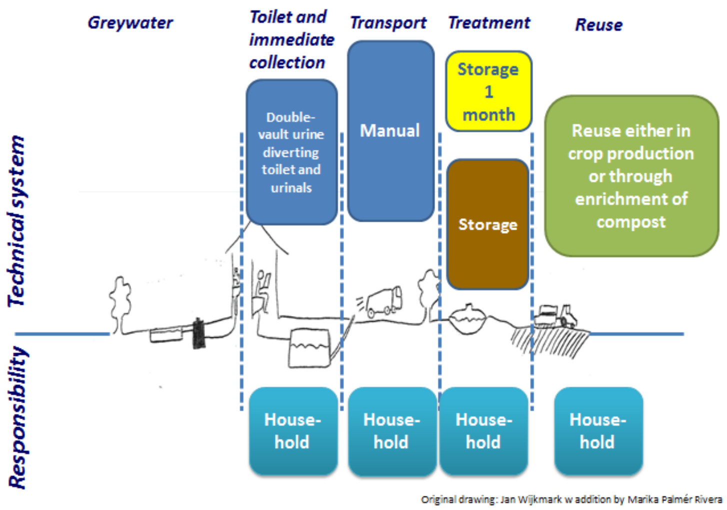

Figure 30: Schematic overview of technical system and responsibilities in Aguié.

Figure 31: The toilets and urinals. Photos: L. Dagerskog.

The households handle the urine collection, storage and reuse themselves. The feces are treated in the pits/vaults, where 12 months undisturbed storage is achieved in the double-pit/vault system.

Reuse

125 m^3 of urine was collected under 2009 in the pilot villages. 25 vegetable farmers and 120 cereal farmers took part in the demonstration cultivation using urine as a fertilizer. Increased crop yields, compared both to a control receiving a base organic fertilizer and to urea, were shown for a number of different crops, Figure 32. Urine in general gave 20% higher yields when compared to urea on cereals, and 40-50% higher when compared to organic base fertilizer only. For rain-fed agriculture it was shown that each jerry can, 25L, of used urine, gives 2-3 kg extra of millet when compared to the

base organic fertilizer. In two villages signs of valuing urine as a commodity emerged, with several hundred of jerry cans of urine were sold to more well-off farmers.

Storage capacity is an issue for the smallholder farmers as is water availability. To make best use of the urine as a fertilizer under water scarce circumstances it should be stored and used under rain-fed agriculture in June-August. However, for a family of nine storing urine for nine months of the year would mean that each family would need a storage capacity of about 3-4 m^3. Therefore alternative strategies have been developed. Families that have a good source of water during the dry season use the urine, with very good results, for vegetable production from Oct – March. If water availability is an issue the urine is instead used to enrich the composts made by the farmers from agricultural residues, farm yard manure and household organic waste during the dry season. In the rainy season, June to August, it is used directly into the rain-fed agriculture.

Figure 32: Agricultural use of urine. Photos: L. Dagerskog.

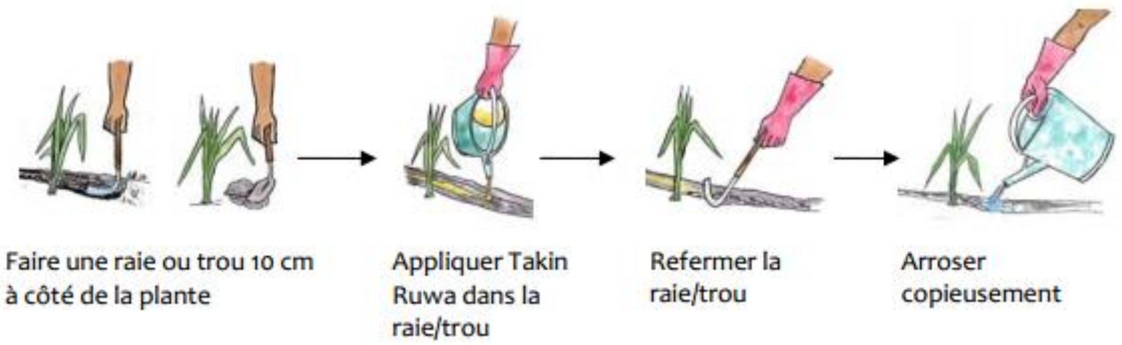

Figure 33: Urine use in crop production, guidelines developed for Niger[59].

Organization

Roles and responsibilities

The roles and responsibilities once the toilets were installed are straightforward for the Aguié province project: the households are responsible for their toilets, for treatment, transportation and reuse.

Economy

The costs are summarized in Figure 34. The toilets are very low-cost. The project contributed with a subvention of USD 45 per toilet for the slab and the vent pipe, and the household contributed with local material and labor. The jerry can-based urinals cost USD 3. Large-scale storage, to maximize the fertilizing value of the urine in the absence of a water source for vegetable farming during the dry season would present an additional cost. In the case of Aguié the lack of storage capacity was dealt with by incorporating the urine in the traditional compost process during the dry season.

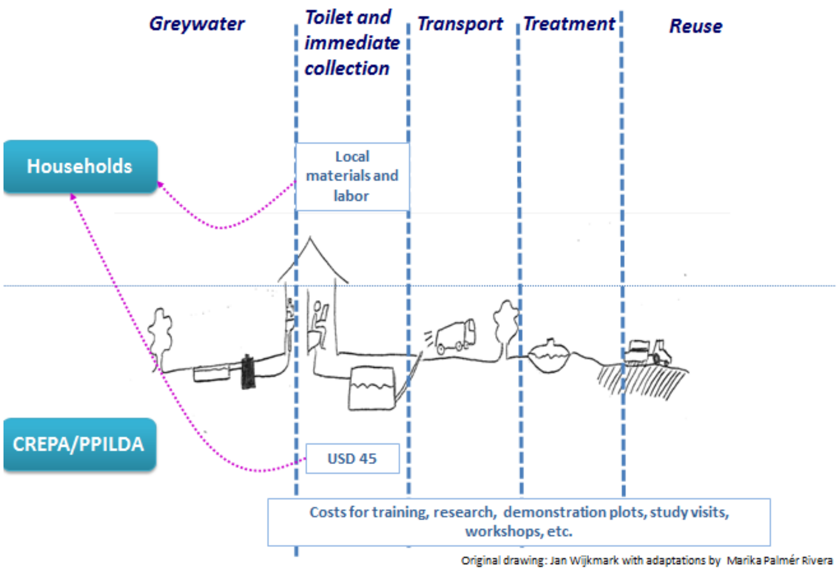

Figure 34: The costs for Aguié

Conclusions and lessons learned

The cooperation between sanitation and agricultural actors in the Aguié province project has been very successful, showing the power of combining two crucial messages in relation to human excreta:

59 http://www.ecosanres.org/aguie/documents/FicheTechniqueApplicationUrine-BARAGE.pdf

its dangers and its resources. The PHAST/SARAR methodology, adapted to also include elements on agricultural reuse, together with participatory cultivation experiments, tasting evaluations, study visits between villages, collaboration with Burkinabè actors, clearly differentiating between untreated urine and feces and liquid and solid fertilizers, and working within existing practices and beliefs worked as approach to convey the dangers and the resources messages of human excreta.

The toilets, albeit their low cost and simple appearance, are highly appreciated by villagers who emphasize the comfort, dignity and pride of having access to a toilet. Also, the collection of urine on household level has reduced the nuisance of urine odor in the traditional shower and ablution area, something especially the women appreciate.

The Aguié approach helps maximize the use of locally available fertilizing resources in a context where chemical fertilizers often are out of reach for the farmers and the approach thus contributes to an improved food security to marginalized populations. Similar projects to Aguié are currently implemented in several regions/districts of Niger.

Further reading on Aguié:

- Dagerskog, L. 2010. Productive sanitation in Aguié, Niger – Testing a nutrient recycling system with a view to measure its potential for improving agricultural productivity. Technical Advisory Note to IFAD, downloadable at http://www.ecosanres.org/aguie/documents/TAN%20Niger%20Aguie%20Prod%20Sanitation%20CREPA%201049%20(4).pdf
- Project web page: http://www.ecosanres.org/aguie/
- Short films on the Aguié project: http://www.ecosanres.org/aguie/films-en.htm
- Guidelines for Mayors: http://www.ecosanres.org/aguie/documents/GuideDesMairesNiger.pdf
- Factsheets and FAQs: http://www.ecosanres.org/aguie/factsheets.htm

Contacts for more information on Aguié:

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2.2.3 Hölö, Sweden

Hölö is located in Södertälje[60] municipality and it is a low population-density, country-side area where the inhabitants rely on on-site sanitation since centralized collection and treatment is not financially viable. Hölö has two of the most eutrophic lakes in Sweden, Lillsjön and Kyrksjön, within its boundaries. The situation was so severe that no building permits were issued in Hölö for a long time, since the lakes cannot manage any more nutrient-rich effluent from more on-site sanitation systems. Thus, the eutrophication problem hindered the social, demographic and economic

[60] Södertälje municipality is located just south of Stockholm and has about 85000 inhabitants.

development in this rural area, strategically located close to both Södertälje, Stockholm and other towns.

In order to reduce the eutrophication and also to allow for new building permits and more sustainable recycling of nutrients in wastewater the utility Telge Nät, Södertälje Municipality, the Federation of Swedish Farmers and the Swedish University of Agricultural Sciences, among others, together developed a recycling policy (see Box B), knowledge and a new concept based on (i) concentrated blackwater collection in holding tanks, (ii) a treatment plant applying heat and urea addition to black water as a sanitization method and (iii) reuse of the hence produced liquid fertilizer in agriculture.

The cooperation is unique in its kind, including the municipality, the utility and the Federation of Swedish Farmers, where the latter has taken a strong stance embracing the blackwater technology and the resulting liquid fertilizers as very important steps towards a sustainable management of plant nutrients.

Box B – The Recycling Policy of Södertälje Municipality

The recycling policy of Södertälje municipality was approved in 2010 and it stipulates that in the case of upgrading of existing on-site systems in Södertälje, or constructing for new houses the first choice of sanitation technology shall be a vacuum toilet, or other low-flush solution (max 0.6L per flush), that is connected to a water-tight holding tank, since this system is the best in terms of meeting environmental objectives and avoiding eutrophication.

Source: Södertälje Municipality.

An inventory of existing on-site systems in Hölö showed that 40% of the investigated systems were outdated. About 30% of the households with non-functional on-site systems have to date applied for permits, under the new policy, to replace their existing systems with blackwater systems. New building permits are once more issued for the area.

Technical system design

A schematic picture of the Hölö technical system and the roles and responsibilities is shown in Figure 35. The *blackwater systems on household level* can be either of the type very low-flush (max 0.6L/flush) or vacuum systems. Households that are about to upgrade their on-site system or will apply for building permits can try out different types of blackwater systems at a demonstration center at a school in Hölö before making their decision. The households can also visit the website http://avloppsguiden.se/ which is a national knowledge portal for on-site sanitation for households, authorities and the sector in general. The site is financed through membership arrangement of municipalities and 214 of Sweden's 290 municipalities are members of the portal.

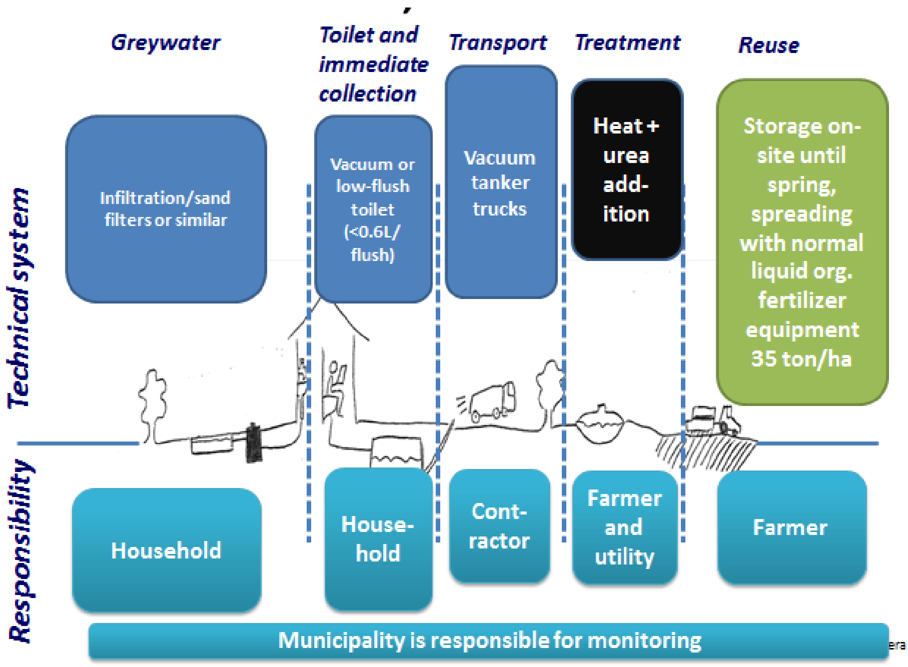

Figure 35: PPT schematic overview of the technical system in Hölö and who is responsible for what.

The liquid compost reactor is fed by blackwater collected from household holding and septic tanks and the effluent from this process is returned to agricultural land.

The blackwater treatment plant is dimensioned to receive blackwater from 500-700 household holding tanks. Today, one year after its inauguration by the Swedish Minister of the Environment, Lena Ek (Figure 36), it is not yet working at its maximum capacity.

The tanker trucks discharge the blackwater into primary storage tanks (two storage tanks of 200 m^3 each). From these the blackwater is fed into the reactor (two in parallel, 32 m^3 each) where it is subjected to an increased temperature under aerobic condition in combination with urea addition, which allows for sanitization of the blackwater. After completion of the treatment cycle the sanitized blackwater is released to a final storage tank (1,500 m^3), where it is stored until it is reused as a liquid fertilizer during the growing season.

The liquid compost reactor is operated by the farmer who will reuse the liquid fertilizer on his fields. He has a 5 year contract with Telge Nät, the utility, to operate the liquid compost reactor.

Figure 36: Inauguration in August 2012 of the Hölö blackwater treatment plant by the Swedish Minister of Environment, Lena Ek the final storage tank, and the farmer, Jan-Christer Carlsson. Photos: E. Kvarnström and K.A. Reimer.

Reuse

The liquid fertilizer produced from the blackwater at the treatment plant in Hölö meets the newly developed Swedish certification standards for wastewater fractions for reuse from on-site and smaller wastewater treatment systems[61], a "light version" of the certification that exists for sewage sludge that is intended for agricultural reuse. A brief summary of the certification system is shown in Box C. Initial quality tests showed too high Cu values, which has been corrected by exchanging some brass faucets at the treatment plant.

The farmer who will use liquid fertilizer, Jan-Christer Carlsson, has been awarded the title "The Best Swedish Baltic Sea Farmer of 2013" by the Swedish chapter of World Wildlife Fund[62] for his long-standing environmental work with protective zones around the watercourses to reduce nutrient leaching and especially for his engagement in nutrient recycling by being closely involved in the operation in the treatment plant and the use of liquid fertilizer on his fields. His farm has 290 ha cropland, 80 ha of forest and 10 ha of pasture land. The farm has about 65 cows, about the same number of young stock and a varying number of calves. Jan-Christer Carlsson's farm produces milk and he grows ley and corn used in the milk production and also cereals, which are sold. The liquid fertilizer will be used first time during the spring 2014, and it will be spread on wheat.

[61] http://www.sp.se/sv/units/certification/product/Documents/SPCR/SPCR%20178.pdf
[62] http://www.wwf.se/press/pressrum/pressmeddelanden/1528666-rets-bsta-svenska-stersjbonde-utsedd

Box C: Certification standards for wastewater fractions from on-site and small wastewater systems.

SP Technical Research Institute of Sweden manages a certification system for wastewater fractions from on-site and small (<50 pe) wastewater systems. The wastewater fraction must be interesting from a fertilizer perspective, such as *urine*, *blackwater* and *fecal sludge from dry toilets.* Septic tank sludge, with its comparatively low content of nutrients not included in this certification. *P-precipitated sludge* from decentralized wastewater treatment plants, with a max of 50 pe connected, can also be certified through this system. Another fraction that falls under this certification is *P-saturated filter bed material* from on-site sanitation systems.

An approved certification allows the producer of the ”fertilizer” to use the SP label below.

Traceability from wastewater fraction origin to the field where it is used, quality control, routines for sampling, and self-monitoring are the cornerstones of the certification process, and all treatment and transport has to be done so that the quality of the “fertilizer” is not impaired.

All wastewater fractions, except urine, need to be subject to a sanitization process to reduce Enterococci<1000/g TS, Salmonella<0/25 g wet weight, and E.coli<1000/g TS:

- Thermal treatment (80°C during 10 min)
- Pasteurization (70°C during 60 min)
- Thermophilic aerobic or anaerobic treatment (from 52°C during 10 hr to 60°C under 2.5 hr)
- Lime treatment (pH 12 plus 55°C under 2 hr)

Other methods, as urea treatment, can also be accepted as long as the hygienic standards outlined above are achieved. The wastewater fractions can, after sanitization, be used for cereals and other crops that go through a processing stage before consumption.

Urine sanitization is achieved through storage as long as the N concentration is at least 1g/L and pH 8.8. Different storage temperatures gives different storage times for different crops. After 1 year of undisturbed storage urine is allowed as a fertilizer to all crops.

The producer has to sample the “fertilizer” once it has been sanitized and label the shipments with parameters below, including a recommended dose per hectare, based on the analyses results.

Parameter	**Requirement**
pH	Needs to be declared
Salmonella	Need to be negative
BOD_7	Needs to be declared
Tot-P	Needs to be declared
Tot-N	Needs to be declared
Cd/P	Max 25 mg Cd/kg P. After 2020 max 17 mg Cd/kg P
Pb	Max 25 g/ha,yr
Cd	Max 0.75g/ha,yr
Hg	Max 1.5 g/ha,yr
Cu	Max 300 g/ha,yr
Cr	Max 40 g/ha,yr
Ni	Max 50 g/ha,yr
Zn	Max 600 g/ha,yr

The producer also has a responsibility to inform the households that a fertilizer is produced from their wastewater fraction and to educate them on what can be flushed/not flushed down the toilets. For a blackwater collection systems it is important that e.g. water from floor mopping does NOT go into the toilet bowl.

Organization

Roles, responsibilities and economy

The roles and responsibilities for the Hölö system are outlined in Figure 35. The municipality has the overall responsibility of monitoring of the system as it has for any sanitation system. Contractors are used for emptying the blackwater holding tanks. The treatment plant is operated by the utility, Telge Nät, in cooperation with the farmer. The farmer is responsible for the reuse. Cost-wise the households are paying for emptying services, as for any on-site system. Blackwater collection systems on household level are financed by the households themselves with the possibility of obtaining a small grant from national funds. An upgrade/change to a vacuum system or other extreme low-flush alternatives costs from about USD 8,000 and upwards. The households also pay for the emptying of the systems, as they would for any on-site system (USD 170 per emptying). The blackwater treatment unit cost USD 1.25 million, which is considerably cheaper than the alternative which was to expand the sewer network into a very rural area. The utility, Telge Nät, received national funds and loans to finance the blackwater treatment unit.

Conclusions and lessons learned

In the case of Hölö, the utility, Telge Nät, thinks that the project is a success since it will contribute to reduced eutrophication of lakes and the sea in a less costly manner than expansion of the centralized sewer system (main initial motivator), it opens up for new building permits in a countryside setting close to Stockholm and other cities around, it has spurred technical development of blackwater treatment which is now patented with Telge Nät, and the process produces a certified liquid fertilizer desired by farmers and which can be spread with conventional farming equipment. An interesting entrepreneurial arrangement between utility and farmer is another result from this project.

Agricultural reuse from wastewater flowstreams is a complex matter, since it involves not only technical and institutional complications compared to the conventional wastewater system the legislation and institutions are all formed for but it is also has to confront emotional challenges. To tackle the technical and institutional complications it is important to work cross-sectional with, in the case of Sweden, both local politicians, the utility, and the involved municipal departments (technical, environmental, planning) together with the farming community and, if need be, with researchers, to make all pull in the same direction. Emotional challenges, the “yuck factor”, has to be handled carefully with facts, information, education, and communication and it is important to understand that it takes time.

Trust between the involved stakeholders is a crucial factor, which also takes time and commitment to develop and nurture. The certification system, developed in cooperation with the Hölö project, is a mean to keep trust going for systems that are recycling different wastewater flowstreams. The key actor in nutrient reuse is the farmer, therefore a strong relationship with the farmer community is absolutely essential.

Further reading on Hölö:

- Certification document for wastewater fractions from on-site sanitation systems (in Swedish with an English abstract): http://www.sp.se/sv/units/certification/product/Documents/SPCR/SPCR%20178.pdf

Contacts for more information on Hölö

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- Karl-Axel Reimer, Director at the Department of Environment at Södertälje Municipality: karl-axel.reimer@sodertalje.se.

2.2.4 San Miguel Suchixtepec, Oaxaca, Mexico

El trabajo realizado en estas 2 escuelas estuvo dentro del Programa Agua, Saneamiento e higiene más impacto en comunidad (SWASH+) en la Sierra Sur de Oaxaca. Este proyecto fue ejecutado con fondos de Global Water Challenge (GWC, provenientes de Fundación Coca Cola Atlanta), operado por Sarar Transformación y en alianza con el Wild Life Fund, WWF México).

El Programa Swasw+ se implementó en la Sierra sur de Oaxaca en 17 escuelas de 3 cabeceras municipales las cuales además de ser consideradas como zonas de alta marginalidad, forman parte de la Cuenca Copalita que drena hacia el Oceano Pacífico. Dicha Cuenca además de estar muy bien conservada y contar con una biodiversidad muy grande, abastece de agua al complejo turístico Bahias de Huatulco, uno de los principales complejos de playa turísticos en México.

Casi todas las escuelas en las que operó el programa, se contaba con red local de abastecimiento de agua y sistemas de saneamiento con arrastre de agua y fosa séptica. Sin embargo durante varios meses del año las escuelas no contaban con agua para usos esenciales ni con saneamiento. Esto debido a que durante la estación de secas (entre los meses febrero a mayo o junio, dependiendo de cuando inicia la época de lluvia), el suministro de agua de la red se interrumpe, por disminución del flujo de agua en los manantiales.

Otra razón por la que algunos sistemas de saneamiento dejaban de funcionar era cuando se llenaban las fosas sépticas y la escuela no contaba con recursos económicos para pagar un servicio de vaciado de las mismas, además, este tipo de servicios tampoco garantiza la buena disposición de los lodos (se desconoce a donde van).

El Programa SWASH+ tuvo por objetivo dar solución a los problemas de agua y saneamiento en las escuelas además de impulsar el lavado de manos con agua y jabón. Las soluciones propuestas buscaron la sostenibilidad en la intervención, incluyendo esto el aspecto social, la salud, el cuidado al medio ambiente y del agua. El Programa consideró la participación de diferentes actores en la comunidad y a nivel escolar trabajó con miembros de la comunidad escolar (directivos, maestros, padres y madres de familia, intendentes y estudiantes) en aspectos de sensibilización y capacitación, utilizando la Metodología Participativa SARAR. Las tecnologías propuestos para dar solución a la carencia de agua y saneamiento fueron sanitarios secos desviadores de orina (UDDT), sanitarios de huerto (Arbor Loo/fosas alternas) con cierre de ciclo de nutrientes en la misma escuela o en las cercanías, filtros para aguas jabonosas, sistemas de captación de agua de lluvias y filtro potabilizadores. Una vez construidos los sistemas se realizaron capacitaciones de uso y mantenimiento y de manejo y uso seguro de excreta (de acuerdo a los lineamientos de manejo y uso seguro de excretas en la agricultura de OMS, WHO Guidelines), para el cierre de ciclo de nutrientes.

En uno de los municipios, San Miguel Suchixtepec, ya existían sanitarios secos desviadores de orina construidos por WWF en 3 de las escuelas. El programa SWASH+ fortaleció estas experiencias y amplió la cobertura al resto de las escuelas de la comunidad. Una de las escuelas que ya contaba con UDDT era la Secundaria Técnica 131 y fueron tan buenos los resultados que se construyó un nuevo módulo de UDDT, una zona de acopio de orina, una de acopio de heces (poposteros), filtros para las aguas jabonosas, filtro potabilizador y captación de agua de lluvia. Esta escuela es un ejemplo en manejo de agua y saneamiento para toda la región.

A continuación se describe la experiencia en cierre de ciclo de nutrientes en 2 de las escuelas de San Miguel Suchixtepec, la de Secundaria Técnica 131 (con 262 alumnos) y la Primaria Hidalgo (con 273 alumnos) por ser un sistema de saneamiento distinto: fosas alternas

Technical system design

2 tipos de Sanitarios secos ecológicos fueron instalados, sanitarios secos desviadores de orina (con taza o con asiento desviador) y Fosas alternas. La decisión en la construcción de uno u otro sistema fue tomada por los comités de padres de familia, la dirección de la escuela y algunos maestros. Para esto se llevaron a cabo actividades de sensibilización en torno a agua y saneamiento y la presentación de las diferentes opciones tecnológicas.

Solución de saneamiento con UDDT

Son sanitarios de 1 cámara con un contenedor plástico de 50 lts para colectar las heces y un contenedor externo (“poposteros”), para el tratamiento de las mismas. El tratamiento de las heces en el “popostero” se lleva a cabo mediante tiempo de reposo, 2 años o más, como forma de disminuir riesgos sanitarios. El acopio de orina se lleva a cabo en un espacio debajo del sanitario en contenedores de 20 lts (si el volumen es poco) o bien en contenedores de 1,100 lts en un área aledaña al sanitario en donde se lleva a cabo el acopio y tratamiento (mediante 3.3 meses de tiempo de reposo).

Figure 37: Módulos de UDDT, Secundaria 131 y Bachillerato, San Miguel Suchixtepec, Oaxaca

Manejo de heces.

Cada viernes se vacían los contendores plásticos de 50 lts que se encuentran en las cámaras bajo el sanitario, de esta manera los sanitarios quedan listos para el inicio de semana el día lunes. Los contenedores de 50 lts se vacían en un contenedor externo, el “popostero”. Los poposteros NO compostean el material, solo lo contienen.

Los “poposteros” se encuentran divididos de manera tal que cada compartimento tarda entre 3-4 meses en llenarse, una vez que se llena uno, se comienza el llenado del siguiente y así sucesivamente. Este sistema permite que la heces provenientes del sanitario reposen por un periodo de 2 años o un poco más. La implementación de poposteros en las escuelas facilita el vaciado del material de las cámaras y permite la disminución de riesgos sanitarios antes del reuso del material.

Figure 38: Popostero Sec undaria Técnica 131, San Miguel Suchixtepec. área superior y parte trasera por donde se vacían las heces una vez reposadas

Popostero Bachillerato, IEBO 99, San Miguel Suchixtepec

Figure 39: Zona de tratamiento de heces , “poposteros”, permite un vaciado rápido de los contenedores bajo el sanitario y el reposo del material por 2 años o más.

Manejo de la orina

Figure 40: Zona de acopio de orina en contenedores de 1,100 lts.

Bateria de 5 contenedores, cada contenedor se llena en un mes. Una vez que se llena uno se comienza a llenar el siguiente y así sucesivamente, de esta manera mientras se llena uno reposa la orina de los otros. Este sistema permite alcanzar un tiempo de reposo de 3.3 meses.

Reuse

La estrategia general para el cierre de ciclo de nutrientes fué capacitar a la comunidad escolar en el uso de la orina y heces como fertilizante, para ello se llevaron actividades prácticas dentro del perímetro de la escuela con maestros, padres de familia, alumnos y personal dentro de la escuela , dependiendo del nivel escolar, se involucró más o menos a los alumnos. También se estableció un vínculo con algunos productores forestales.

En la Secundaria Técnica 131 en San Miguel Suchixtepec (Sec Téc 131) cada grado escolar cuenta con un jardín (cercado) que los alumnos tiene que plantar y cuidar. Después de la capacitación en el uso de orina y heces, la escuela decidió que cada jardín reciba aplicación de orina una vez por mes. Esta aplicación la llevan a cabo los alumnos con el apoyo del maestro titular y el intendente de la escuela. De esta manera los alumnos aprenden el valor de la orina como fertilizante y cómo aplicarla.

Sin embargo la escuela no cuenta con suficiente espacio (área) para todo el volumen de orina que se acopia, por lo que se canalizó la orina a un vivero forestal, para la fertilización de las plántulas de pino. El procedimiento era el siguiente: el productor iba a la escuela por la orina, con una camioneta que tenía en la parte trasera un contenedor de 450. La orina ya reposada era vaciada por medio de una manguera al contenedor de la camioneta, esto se hacía por gravedad. Posteriormente la orina era transportada al vivero forestal y por gravedad, mediante manguera se aplicaba sobre las plántulas de pino. La aplicación se hacía sin diluir la orina y posterior a la aplicación, se regaban todas las plántulas de pino con agua.

Figure 41: Transporte de la orina, aplicación de orina, Vivero forestal.

Este sistema funcionó muy bien hasta que las condiciones del camino hacia el vivero empeoraron, debido a las lluvias y ya no fue posible trasladar la orina. Posteriormente se descompuso la camioneta de los productores y se volvió a parar la actividad. Ya que la escuela necesitaba vaciar los contenedores de orina, fué necesario como medida provisional, hacer una zanja larga y poco profunda para la infiltración de la orina en el suelo.

En cuanto al manejo de heces, una vez que habían alcanzado 2 años 3 meses de reposo, se envió una muestra representativa del material al laboratorio. Los resultados fueron negativos a la presencia de parásitos y patógenos. La dirección de la escuela decidió que se utilizara el material para la siembre de árboles forestales y para el mejoramiento del suelo de los jardines. En esta actividad, se aflojó previamente el suelo, se aplicó el material, se agregaron 10 cm de tierra encima y finalmente se cubrió con hojas. La aplicación de heces fue llevada realizada por toda la comunidad escolar, una vez realizada una capacitación de los riesgos sanitarios que representa el manejo de heces y la importancia del uso de equipo de protección y del comportamiento higiénico en del manejo. Posterior a esta práctica, algunos productores de manzanas han solicitado este material para abonar sus huertos.

Solución de saneamiento con Fosas Alternas (sanitarios de huerto con triple fosa)

Son sanitarios de composteros con una fosa poco profunda (1 mt), en ellos la orina, las heces y el papel caen dentro de la fosa. Este tipo de sanitario fue implementado en una Escuela Primaria que no contaba con sanitarios debido a que la fosa séptica estaba llena y no contaban con recursos para vaciarla 3 veces al año, que era la velocidad de llenado de la misma. El Programa SWASH+ construyó 3 casetas sanitarias. Una para 1º y 2 º, otra para 3 º y 4 º y otra para 5 º y 6 º grado de primaria. Posteriormente los padres de familia replicaron los sistemas y construyeron otras 3 casetas con sus respectivas fosas y un área de mingitorios secos para hombres (con apoyo e WWF).

El funcionamiento de este sanitario es que cada vez que se utiliza, es necesario agregar aproximadamente una taza de tierra cernida encima de la excreta, una vez al mes se agregan hojas en la fosa. La recomendación para la escuela fue dar mantenimiento continuo de la fosa (1 o 2 veces a la semana), esto es, meter un palo largo por la taza, remover el material abajo y volver a cubrir con tierra. Cuando la fosa se encontraba a 30 cm de la superficie, era necesario cambiar la caseta a la siguiente fosa.

Figure 42: Casetas de fosa Alterna construidas en la Primaria Hidalgo.

Durante la estación de lluvias los padres de familia cambiaron el material de cobertura por aserrín, ya que no había tierra seca en el entorno. Algunos padres de familia tenían hijos en la Secundaria 131 y decidieron agregar ceniza junto con el aserrín.

Este tipo de sanitarios permitió solucionar la falta de sanitarios en la escuela, además de ser bien recibido por la comunidad escolar, sin embargo fue necesario dar un seguimiento muy cercano al mantenimiento de los mismo, ya que eran los padres de familia los encargados de la limpieza y al comienzo no se aseaban seguido.

A finales del 2011, se empezaron a construir unos nuevos sanitarios de agua en la escuela a través de un fondo de gobierno que llegó a la comunidad para este fin.

Reuse

Al año de uso las tres fosas se encontraban llenas. Para el manejo de excretas se trabajó con el Comité de Padres de familia y se les solicitó que trajeran árboles frutales que quisieran sembrar en la escuela. Previo al vaciado de la primera fosa, se realizó una capacitación en torno a las propiedades nutrimentales de las excretas y cómo manejarlas y usarlas para que no evitar riesgos a la salud. Después de la capacitación teórica se procedió a la práctica. Durante la práctica quienes estuvieron en contacto con las excretas utilizaron equipo de protección personal y posteriormente a la práctica se realizó el lavado de manos con agua y jabón.

La posibilidad de utilizar el contenido de las fosas como abono para la siembra de árboles entusiasmó mucho al comité de padres de familia. Sin embargo como era fin del año escolar el comité capacitado terminó sus labores y aunque se les solicitó que capacitaran al nuevo comité, esto no ocurrió, por lo que fue necesario volver a realizar un taller con el comité de padres entrante, pero sin la práctica.

Figure 43: Vaciado de una Fosa Alterna y plantación de árbol de aguacate.

Conclusions and lessons learned

Es de vital importancia considerar mayor número de actividades y recursos económicos encaminados al cierre de ciclo de nutrientes, tales como talleres y pruebas de campo con productores, investigación, apoyo económico para la logística de transporte, almacenamiento y seguimiento.

El enfoque de manejo de flujos enfocado en la escuela (HH centre approach), es una estrategia que pone la solución en los usuarios del sistema y da la solución en el mismo lugar, sin embargo en instituciones que cuentan con muchos usuarios y poco territorio (superficie), es necesario tener un alcance fuera de la misma y es cuando se requiere de el vínculo con agricultores locales.

El uso de la orina en el vivero forestal tiene un alto potencial para lograr el cierre de ciclo de nutrientes, pero se requiere de más investigación en cuanto a dosis y modos de aplicación y mayores recursos económicos que apoyen la actividad.

El uso de Fosas alternas en escuelas es una buena alternativa como sistema de saneamiento y cierre de ciclo a través de la plantación forestal. Sin embargo se requiere de un tiempo de seguimiento que garantice la transferencia de la información de un comité al siguiente. Aunque el Programa SWASH+ finalizó en el 2012, quedó conocimiento en la comunidad y gente capacitada para poder dar el seguimiento.

En cuanto a la sobreposición de proyectos, la construcción de nuevos sanitarios de agua y una fosa séptica de mayor capacidad en la Escuela Primaria Hidalgo, por parte del gobierno, fue muy bien recibida por la nueva dirección de la escuela sin tener conocimiento de los problemas vividos con este sistema en ciclos escolares anteriores. Este tipo de programas de gobierno, que cuestan mucho dinero y que no se sustentan sobre un estudio previo, en ocasiones echan abajo proyectos valiosos emprendidos por las organizaciones civiles.

En la implementación de proyectos de saneamiento ecológico en escuelas se tiene varios retos:

Lograr que el trabajo realizado no se pierda con los cambios de maestros y directores, cambios de los comités de padres de familia, cambios de autoridades municipales.

Lograr que los resultados alcanzados no se pierda al término del Programa, por falta de un periodo mayor de tiempo de seguimiento y monitoreo, dada la continua rotación de personal escolar y Comités de Padres de familia.

En general en las escuelas existe una alta participación de los comités de Padres y madres y muchos padres de familia quieren replicar en sus casas los sistemas de las escuelas.

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2.3 Context 3 – Within an existing wastewater jurisdiction with centralized treatment available

2.3.1 Kullön, Sweden

The residential area Kullön is located on an island in the coastal municipality of Vaxholm, about 50 km north of Stockholm. The area is comprised of 250 houses, is beautifully located and has attracted mainly young, well-educated families with children. The first inhabitants moved in during 2000. Kullön is an area of Vaxholm with high environmental ambitions, and in fact, without the high environmental ambition the residential housing development would never have been allowed in the first place on the island. The most thorough and attention-drawing environmental feature is the sanitation system with its combination of double-flush urine diversion toilets, with separate collection of urine in tanks, and tertiary treatment for the remaining wastewater fractions.

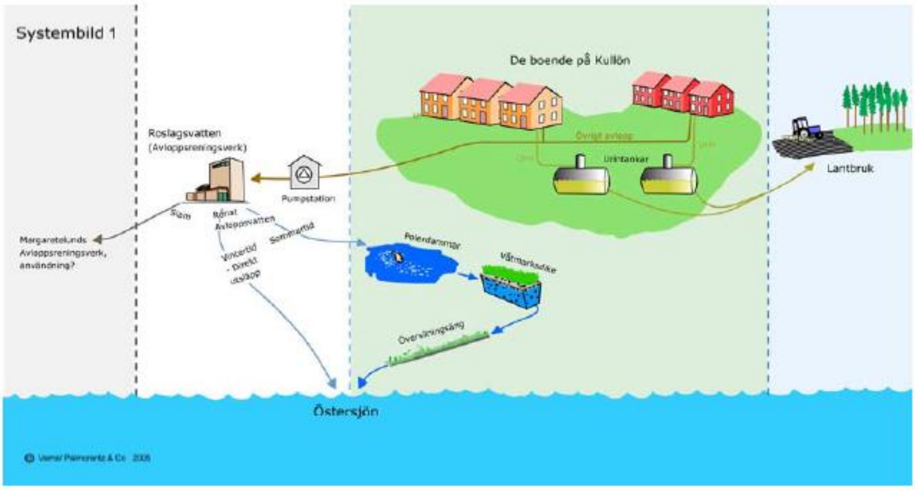

Figure 44: The sanitation system of Kullön.

Figure 45: Kullön residential area. Photo: Anna Richert

Technical system design

Urine is diverted through specially designed flush toilets that divert the urine from the solid parts of the toilet waste. The urine is flushed with a small amount of water and is conveyed in pipes to a collection tank on neighbourhood level. This technology makes it possible to reduce the inflow of nutrients to the wastewater treatment plant with more than 50% of the phosphorous and 80% of the nitrogen.

The treatment plant in the area provides tertiary treatment for the remaining wastewater from the area. The effluent is passing through a polishing pond and wetland ditch before reaching the Baltic Sea during summer and directly discharged during the winter. Given that the treatment plant is receiving a low load of nutrients all year around, the system meets very high effluent standards also during the winter.

Reuse

Reuse of the urine did not happen until almost ten years after the first houses were inhabited, see below under Organization. Since 2008, the urine collected from Kullön is stored on-farm at a farm in a neighboring municipality, where it is used for production of seeds and fodder.

Figure 46: Mr Christian Virgin, the farmer reusing the urine from Kullön. Photo: M. Johansson.

Organization

Roles, responsibilities and economy

The roles and responsibilities have been the largest challenge for the Kullön project[63]. The technical system performs better than the average of Vaxholm municipality, and the Kullön inhabitants contribute to less discharge of nutrients to the Baltic Sea compared to the average Vaxholm inhabitant. The technical system is, naturally, also connected to higher costs, given that urine is diverted and collected separately alongside the tertiary treatment of the remaining wastewater fractions. During the planning phase, the municipality of Vaxholm tried to shift the responsibility of the wastewater system on the future house owners, which is in violation of the Swedish law in terms of both waste collection[64] and wastewater treatment. The lack of municipal engagement and the understandable unwillingness from the Kullön inhabitants to pay a higher wastewater tariff (which is what the municipality wanted) when their system would pose less of an environmental burden to the Baltic Sea led to that the urine actually was NOT collected for years, but instead overflowed to the

[63] For an in-depth look at the twists and turns on the responsibilities in Kullön, check Annex 2 in Sustainable Water Management in the City in of the Future, downloadable at: http://www.switchurbanwater.eu/outputs/pdfs/W6-1_GEN_MAN_D6.1.4_Conflict_resolution_-_Training_manual.pdf

[64] Diverted urine is classified as a solid waste fraction in Swedish law (clarified by the Swedish EPA in the mid-2000) and therefore it is mandatory for a municipality to collect and treat it.

wastewater treatment plant, in spite of all the infrastructure being in place. Push from national actors, the engagement from the housing company, clarification of the fact that diverted urine is classified as a solid waste fraction and thus a municipal responsibility for collection and treatment finally made the Vaxholm municipality take responsibility for the collection and for organizing the reuse of the urine. In 2006 the municipality charged the local utility, Roslagsvatten, with the task to also handle the urine under their operations, a task reluctantly taken on by the utility. The technical and institutional setup of the reuse system, under the utility's operations, was ready by spring 2008 and a tendering process identified a farmer in a neighboring municipality who was interested to reuse the urine for crop production. The farmer receives 10 €/m^3 for covering the extra costs of storage and emptying. The on-farm storage was constructed with national funds from Swedish EPA which the utility applied for.

Lessons learned from Kullön

Kullön is a clear example of where all infrastructures can be in place and working but without the right institutional set-up and the right actors taking responsibility the technical system will not be used. It is also an example of where a more expensive but also better performing system in terms of effluent standard initially was going to be covered by the Kullön inhabitants with a higher Kullön tariff, all in the municipality's strife to keep the municipality's general water tariff low and competitive, which for good reasons did not go down well with the Kullön inhabitants who rightly argued that their somewhat costlier system with its higher performance should be cost-covered through a slight raise of the overall water tariff. It is thus very easy to make a functional system fail by de-incentives and by having it institutionally not organized in the most optimal way. Almost 10 years after the first people moved to Kullön the reuse system is finally up and running, under the utility, Roslagsvatten, which has both the mandate and the skills to manage it.

Further reading:

- Kvarnström, E., Emilsson, K., Richert Stintzing, A., Johansson, M., Jönsson, H., af Petersens, E., Schönning, C., Christensen, J., Hellström, D., Qvarnström, L., Ridderstolpe, P., Drangert, J.O. 2006. Urine diversion – one step towards sustainable sanitation, downloadable in English, Portuguese, Russian and Spanish at http://www.ecosanres.org/publications.htm
- Annex 2 in Sustainable Water Management in the City in of the Future, downloadable at: http://www.switchurbanwater.eu/outputs/pdfs/W6-1_GEN_MAN_D6.1.4_Conflict_resolution_-_Training_manual.pdf

2.3.2 Sneek, The Netherlands

Sneek is a city in northern Holland, where a new housing estate with 250 houses is under construction. 62 houses are constructed and inhabited so far. Reuse does NOT take place currently from Sneek, but it is still included due to its interesting technical features.

The housing area has a separate blackwater collection system, comprised of vacuum toilets (1L/flush) in the houses and each house/apartment has a kitchen grinder connected to the same pipe as the blackwater. The mixed blackwater/organic waste is conveyed under suction to decentralized vacuum units, from which the mixture is pumped to the treatment plant. Biogas is produced from the mixture, about 11 m^3 CH_4/pe,yr. Dutch legislation currently does not allow for agricultural reuse of the anaerobic digestate, even though it contains less heavy metals than cow manure. The greywater is also conveyed to the treatment plant and treated separately.

The households own the installations in the houses, the municipality owns the pipes, vacuum units and the greywater collection tanks. The Water Board owns the treatment plant.

For more information:

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2.3.3 Sao Paolo, Brazil

Uninove university in Sao Paolo has 22,000 students. In 2007 the university decided to cut their water bills by installing vacuum toilets in their buildings. After the installation the water consumption went from 420,000 L/day to 60,000 L/day, representing a reduction in the daily water bill from USD 1,800 to USD 320. The investment paid off in 15 months due to this dramatic decrease in daily water consumption. Clogging and vandalism was a problem with the previous toilets, where one blockage could put a number of toilets out of order. Blockage incidences have gone down dramatically with the vacuum toilets, to a certain degree explained by the students appreciating the new toilets more than the old ones.

Figure 47: Vacuum toilets at UNINOVE University, Sao Paolo, Brazil[65].

[65] http://standard.jetsgroup.com/en/sanitary-systems/buildings/references/sao-paulo-university.aspx

For more information:

- http://standard.jetsgroup.com/en/sanitary-systems/buildings/references/sao-paulo-university.aspx

2.3.4 Interesting developments in Sweden

Royal Seaport Area in Stockholm, Sweden

The Royal Seaport Area is located within walking distance from central Stockholm and is currently an old port with industries and an oil depot. By 2030 the area will be transformed into a 236 ha sustainable urban district with 35,000 work spaces, 12 000 apartments and a modern harbor. The vision of Stockholm City Council is for the Royal Seaport Area to become a show-stopper for urban development and a place where innovative environmental technologies and creative solutions are to be developed, used and displayed. The City Council has set a number of ambitious targets for the area both for environmental, social and economic sustainability. For the water and wastewater systems, nutrient recycling with nutrients in a form attractive to the farmers is one important target, where separation of different wastewater fractions, or flowstreams, are considered to facilitate a nutrient recycling of high quality nutrients. "Triplicate"[66] centralized sewer systems, with greywater, blackwater and stormwater in separate sewers, are currently under investigation for the area. *The ongoing blackwater investigations* are iooking at vacuum toilets, with vacuum units on each plot (serving the dual purpose of both vacuuming out the blackwater from the building and pumping it into the main blackwater sewer in the street), and main blackwater sewers under pressure with pumping stations.

Two key stakeholders are the farmers receiving the treated effluent as a liquid fertilizer and Stockholm Water Company who would be responsible for a third wastewater fraction or flowstream to handle. The Federation of Swedish Farmers has been very supportive of the idea of blackwater collection, treatment and reuse and embraces the proposed development for the Royal Seaport Area. Stockholm Water Company is cautiously positive and supports the development of a triplicate pilot system as long as potential additional costs will be covered. Decision is awaiting an economic study, where a cost benefit analysis will give an understanding of the overall implications of the suggested technical system.

Other sanitation-related targets are max 100 L/pe,day of water use, stormwater incorporation into the landscaping is one feature, as is adaptation to higher sea levels and energy extraction from organic waste.

[66] Triplicate being the next generation sewage system, after the duplicate.

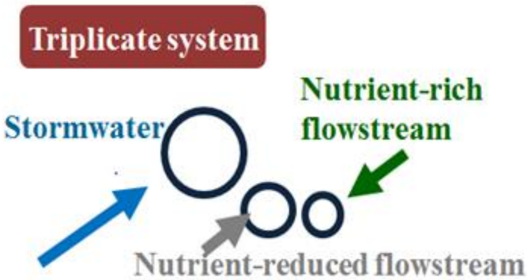

Figure 48: The Royal Seaport Area in Stockholm, shaded in blue, under planning and triplicate sewer system.

For more information:

- Ms Ingmarie Ahlberg, City of Stockholm: Ingmarie.ahlberg@stockholm.se
- Ms Maria Lennartsson, consultant to City of Stockholm: maria.lennartsson@extern.stockholm.se

Helsingborg, Sweden

Helsingborg is located on the South-West coast of Sweden and it is the eighth largest city in Sweden with about 100,000 inhabitants within the city limits. The southern neighborhoods of Helsingborg are struggling somewhat with high unemployment, closing of shops etc. The city council has therefore embarked on a 20 year long urban development project called H+, under which the southern neighborhoods, the harbor and railroad areas will be sustainably developed and also make space for 10,000 new inhabitants.

The project is currently in an intensive preparatory and technical investigation stage where the feasibility, and technical and economic consequences of having three separate waste-flows: (i) blakcwater from toilets, (ii) greywater from shower and laundry, and (iii) organic waste from kitchen grinder-equipped kitchen sink, leaving the houses are investigated for the first two areas to be developed under H+ (600-800 apartments). The reasons for wanting to keep the three flowstreams separate are to keep the recyclable nutrients in blackwater and the organic waste fractions cleaner and more suitable for agricultural reuse and also to optimize treatment efficiency of the different flowstreams in the wastewater treatment plant.

Separate collection in tanks within the area and trucking to the treatment plant of blackwater and the organic waste fraction or centralized conveyance of the fractions to the nearby wastewater treatment plant are two things currently investigated, as is how the extra costs will be covered (within existing tariffs for solid waste and wastewater treatment or through external financing?). The treated fractions will be reused in agriculture. Certification programs for agricultural reuse in Sweden exist both for blackwater (see Box under Hölö) and for organic waste. The zoning consultation is planned for the end of 2013/beginning of 2014, which means that the actual construction can start the earliest by 2015 if there are no delays in the zoning process.

Centralized collection and treatment of three different flowstreams is new. Thus, Lund University, together with the utilities and city councils of Helsingborg, Lund and Malmö have applied for funds from Sweden's Innovation Agency to build test sites to further advance the source-diverting wastewater treatment knowledge in terms of both treatment technologies but also on logistics as transport, in-house technologies, user aspects and institutional implications.

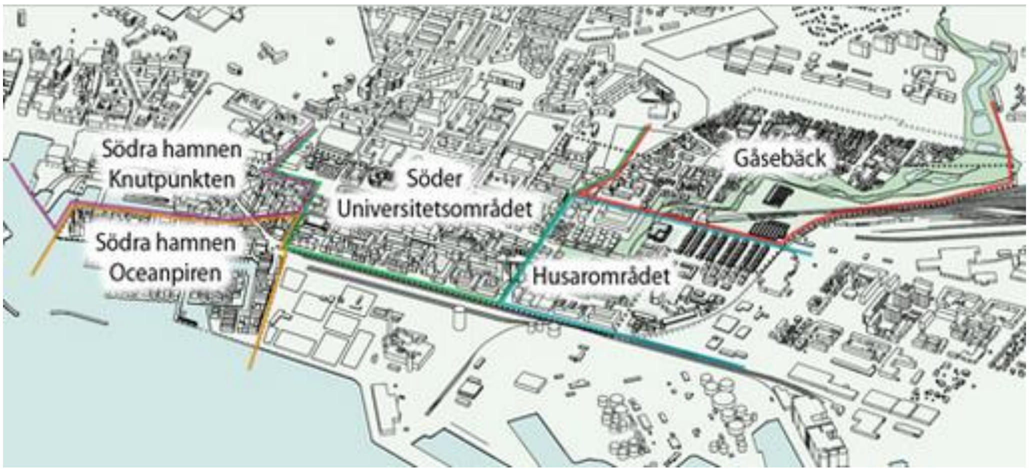

Figure 49: The H+ area. (Source: http://hplus.helsingborg.se/om-hplus/h-omradet-med-delomradet/)

For more information:

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3. Discussion and conclusions

Urine, blackwater and fecal sludge are three different flowstreams with very distinct and different qualities. Using the same logic that has made several cities around the world abandon combined sewers for duplicate ones and the same logic that has made solid waste collection entities in many European countries go for source separation of organic waste, and other fractions such as glass, paper, metal etc. it is of interest to look at separate collection and treatment of the flowstreams. A number of different actors world-wide, acknowledge the different flowstream qualities, and are implementing innovative approaches to sanitation and this report presents some of these innovative projects. The reasons behind adopting a separation of flowstreams are varying between actors and cases from practical and logistical ones, through reduction of eutrophication of lakes and expected tougher effluent requirements, to water conservation and improved food security.

The cases are presented based on three different contexts;

1. On-site sanitation with relatively high population density (peri-urban)
2. On-site sanitation with a relatively low population density (rural)
3. Separate flowstream collection within an existing wastewater jurisdiction (urban)

From the cases presented in the report it can be concluded that *the involvement of the farmer community is key* for any project aiming at nutrient reuse from different flowstreams. For contexts 1 and 3 (and sometimes context 2 too) off-site reuse is necessary for which long-term agreements with farmers are needed to guarantee the functionality of the system. It is moreover important that the products produced are adapted to the needs/demands/equipment of the farmer to the largest degree possible. In the Hölö case, the farmers' demands on the end product (no mixing with greywater, sanitized product, certified product) strongly influenced policy decisions within the municipality and the subsequently developed blackwater collection and treatment system. The Aguié province case in Niger shows how rural sanitation improvements can be achieved through a strong cooperation with the agricultural sector, which usually has a stronger profile in many developing countries compared to the sanitation sector. In the case of Niger, where the systems produce earlier unknown wastewater flowstreams such as human urine, the cooperation with farmers for participatory demonstration of crop cultivation is of utmost importance.

The importance of *working through the entity in charge of sanitation services* is especially clear for contexts 1 and 3, for which there usually is a utility or equivalent in charge of service delivery. Water utilities in general have long-standing experiences of service delivery and highly skilled technical staff used to solve technical and logistical problems. With a *visionary leadership* as in eThekwini Water and Sanitation in Durban, when service delivery is sought for all citizens, and where engineering and service delivery skills are used irrespective of whether the systems are on-site or centralized, professional and robust service delivery, innovation and development happen also for on-site sanitation systems. eThekwini Water and Sanitation has not only incorporated and fully embraced on-site service delivery among its business areas but is also pushing the technical innovation forward within the field of on-site and dry sanitation systems together with its strategic research partners[67]. Hölö in Sweden is another example of the powerful changes and innovation that are possible when a professional utility steps in and applies its technical and logistical knowledge to a new wastewater flowstream.

Another important feature of a utility in charge of all sanitation service delivery within a jurisdiction is that the often unfair and against-poor subsidies on centralized sewer systems become clearer and a more equitable utility budgeting between sets of customers can be made.

The systems presented from Bolivia and Burkina Faso are not relying on professional utility involvement at the moment. In Ouagadougou there is a municipal engagement into the system's operation, with a budget line for support to keep it going but ONEA, the utility in charge, is not engaged. Both the Bolivian and Burkinabè systems are therefore institutionally more vulnerable, and it is unclear how they will survive in the future unless firmly embedded into the utilities/entities

[67] See e.g. http://www.eawag.ch/forschung/eng/gruppen/vuna/index_EN and http://www.irc.nl/docsearch/title/180877.

delivering sanitation services in El Alto and Ouagadougou and unless they are subject to the same type of subsidies that the centralized systems in Ouagadougou and El Alto are receiving.

Legislation and institutions are normally not organized today for separate collection, treatment and reuse of different flowstreams, so a strong *cross-sectoral work within the municipality* or other entity responsible for the service delivery, physical planning and monitoring is necessary, since the collection and reuse of e.g. urine or blackwater will inevitably run into institutional unclarities, legislative question marks and responsibility confusion within many different municipal departments. This has been the experience for a number of Swedish municipalities and it is highlighted e.g. by the Hölö case. In Hölö the municipal technical and environmental department worked closely together both with the utility and to a certain extent with the planning department to achieve the blackwater reuse system for Hölö, all the while running into logistical/policy/legislative/responsibility issues.

Trust is another important key for nutrient reuse systems. Trust is fostered through serious stakeholder involvement oriented around the farmers, good communication, traceability through e.g. the certification system for reuse (see the Hölö case), by filling knowledge gaps as they emerge, and by the utility/municipality being in charge of the treatment and reuse until there are farmers taking on that role.

For context 3, separate collection of different flowstreams within an existing wastewater jurisdiction, in an EU context, great investments will be made the coming years to meet more stringent removal demands on e.g. nutrients to the Baltic Sea. The detrimental effect on aquatic life in recipients originating from pharmaceuticals in treated wastewater is another concern and it is possible that there will be future removal demands on both pharmaceuticals and other priority chemical compounds. Swedish EPA has proposed recycling targets of 40% P and 10% N from wastewater. An important strategic decision for politicians and other decision-makers to ponder is whether it is the best way forward to continue to tweak the duplicate wastewater system and make investments at the end of the pipe to meet future more stringent effluent qualities and potential reuse demands. Within the solid waste sector separation of flowstreams into e.g. organic/inorganic, paper, glass, metal is gaining more and more ground at least in Europe, after some not so successful attempts at separating organic from inorganic waste from mixed solid waste during the 80’s and 90’s. Separation of flowstreams is not new even to the wastewater sector. Even though combined sewers are frequently occurring in old city centers, duplicate systems, with stormwater separated out from the wastewater, are often installed in newly developed areas. Many countries, Sweden included, are working hard on upstream disconnection of industrial wastewater for separate industrial wastewater treatment. So building on existing sanitary engineering experiences, the centralized separation of another very different flowstream, urine or blackwater, from the wastewater is both logical and makes sense from a treatment optimization perspective. A *triplicate wastewater system*, with (i) stormwater, (ii) the nutrient-rich flowstream and (iii) the remaining nutrient-deprived wastewater all conveyed separately is probably the most strategic way forward to meet both more stringent effluent quality, increased agricultural reuse of nutrients in the wastewater, and also to allow for treatment of pharmaceuticals on a more concentrated fraction, should there be a need. Some bold and visionary politicians, utilities and municipalities are needed to lead the development of triplicate wastewater systems in the world. The development in the cases presented from Helsingborg and Stockholm, Sweden, is ultimately dependent on such political boldness.