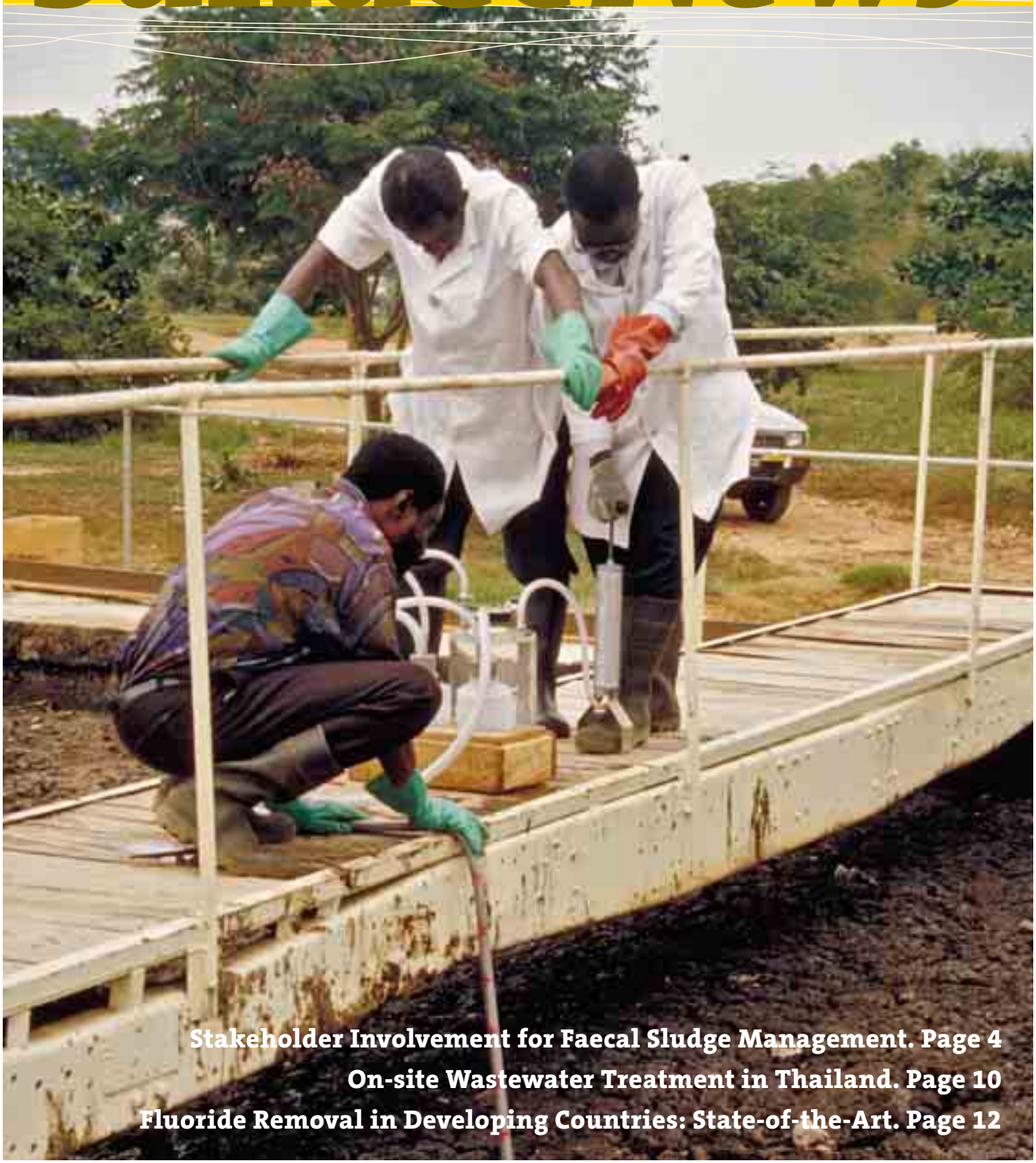
eawag
aquatic research

Sandec: Department of Water and Sanitation in Developing Countries
April 2006, No. 7

Sandec News



Research Partnership is not just a Buzzword

“Knowledge is like light, weightless, intangible, it can easily travel the world, enlightening the lives of people everywhere”

With the current rapid dissemination of information on the Internet, we are sometimes blinded by too much light and need to filter the useful from the irrelevant, as well as bundle and focus the light to obtain the best possible result. In some subjects, however, we are still very much in the dark. Shedding light into dark corners and filtering the useful from the less relevant are two of Sandec’s important mandates.

In content, this Sandec News walks in the footsteps of our previous newsletters. Its objectives are to inform you – our readers – on Sandec’s current and future activities. The individual articles provide insight into Sandec’s specific themes and research topics. Though the articles in this newsletter contain only succinct overviews of our research results, we hope they will raise your interest in looking for more in-depth reading. However, Sandec News is not just about informing, but more importantly, it solicits feedback, asks for advice and invites to work in partnership with you in some way – however small. Partnership is not just a buzzword; it is a fundamental tool of Sandec’s working principle. Partnership is about finding interest in a common theme, but also relies on personal relationships, an agreement on roles and work assignments, a sharing of time and money, and most importantly, effective communication. With its ups and downs, it is a continuous but exciting challenge for Sandec staff to help set the enabling environment and develop/contract effective partnerships.

Sandec News is also about sharing “internal affairs”. One determining event this year will be Martin Strauss’ retirement. Writing about retirement is no easy task.

A few months after I joined Sandec, I had to introduce Sandec’s activities to foreign students from the UNESCO-IHE University of Delft. With great care and patience – two typical and extraordinary characteristics of Martin – he gave me a comprehensive “session” and in-depth account of faecal sludge management. From that day onwards I was truly convinced that we are tackling the relevant questions. Faecal sludge management would not be at the level of knowledge and attention globally were it not for Martin Strauss and his expertise and never relenting energy. The articles in this issue prove this fact. For Martin it will be sad and hard to leave friends, partners and colleagues behind after so many years of fruitful collaboration. It is the end of an important era and the start of another, certainly not less gratifying. Martin … you will be sorely missed! Albeit sad in saying goodbye to Martin, we at Sandec are also happy and extremely lucky to have Doulaye Koné who will take over Martin’s position and continue in his stride with as much vigour and enthusiasm.

Based on the published HCES Guidelines, Sandec is initiating case study projects to field-test household-centred planning approaches in environmental sanitation. Christoph Luethi, urban planner by profession, joined Sandec in November 2005 and will tackle these issues together with Roland Schertenleib.

Although click-browse-click is the current trend, your feedback and reaction to our last newsletter published in April 2005 have encouraged us to continue publishing an annual hardcopy. The new layout of this “Sandec News”, which is more spacious, colourful and hopefully also more stimulating and attractive to our readers, now complies with the standards of Eawag’s new corporate identity.

Looking forward to your opinions and wishing you happy reading.

Chris Zurbrügg
Director Sandec

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Water and Sanitation in Developing Countries

Publisher: Eawag, P.O. Box 611, 8600 Dübendorf, Switzerland, Phone +41 (0)44 823 52 86, Fax +41 (0)44 823 53 99, caterina.dallatorre@eawag.ch, www.sandec.ch

Editors: Sylvie Peter and Chris Zurbrügg, Eawag

Publication: Sandec News appears once a year and is free of charge. Our newsletter is available as printed copy, as e-mail attachment or it can be downloaded as pdf file from our homepage www.sandec.ch

Cover: Sampling of faecal sludge in the Achimota (Accra, Ghana) faecal sludge treatment plant by laboratory technicians of the Ghana Water Research Institute. (Photo Sandec)

Concept: TBS Identity, Zürich; Peter Nadler, Küsnacht, Switzerland

Layout and figures: Peter Nadler, Küsnacht, Switzerland

Printer: Mattenbach AG, Winterthur, Switzerland

Circulation: 4000 copies printed on original recycled paper

New subscribers: Should contact caterina.dallatorre@eawag.ch

ISSN 1420-5572

Eawag: Swiss Federal Institute of Aquatic Science and Technology

Stakeholder Involvement and Money Fluxes for Sustainable Faecal Sludge Management in Burkina Faso

A major challenge in securing sustainable urban sanitation consists in identifying and analysing the roles of the relevant stakeholders, and creating an environment conducive to their coordinated involvement in planning and implementation. In his PhD thesis[1], Halidou Koanda[2] has developed methodologies for devising sustainable FS management strategies based on stakeholder involvement and money flux considerations. Both may serve as useful urban sanitation upgrading tools. Halidou Koanda, Doulaye Koné, Martin Strauss

The "scene"

In Ouahigouya, Burkina Faso (population: 65,000), 96 % of the households use traditional latrines and the remaining 4 % other types of FS facilities such as septic tanks and VIPs. Since the faecal sludge is discharged on streets, into surface drains or reused untreated in urban and periurban agriculture, there is a high risk of excreta-related disease transmission. Households resort to private service providers to empty and dispose of their latrine contents. Latrine emptying is mainly conducted by manual emptiers (70 %) and 30 % mechanically by a single truck owned by the municipality. The thesis focuses on creating a well-functioning "faecal sludge market", based on stakeholder analysis, concertation, strategic scenario validation, and money flux analyses.

Methodologies

- A "Stakeholder Analysis" Method (DFID, 1993) was applied to analyse stakeholders' influence and perceived roles, as well as to ascertain the long-term involvement of each stakeholder or group of stakeholders. This method consists in identifying and classifying the stakeholders according to their importance and influence, and in defining their roles and responsibilities in the sustainable management strategy.
- The overall financial analysis of the mechanical emptying enterprise included operating costs and income. The truck was accompanied for two weeks to assess emptying operations, distances covered, operating time, and fuel consumption.
- A household survey was conducted to evaluate the willingness-to-improve FS management. A total of 646 households were interviewed over a period of four weeks using a semi-structured questionnaire. Willingness-to-use hygienically safe biosolids produced from faecal sludge or faecal sludge-solid organic waste mixtures by 175 vegetable farmers was also assessed in the field.
- Focus group meetings with the specific stakeholders and a final all-stakeholders workshop were organised to present, discuss and validate the scenarios on money fluxes, institutional framework and optimum location of the future treatment plant. All stakeholders; i.e. municipal authorities, manual and mechanical emptiers, farmers, the national water and sanitation agency, and NGOs, participated in the final workshop.

Results

According to the stakeholder analysis, the municipality and households are important and influential stakeholders in FS management in Ouahigouya. Important but not very influential stakeholders are emptiers for their sludge emptying and disposal activities, farmers for their biosolids reuse project and Women's Associations for their sludge composting projects. Based on

Final, all-stakeholders workshop on strategic FSM planning in Ouahigouya, Burkina Faso. Manual and mechanical pit emptiers (equipped with protective clothing; background) discussing with decision-makers and politicians (foreground), filmed by cameramen of the national TV of Burkina Faso.

Photos: Sandec

[1] This PhD thesis, on which this article is based, was financed by SDC, the Swiss Agency for Development and Cooperation, supervised by Prof. Joseph Tarradellas of the Swiss Federal Institute of Technology (EPF), Lausanne, and co-supervised by Eawag/Sandec and CREPA, Ouagadougou.

[2] koanda.halidou@fasonet.bf

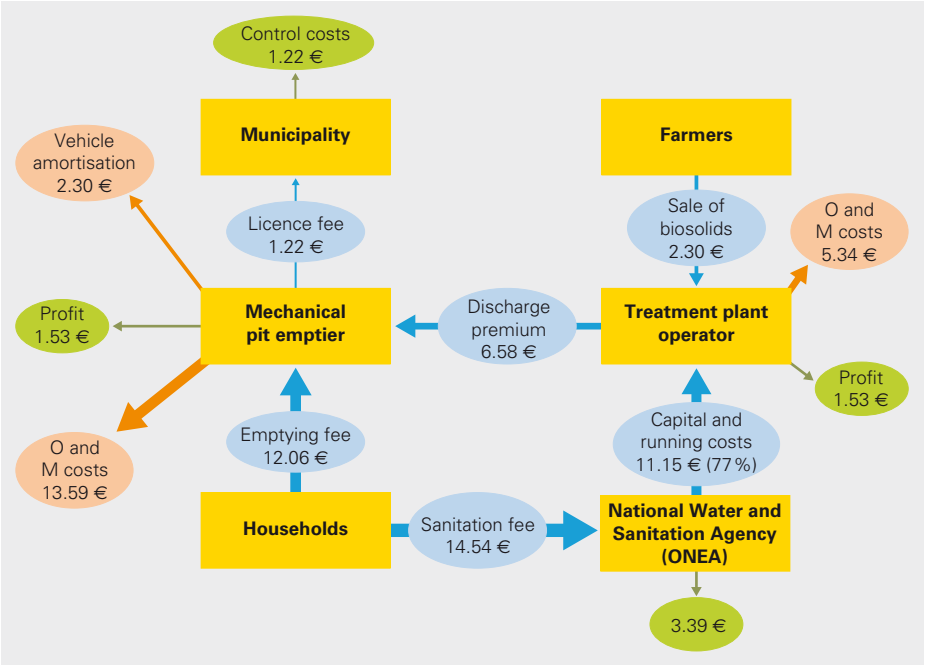
Stakeholders divided into two groups discussing the scenarios during the final workshop on strategic FSM planning in Ouahigouya, Burkina Faso.

these results, we chose the involvement approach consisting of focus group discussions and all-stakeholders workshops. During the final workshop, the entire involvement process was evaluated by the stakeholder themselves through a questionnaire.

Fig. 1 presents a sustainable money flux scenario ensuring minimum profits for both the emptier and treatment plant operator. This scenario, chosen by all stakeholders, can be successful if 77 % of the sanitation fees levied by the central government are injected into its application. Truck leasing or licencing fees levied by the municipal authority should be used to cover the monitoring and control costs. To increase their profit, the operators should apply sound management principles such as for example optimisation of FS operation and maintenance costs, marketing, availability, affordability, adequate quality, and service provision at the right time.

The experience gained in Ouahigouya reveals also the need for capacity building of locally important stakeholders without power to influence the decision-making process. Furthermore, a balanced partnership between municipalities and small entrepreneurs is essential to ensure continuous and sustainable sanitation services, which are affordable and thus accessible to all social groups, particularly to the most disadvantaged.

Figure 1: Sustainable money flux scenario for faecal sludge management in Ouahigouya, Burkina Faso (numbers indicate cost or income in Euros per round trip of the 8 m^3 suction vehicle).



Conclusions and recommendations

Stakeholder analysis, combined with focus group discussions and all-stakeholders workshops, as well as money flux modelling, offer key tools to improve the understanding of stakeholder roles, perceptions and relationships, to allow concerted and meaningful stakeholder involvement and to reach sustainable financial scenarios for faecal sludge management. To devise urban sanitation upgrading strategies with a long-term sustainability potential, we recommend the use of the aforementioned key tools or case specific versions thereof. ○ ○ ○

[1] DFID (1995): Guidance note on how to do stakeholder analysis of aid projects and programmes. DFID, London, U.K.

[2] Grimble R. and Wellard K. (1997): Stakeholder methodologies in natural resource management: a review of principle, contexts, experiences and opportunities. Agricultural Systems *55,* No. 2, 173–193.

[3] Strauss M., Barreiro W.C., Steiner M., Montangero A., and Koné D. (2003): Urban excreta management – situation, challenges, and promising solutions. In: Proceedings, Asian Waterqual 2003-IWA Asia-Pacific Regional Conference, Bangkok, Thailand, Oct. 19–23.

[4] Water and Sanitation Program-Africa Region (2002): The Ouagadougou Strategic Sanitation Plan: A Holistic Approach to a City's Problems. WSP Field Note 10.

[5] Wright, A. (1997): Towards a strategic sanitation approach: Improving the sustainability of urban sanitation in developing countries. UNDP-World Bank Water and Sanitation Program.

Partnership for Building Expertise on Faecal Sludge Treatment in West Africa

About ten years ago, Senegal initiated a dynamic process to increase urban sanitation coverage, with on-site sanitation as its main focus. Provisions have also been made to treat the increasing volumes of faecal sludge (FS) in decentralised treatment plants. In 2005, the national sanitation agency (ONAS) engaged in a collaboration with Sandec to build FS management expertise and provide pilot facilities for testing and investigating appropriate FS treatment options in Senegal.

Alexandra Baumeyer, Doulaye Koné, Martin Strauss

Continuous upgrading of Dakar's sanitation system

Dakar, capital of Senegal, with a population of 2.5 million in 2005, is situated on a peninsula of about 550 km^2 at the most western point of Africa. It has one of the highest sanitation coverage in Africa. This is attributed to the willingness of Senegal's government to attain the "Millennium Development Goals" by 2015. ONAS was assigned the task of developing the "Target 10" of the MDGs, i.e. to reduce by half the number of inhabitants without sustainable access to safe drinking water and adequate sanitation. In 2002, the *"Projet Eau à Long Terme"* (PLT) was thus initiated with the support of the World Bank to substantially increase water supply and sanitation coverage. In particular, excreta management is to be improved by enhancing household access to on-site sanitation, developing effective pit emptying and implementing faecal sludge treatment plants in peri-urban areas of Dakar.

Paqpud *(programme d'assainissement des quartiers péri-urbains de Dakar),* a component of PLT, will furnish 60,000 households with on-site sanitation systems and cater for the implementation of 160 condominial schemes[1] by 2008. Regarding sanitation access in Dakar, Paqpud's objective is to attain sanitation coverage of 85 % of the population by 2015 (coverage in 2002 amounted to 57 % and 64 % in 2004), compared to 60 % urban sanitation coverage in the country as a whole.

Both individual and condominial septic tank systems require the settled sludge to be pumped out at a frequency of once every 1–4 years, depending on the number of users and tank size. According to forecasts by ONAS, some 1,000 m^3 of faecal sludge may have to be treated daily upon completion of the envisaged sanitation infrastructure by 2008.

Faecal sludge and wastewater disposal in Dakar

An integral component of sanitation upgrading in Dakar is the implementation of FS and wastewater treatment plants. Prior to the sanitation project, Dakar's faecal sludge was treated in the Belair treatment plant located in the town centre and discharged into Hann Bay. Since very dense traffic often hindered the suction vehicles from reaching the septic tanks, most of the FS produced in Dakar never reached the treatment plant but were disposed of either in sewer manholes, on open land or buried into roadside holes or directly in courtyards. The Belair plant provided only partial treatment. The sewage from one sector of the city was partly treated in a wastewater treatment plant (WWTP) in Cambérene, and the sewage from the other part of Dakar was disposed of directly into the sea (Fig. 1).

In recent years, three wastewater and FS treatment plants were constructed. The FS treatment plants, with an overall capacity of 220 m^3 FS/day, were built at the same sites as the WWTPs. They comprise solids-liquid separation in sedimentation/thickening tanks. The solids are subjected

Figure 1: Overview of Dakar's faecal sludge and wastewater discharge before implementing Paqpud, the World Bank co-financed sanitation upgrading programme.

[1] Condominial systems, which rely on cistern-flush toilet installations and make use of small-bore sewerage, may comprise a septic tank collecting the faecal matter from a group of houses. Such systems prove appropriate in densely built-up housing areas where there is a lack of space for latrines and emptying vehicles to access individual on-site sanitation installations. Such systems require an adequate and reliable quantitative water supply.

[2] The three-year Velux project includes a second sub-project located in Bangkok, Thailand, where a PhD thesis will be conducted on sludge reed bed (constructed wetlands) treatment, including the development of FSM dissemination material.

[3] Velux is a Danish-Swiss firm producing in-roof windows.

to dewatering/drying on sludge drying beds followed by prolonged storage to reach hygienic standards. The liquids resulting from these plants (supernatant and percolate) are added to the raw wastewater entering the WWTPs. Components of the FS treatment plant in Cambérene are illustrated in the photos on the right.

Further FS treatment plants will be constructed under the PLT in three secondary cities of Senegal, viz. Saint-Louis, Louga and Kaolack.

Sandec

FS plants in Dakar prior to commissioning: (left) settling-thickening tank seen from the outlet end, (rignt) drying beds for the separated solids.

Reinforcing expertise in FSM – A component of the Velux project in Dakar

Right from the start of the PLT, ONAS was aware that project success would primarily depend on its acceptance by Senegal's sanitation experts. ONAS, conscious that sustainability of the newly built or future FS treatment plants in Dakar goes hand in hand with the training level of the staff responsible for the plants, approached Sandec in 2004 and requested its assistance in developing expertise in the FSM sector. A collaboration agreement was subsequently signed. Furthermore, a grant received from the Velux Foundation[2,3] will allow establishing a pilot demonstration facility for FS treatment options and an investigation site for researchers. It will further contribute to gaining and disseminating knowledge on FSM. Training events will be organised for planners, managers and technical staff as well as for trainers. Sandec's training involvement will be high at first and decrease at the pace at which local expertise is being developed. ONAS and Sandec plan to expand their partnership to include UCAD (University of Cheikh Anta Diop, Dakar). The partners aim at involving MSc and PhD students to conduct applied field research on FS treatment. This will assist the University in creating a pool of competence and expertise in water and sanitation in Senegal and other West African countries.

The FS pilot plant

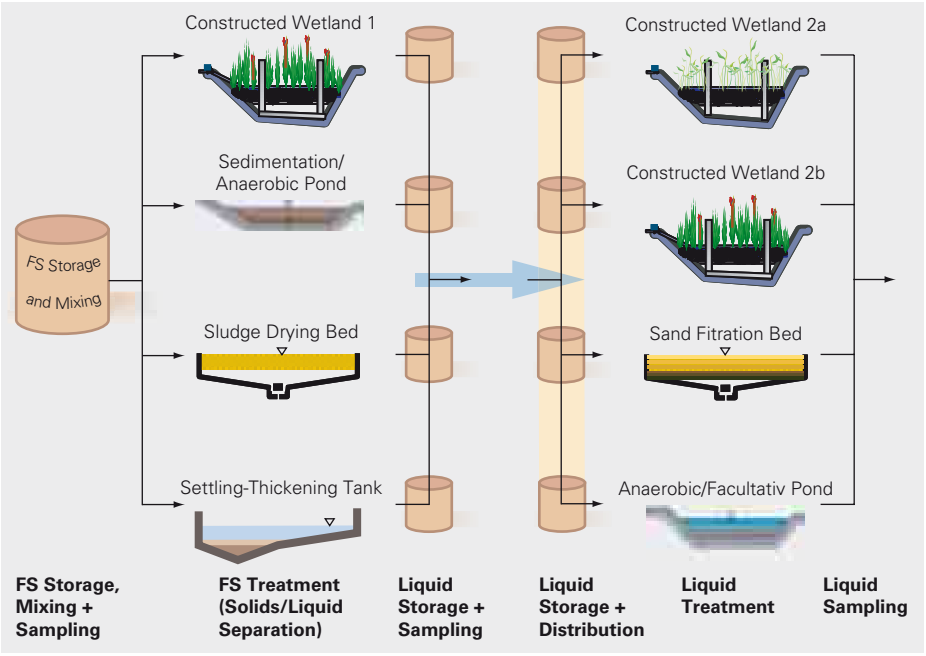
The plant, which will comprise several FS treatment options, shall serve as a demonstration and training site, as well as a place for investigations by researchers. It will supply information on performance, process understanding, design and operation of different treatment methods and process combinations. These combinations aim at producing effluents, which should not require further treatment prior to their discharge into receiving waters, and generating hygienically safe biosolids, which can be used as soil amendment-cum-fertiliser.

The FS pilot plant will be installed adjacent to the Cambérene full-scale FS and wastewater treatment plants to make use of ONAS's own laboratory located on the same site. It is conceived as four 2-stage treatment series, each comprising a solids/liquid separation and a liquid treatment step. A functional sketch of the pilot plant is provided in Fig. 2.

Each option can be used as a large-scale "laboratory" unit for research on mechanisms of sludge/effluent treatment, and will be complemented by laboratory or yard-scale studies as required. Topics for the applied research to be conducted on the pilot station have not yet been identified but will be chosen based on related gaps-in-knowledge identified to date and upon joint deliberation.

The pilot plant design should allow inclusion of a wide range of studies in disciplines such as treatment engineering, microbiology, hydrobiology, and botany. We hope that the future FS treatment plants built in Senegal and elsewhere can profit from the enhanced knowledge on FS treatment mechanisms, and that a sound basis for the formulation of treatment standards for FS treatment plants can be laid. ○ ○ ○

Figure 2: Functional sketch of the planned FS pilot treatment plant in Cambérene, Dakar, Senegal.



[1] Web page of ONAS: www.onas.sn/onas.htm

[2] CREPA-Sénégal: PROGEBOUE: Projet de Gestion des Boues de Vidange, État des lieux (2002).

[3] ONAS: Mise en œuvre et état d'avancement, résumé réalisations PAQPUD (2005).

[4] For general reference, consult Sandec's website on FS treatment and management www.sandec.ch/FaecalSludge

Household-Centred Environmental Sanitation – Call for Collaboration

HCES, the new multi-sector strategic planning approach is now moving from theory to practice. Sandec's Strategic Environmental Sanitation Planning Unit is currently looking for partners interested in field-testing HCES in selected pilot sites around the globe. Christoph Lüthi, Roland Schertenleib

The HCES approach

The Household-Centred Environmental Sanitation (HCES) approach, based on a series of international workshops (see Sandec News No. 6, April 2005), was developed by the Environmental Sanitation Working Group of the Water Supply and Sanitation Collaborative Council and supported by Eawag/Sandec. Preliminary guidelines, published in June 2005, target public officials, decision-makers and sector specialists. The guidelines are currently being translated into French and Spanish and will shortly be available on the Internet.

The HCES approach is a new multi-sector approach placing the household and neighbourhood at the core of the planning and implementation process. Decisions on determining the type of environmental sanitation services to be implemented is heavily based on the actual *needs* and *means* of the users and conducted in close consultation with all stakeholders. Local authorities and government agencies respond to the needs by providing an environment to allow successful implementation of these services. A further innovative feature is the environmental sustainability concept based on circular resource management systems, where environmental sanitation problems are addressed as close as possible to their source and emphasis is placed on resource conservation and waste reduction.

HCES – next steps

The planning approach, developed by sector experts and based on experience gained and research conducted over the past decades, is yet to be tested in real-life situations. Sandec is now spearheading this field-testing in a number of cities in the developing world. In a first step, existing procedures are being reviewed, which are compatible or show some similarity to the HCES approach (open planning of sanitation systems, community action planning, stakeholder planning approach etc). Secondly, suitable sites and partners are currently being identified to field test the integrated HCES approach, which will later be implemented in some 6–8 pilot sites.

We are therefore actively seeking appropriate test sites in a variety of urban and peri-urban environments in Africa, Asia, Latin America, and the Caribbean. The following built environments and settings are of particular interest:

- Densely populated urban formal or informal settlements.
- City-fringe peri-urban settlement patterns.
- Small and medium-size towns lacking environmental sanitation services and systems.

Sandec's criteria for field-testing the HCES include inter alia and most importantly an *enabling environment* to ease the planning process. By enabling environment we mean favourable government support, a legal framework facilitating the participatory planning approach, financial and institutional arrangements permitting rapid implementation and, last but not least, human resources and skills needed to conduct such a multi-stakeholder exercise.

Your suggestions are welcome!

We are open to your suggestions regarding submission of a specific area or neighbourhood in the initial field-testing of the HCES planning approach, or potential collaboration with us in this exercise, provided your suggestions meet the aforementioned criteria. Kindly contact us and submit a short description of your suggested town/city. ○ ○ ○

The provisional HCES guidelines are available in English and shortly also in French and Spanish from www.wsscc.org.

A community-centred approach is key to HCES, both during planning and implementation. The photo illustrates a community meeting in Pikine, Senegal.

Sandec

Greywater Management

Based on the analysis of case studies worldwide, Sandec is currently compiling a report on greywater management systems implemented on household and neighbourhood level in low and middle-income countries. Stefan Diener, Antoine Morel

The issue of greywater management, which includes wastewater from bath, laundry and kitchen but excludes toilet wastewater, is steadily gaining importance, especially in low and middle-income countries (LMIC) where inadequate wastewater management has a detrimental impact on public health and the environment. In recent years, inadequate greywater management has not only been linked to environmental degradation and serious health risks, but has also been increasingly identified as a valuable resource rather than a waste. Appropriate reuse of greywater not only reduces both the agricultural use of drinking water and water costs, but also increases food security and improves public health.

This project aims at compiling international experience in greywater management on household and neighbourhood level in low and middle-income countries, and at providing a comprehensive description of the main components of successful greywater management. Recommendations will be formulated for control measures at the source, design of primary and secondary treatment systems as well as safe reuse and disposal of treated greywater. It will present context specific selection criteria and identify gaps in knowledge, including interesting research topics. The final product will hopefully provide a valuable tool for interested development agencies, NGOs and CBOs working in environmental sanitation in low and middle-income countries.

Common practices

In most instances, greywater management is not perceived as a priority issue. In urban areas of LMIC, greywater is commonly discharged untreated into drainage channels, on open fields or into natural aquatic systems. The rural and peri-urban areas mainly use untreated greywater for agricultural purposes, thereby leading to environmental degradation and exposing the population to health risks. Though greywater is generally less polluted than domestic or industrial wastewater, it may still contain high levels of pathogenic microorganisms, suspended solids and substances such as oil, fat, soaps, detergents, and other household chemicals (Tab. 1). Since the characteristics of greywater are a reflection of the household activities, they are strongly dependent on factors such as cultural habits, living standard, household demography or type of water supply. 90–120 l/p·d greywater are typically produced where a continuous supply of piped water is available to the household. This figure drops significantly with scarce water resources and poor water supply services.

Greywater production	~100 l/p·d	~30–50 l/p·d
BOD (mg/l)	100...**250**...500	300...**700**...1500
SS (mg/l)	50...**150**...500	150...**500**...1500
TP (mg/l)	1...**15**...100	5...**30**...200
TN (mg/l)	1...**10**...50	1...**20**...80

Table 1: Typical and extreme key concentrations in greywater (based on data in over 10 countries).

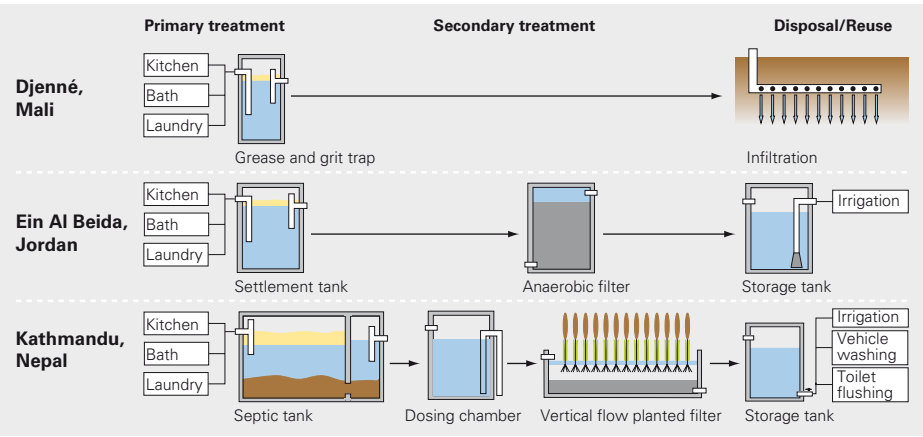
Greywater management systems

Decentralised, individual greywater management schemes became popular in the last two decades and are still applied mainly in rural areas of industrialised nations such as the USA, Canada, Australia, and Northern Europe. Information on greywater management experience in LMIC is scarce. Only few cases of implemented engineered greywater management systems have been identified. The documented systems, which vary significantly in terms of complexity, performance and costs, range from simple systems for single-house applications (e.g. local infiltration or garden irrigation) to rather complex treatment trains for neighbourhoods (e.g. series of vertical and horizontal-flow planted soil filters). Treated greywater is not always reused. In regions with water scarcity and poor water supply services for example (e.g. Middle East, Africa), emphasis is placed on agricultural reuse of treated greywater, whereas in regions with abundant water, greywater reuse is of minor importance and locally infiltrated or discharged into nearby water streams (Fig. 1).

Economic benefits

Industrialised nations still implement household greywater management systems mainly for idealistic reasons. The identified cases in LMIC reveal, however, that application of such systems is strongly governed by economic considerations and not so much by environmental and public health concerns. In Jordan, introduction of simple greywater recovery systems for home gardening have reduced household water bills by 27 % while generating income through the sale of surplus food production. This inevitably leads to increased social acceptance and motivates owners to appropriately operate and maintain their system. This is crucial as inappropriate operation and maintenance appears to be the most common cause for system failure. Full report: www.sandec.ch

Figure 1: Implementation of three different greywater treatment systems.



On-site Wastewater Treatment in Thailand – A Comparative Study

A comparative study conducted at the Asian Institute of Technology in Bangkok, Thailand, demonstrated the suitability of an anaerobic baffled reactor, an anaerobic filter, an intermittent sand filter, and a vertical-flow constructed wetland for decentralised treatment of domestic wastewater. The findings were translated into technical guidelines and a first full-scale treatment plant was implemented. Antoine Morel, Thammarat Koottatep

The discharge of untreated wastewater into the environment is one of the main causes of water-borne diseases worldwide. The need to increase sanitation coverage is widely recognised. However, given the important demand for investments and lack of local expertise on low-cost treatment alternatives, many governments find it difficult to reduce the number of people without access to adequate sanitation services. Since 1992 for instance, the Royal Thai Government has invested more than USD 1.5 billion for the implementation of wastewater collection and high-tech treatment systems in 85 municipalities, over 60 % of which are currently malfunctioning.

Decentralised treatment

Aware of the difficulties in providing sustainable sanitation services in peri-urban and rural communities, the Thai Pollution Control Department (PCD) mandated the Asian Institute of Technology (AIT) to conduct a comparative study on different low-tech systems for decentralised treatment of toilet wastewater (blackwater). Decentralisation of wastewater management is increasingly gaining recognition for the following reasons:

- Broadens the technology options to allow tailor-made solutions to prevailing conditions.
- Minimises the freshwater requirements for waste transport.
- Reduces the risks associated with system failure.
- Allows to segregate the different wastewater types (greywater, blackwater, stormwater) at source.
- Increases local wastewater reuse opportunities.
- Permits incremental development and investment in community wastewater systems.

Thammarat Koottatep is Assistant Professor at the Asian Institute of Technology (AIT) in Bangkok, Thailand and engaged in environmental sanitation. He is also Regional Coordinator of the NCCR North-South research programme.

Pilot-scale comparative study

The objective of this study was to determine the treatment potential, range of application and optimum operation conditions of 3 blackwater treatment systems and their compliance with the national discharge standards. The pilot-scale experiments were conducted at the Environmental Research Station of AIT, where two-stage treatment processes were investigated: An anaerobic baffled reactor (ABR) with 1 sedimentation and 3 up-flow chambers (HRT = 2 d) was used as primary treatment unit. The effluent of the ABR was subsequently treated in 3 parallel secondary treatment units, comprising a three-chamber anaerobic filter (HRT = 2–4 d), an intermittent sand filter (HLR = 5–10 cm/d) and a vertical-flow constructed wetland planted with cattail (HLR = 6–20 cm/d) (Photo 1). The 3 systems were fed with blackwater (COD = 1000 mg/l) and the treatment performance was monitored in terms of oxygen demand (BOD, COD), suspended solids (SS) and nutrients (NH_4-N, NO_3-N, org-N, TP) removal efficiency.

AIT

Photo 1: Pilot-scale experimental setup with constructed wetland, sand filter and anaerobic filter (left to right) at AIT, Bangkok, Thailand.

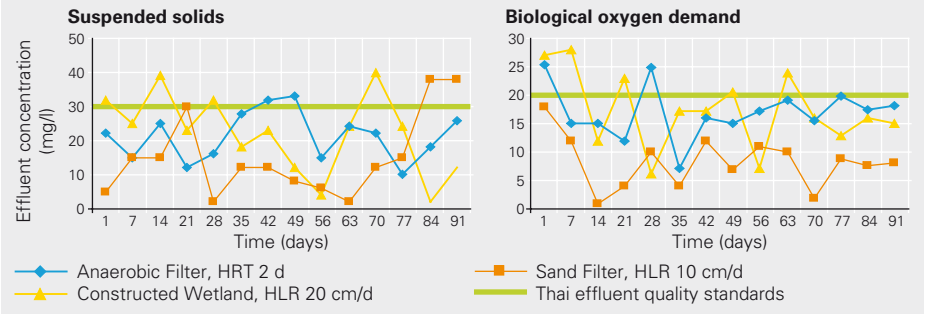
Anaerobic baffled reactor

The anaerobic baffled reactor proved to be an efficient technology for primary treatment of blackwater. With a hydraulic retention time (HRT) of 2 days, the anaerobic baffled reactor (ABR) can produce an effluent with an average BOD and SS concentration of 55 and 65 mg/l, respectively, corresponding to an 83 % (BOD) and 93 % (SS) average removal efficiency. Despite its apparent efficiency, the ABR was unable to produce an effluent complying with Thai domestic wastewater discharge standards (SS < 30 mg/l; BOD < 20 mg/l; TKN < 35 mg/l). This clearly reveals the need to include a secondary treatment step prior to releasing the treated blackwater into the environment.

Secondary treatment units

The three secondary treatment units were fed with ABR effluent at different hydraulic

Figure 1: SS and BOD treatment efficiency of three secondary treatment systems compared with Thai domestic wastewater discharge standards.



loading rates (HLR) and hydraulic retention times (HRT). The experiments revealed that the anaerobic filter is best operated at a hydraulic retention time of 48 hours. The vertical-flow constructed wetland showed highest SS, BOD and TN removal efficiencies at a hydraulic loading rate of 6 cm/d, whereas the intermittent sand filter produced high quality effluent even at higher loading rates (10 cm/d).

In terms of solids removal, the intermittent sand filter offered the highest SS removal rates (85 %), with average SS concentrations amounting to 15 mg/l. The effluent SS concentrations of the other two units were slightly higher, but all three secondary treatment units produced an effluent which met the Thai effluent standard of 30 mg SS/l.

The sand filter produced an effluent with a BOD concentration as low as 7 mg/l, whereas the average BOD concentrations in the effluent of the anaerobic filter and constructed wetland amounted to 20 and 15 mg/l, corresponding to removal efficiencies of 64 % and 70 %, respectively. The three systems could on the average reach the Thai effluent discharge standard of 20 mg BOD/l, with some transgressions observed (Fig. 1).

Nutrient removal

In raw blackwater, virtually all nitrogen is found as organic nitrogen (org-N) or ammonium (NH_4). In the anaerobic baffled reactor (ABR), organic nitrogen undergoes mineralisation and is transformed into ammonia, resulting in primary treated blackwater with nitrogen mainly in the form of ammonia (75 %). The fate of nitrogen in the three secondary units is variable (Fig. 2). In the anaerobic filter, nitrogen is mainly removed through filtration and sedimentation of org-N and uptake by anaerobic bacteria for cell growth. Nitrogen removal rates observed in the anaerobic filter did not exceed 10 %. Given the absence of oxygen and, thus, nitrification in the anaerobic filter, nitrogen leaves the system as NH_4-N.

The intermittent sand filter revealed a high nitrification efficiency but rather low total nitrogen removal rates (44 %). Ammonia is converted to nitrate (NO_3) – 92 % of the nitrogen leaving the intermittent sand filter was in the form of nitrate.

The lowest total nitrogen concentration (15 mg/l) was observed in the effluent of the vertical-flow constructed wetland operated at 6 cm/d hydraulic loading rate. An increase of the loading rate from 6 cm/d to 20 cm/d led to decreased nitrogen removal rates from 80 % to 32 %. In constructed wetlands, plants play an important role in nutrient transformation and removal, yet the exact mechanism is still not fully understood. Plant uptake is only one form of nitrogen removal and usually does not exceed 10 % (provided plants are harvested). Due to their effects on other removal processes, plants primarily facilitate indirectly improved nutrient removal. Plants enhance key nutrient transformation processes (i.e. nitrification and denitrification) through low-level, root-zone oxygen release via their rhizomes. They provide an appropriate environment for microbial attachment and growth, and stimulate soil activity by root excretions.

Th. Koottatep

Photo 2: Wastewater treatment plant comprising an anaerobic baffled reactor, a constructed wetland and three sludge drying beds in Songkla Province, Thailand. The system treats domestic wastewater of 50 households.

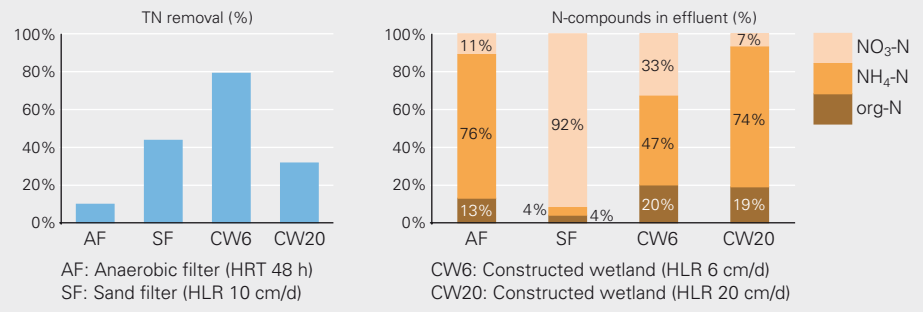
The intermittent sand filter and constructed wetland can easily meet Thai effluent standards in terms of TKN (35 mg/l), whereas the anaerobic filter fails to do so. Phosphorus removal was rather low in all systems, with highest rates observed in the constructed wetland (25 %) and lowest rates monitored in the anaerobic filter (12 %).

Guidelines and full-scale application

The comparative study clearly reveals that simple treatment systems can efficiently treat blackwater up to the required effluent standards – with treatment performances as high as 98 % in terms of solids and BOD removal (ABR with intermittent sand filter), and 85 % in terms of total nitrogen removal (ABR with constructed wetland). Rather than selecting the most appropriate system, the fields of application of the different treatment systems should be defined. The ABR with anaerobic filter produces a nutrient-rich effluent with low suspended solids concentrations, thus making it a potentially appropriate treatment system allowing wastewater to be reused for irrigation. Where receiving water systems should be protected, the two other systems are best applied.

The findings of this comparative study were translated into technical guidelines published by the Thai Pollution Control Department, which intends to apply them to small-scale communities in peri-urban and rural areas. The first full-scale wastewater treatment system was implemented in a small community of 50 households on the shore of Songkla Lake, Songkla Province, Thailand (Photo 2). The system comprises an ABR for primary treatment, a constructed wetland for secondary treatment and three sludge drying beds for treatment of excess sludge from the ABR. Additional applications should follow shortly. ○ ○ ○

Figure 2: Nitrogen removal rates and nitrogen compounds in the effluent of the three investigated secondary treatment units.



AF: Anaerobic filter (HRT 48 h)
SF: Sand filter (HLR 10 cm/d)
CW6: Constructed wetland (HLR 6 cm/d)
CW20: Constructed wetland (HLR 20 cm/d)

Fluoride Removal in Developing Countries: State-of-the Art of Defluoridation Techniques in East Africa

So far, only few fluoride removal techniques have been implemented on a wider scale, especially in low and middle-income countries. A group of scientists at Eawag/Sandec is currently focusing on evaluating, developing and disseminating such fluoride removal techniques. In a first phase, different defluoridation methods were assessed in East Africa. Kim Müller, Annette Johnson, Regula Meierhofer, Martin Wegelin

Fluoride, the 13th most abundant element in the earth crust (625 mg/kg), often has a natural rock-derived origin in water [1]. Different minerals and their corresponding rocks, such as granites, basalts, syenites, shales etc., can contain high fluoride concentrations. Groundwater, interacting with these rocks, can dissolve fluoride and pose a fluoride risk if used for human consumption. Not only the fluoride content of the rocks, but also groundwater characteristics (e.g. residence time, calcium concentration etc.) as well as environmental conditions (e.g. ambient temperature, precipitation etc.) influence the amount of fluoride dissolved in groundwater [2].

Drinking water is, however, the main source of total fluoride intake in areas where fluoride concentrations in groundwater and/or surface water are high. The WHO international guideline value for fluoride in drinking water amounts to 1.5 mg/l. Due to higher water consumption, this limit is more stringent in hot climates and ranges between 0.6–0.8 mg fluoride/l [3]. Defluoridation experts participating in the 3rd International Workshop on Fluorosis Prevention and Defluoridation of Water have even suggested lowering the fluoride threshold concentration to 0.5 mg/l [4].

Call for Cooperation
Eawag/Sandec and CDN are launching a cooperation to further develop and promote defluoridation using bone char and contact precipitation. The scientists are interested in an information exchange and/or cooperation with other institutions investigating defluoridation techniques. For first contacts, write to annette.johnson@eawag.ch and cdnwaterquality@yahoo.com

The "Water Resource Quality" Project
Eawag's interdisciplinary project "Water Resource Quality" (WRQ) aims at tackling geogenic contamination of groundwater on a global scale. Areas of potential contamination will be determined and appropriate removal techniques developed. In its first phase, the project examines arsenic, fluoride, selenium, and uranium.

Photos: Sandec

Photo 1: Kenyan girl affected by dental fluorosis.

Excess fluoride intake causes different types of fluorosis; primarily dental and skeletal fluorosis. White line striations followed by brown patches and, in severe cases, brittling of the enamel are common symptoms of dental fluorosis (Photo 1). Skeletal fluorosis first causes pain in the different joints then limits joint movement, leading to stiffness and finally to joint crippling. Since fluorosis affects over 100 million people worldwide, it poses a serious health problem on a global scale. For lack of effective health treatment, fluorosis can only be avoided by preventing excess fluoride intake.

To combat fluorosis, drinking water from alternative water sources with low fluoride content should first be identified. If alternative sources are not available, defluoridation methods have to be introduced.

Defluoridation

In the past decades, a wide range of defluoridation materials and methods have been investigated and analysed, mainly on a laboratory scale. Insufficient removal efficiency, complicated maintenance and/or unaffordable costs, particularly for rural populations, are the main reasons why these methods have rarely been implemented in developing countries, except in some areas.

Sorption on activated alumina, co-precipitation on aluminium hydroxide (known as the Nalgonda Technique) and sorption on bone char are the most common defluoridation methods used in developing countries (Fig. 1).

Activated alumina

Activated alumina (γ-Al_2O_3), often used as a filter medium to remove fluoride, is especially widespread in industrialised nations. However, in India, UNICEF is financing defluoridation projects using activated alumina for household water treatment, and supporting more than 25,000 households with defluoridation units.

In East Africa, only two community units (in the central parts of Ethiopia) treat fluoride-rich groundwater with activated alumina. These plants have been in operation for more than 40 years without major upgrading. Their removal efficiency is relatively low (~60 %) on account of maintenance and age problems. Another drawback of this method in Ethiopia is the high cost of activated alumina, a chemical that has to be imported from overseas.

Nalgonda Technique

After adding alum and lime to the raw water, insoluble aluminium hydroxide flocs are formed, sediment to the bottom and co-precipitate fluoride. This method, commonly known as the Nalgonda Technique, was named after the Indian village where it was developed.

Its use is most popular in India; however, it has also been applied in Ethiopia on household and community level. Nalgonda defluoridation units can reduce fluoride

concentrations from ~10 mg/l to ~2.5 mg/l; none of the evaluated plants in East Africa meet the WHO international guideline value of 1.5 mg/l. One of the disadvantages of this technique is that aluminium seems to be toxic at low concentrations (WHO standard: 0.2 mg/l [3]). Any deviation from pH 7 will lead to an increase in residual aluminium concentration, which is also highly dependent on the amount of suspended aluminium hydroxide flocs. Application of the Nalgonda Technique is rather work-intensive, as chemicals have to be added daily and manual stirring for ~15 min is required.

Bone char

Bone char can be produced locally by charring animal bones at approx. 550 °C in a low oxygen atmosphere [5]. After charring, the bones are washed and subsequently used as a filter material.

Filtration with bone char was first introduced in the US in the early 1940s, later replaced by activated alumina and reintroduced in Thailand in the late 1980s. Over 1,000 household- and 40 community filters, equipped with bone char as a filter medium, have been implemented so far in Kenya and Tanzania (Photo 2). According to sampling results, some defluoridation units reveal high fluoride removal efficiencies; others exhibit a marginal fluoride removal capacity. The reason for the different efficiency levels is attributed to the units' operating life, i.e. once the bone char filter media is loaded with fluoride, removal efficiency drops, fluoride concentration in the outlet increases and the filter media will then have to be either replaced or regenerated. This maintenance work was neglected in some of the assessed units. Another major drawback of this method is its restricted acceptance, such as for instance among some Hindu communities, which refused it on account of the cattle bones used in this method.

Photo 2: Bone char household filter implemented by CDN, Kenya.

Contact precipitation, a recently developed method, was first tested in a pilot plant in Tanzania in 1995 [5]. Addition of calcium and phosphate to the raw water leads to a precipitation of fluoride when it comes into contact with bone char. The Catholic Diocese of Nakuru (CDN), a non-profit organisation in Kenya, has recently supplemented its bone char filter units with specially developed pellets releasing calcium and phosphate to the raw water. An evaluation of this kind of implementation is not yet possible as further results are necessary.

Conclusions

Development and Implementation of simple and sustainable defluoridation techniques are urgently needed, especially since groundwater will increasingly serve as a drinking water source.

Identification of the most appropriate defluoridation method is highly dependent on local circumstances. Our field studies reveal that although bone char possesses a high fluoride removal capacity, its implementation is only successful if soft criteria such as acceptance and maintenance are also included in project planning. ○ ○ ○

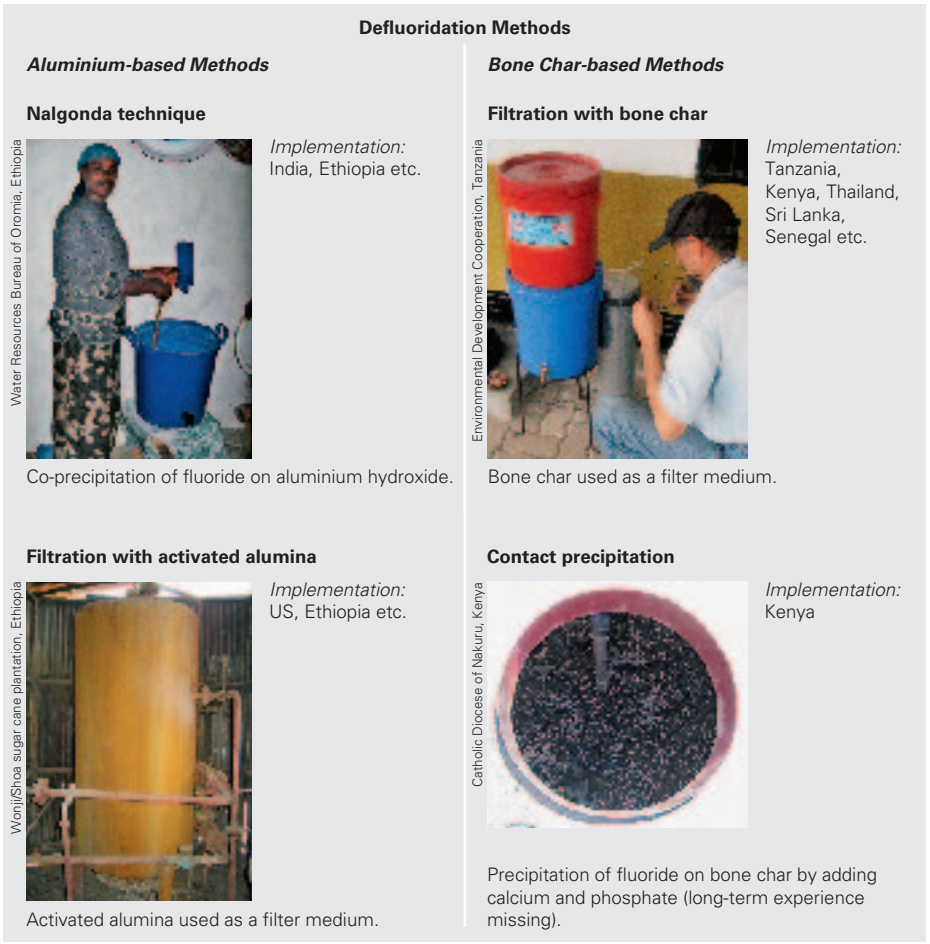


Figure 1: Implementation of different defluoridation methods in East Africa. Contact precipitation has only recently been introduced in Kenya.

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City-wide Decentralised Composting: Additional Costs or Savings?

Sandec's in-depth research on technical, financial and organisational aspects of decentralised composting schemes have revealed the advantages and disadvantages of decentralised composting in cities of low and middle-income countries. Silke Drescher, Chris Zurbrügg, Christian Müller

Potential and problems of decentralised composting

Many decentralised composting schemes in developing countries do not only treat biodegradable waste but also improve the hygienic condition in the neighbourhood, as they are closely linked to an improved primary waste collection service. However, in Asia, Africa and Latin America all these schemes face similar problems, such as a lack of technical skills or organisational constraints hindering sustainable operation. While technical problems can be partly solved by increased training in composting process control, special attention should be given to financial and institutional issues. Such issues are closely related to solid waste management regulations at municipal or national policy level.

One frequently observed shortcoming of decentralised composting plants is the lack of interaction and embedding of the schemes in the municipal solid waste management system. Since many schemes are operated as private or community initiatives, they are not formally acknowledged by municipal authorities. The public land on which they are established is insecure, and the systems often only tolerated by neighbours or municipal officers. Part of their revenues, such as waste collection fees, is often a voluntary contribution by the households, thus making enforcement of payment and revenue security impossible. Such conditions seriously hinder a city-wide replication and implementation of decentralised composting.

Research reveals that decentralised composting schemes need to be embedded in a city-wide solid waste management strategy, and obtain formal support from the municipal authorities to allow their long-term sustainability. However, how can municipal decision-makers be convinced that decentralised composting contributes to improving their municipal solid waste management system? One argument is that decentralised composting schemes allow waste reduction close to their source of generation, thus partly solving waste transport and final disposal problems. This advantage has, however, hardly ever been quantified by specific studies.

Quantifying costs and benefits

To investigate and illustrate the effects of different municipal solid waste management scenarios, Sandec has adopted an approach combining material flow analysis (MFA) and process cost accounting (PCA). A commercially available software tool (Umberto 5.0) was used to elaborate two case studies: the SWM systems of Asmara, Eritrea and Bouargoub, Tunisia. The material flow analysis (MFA) allows visualisation of the waste flows and processes of an urban SWM system. By linking this physical information to the costs and revenues of the processes involved (PCA), a cost-revenue balance for an entire city or community can be calculated. Once the baseline system with its material flows is determined and financial data included, it can easily be modified to simulate alternative solid waste management scenarios. Our special interest focuses on scenarios involving decentralised composting as treatment option of the biodegradable waste fraction.

Material flows and processes in the SWM system of Asmara, Eritrea

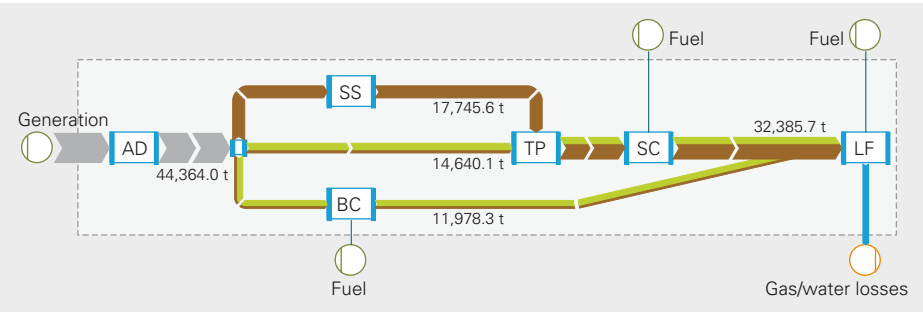
The case of Asmara exemplifies the approach and reveals interesting results [1, 2].

Fig. 1 illustrates the flows of biodegradable waste and rejects through the defined solid waste management system of Asmara. In 2004, the sanitation unit of Asmara collected and transported annually a total of 44,364 tons of waste to the landfill located 6 km from the city.

About 52 % of this waste is biodegradable and suitable for composting (devoid of paper and cardboard). The street sweeping team of Asmara collects 17,745 tons of waste, mainly dust, leaves and litter, which forms part of the total amount of waste.

The available information on waste flows, processes, financial aspects, and additional information on composting processes allows defining various potential scenarios. In a scenario illustrated in Fig. 2, the biodegradable waste is separated and treated in a number of decentralised composting plants located in the city. Only rejects and waste from street sweeping are directly transported to the landfill site. The data obtained reveal that decentralised composting not only reduces by 35 % the amount of waste to be transported to the landfill, but also minimises transport efforts and costs. Furthermore, since the landfill receives less waste, its remaining operating life is prolonged. In a second step, the PCA allows

Figure 1: Processes and material flows in the current solid waste management system of Asmara (Baseline). AD: Administration, SS: Street Sweeping, TP: Transfer Point, SC: Container Collection, BC: Block Collection, LF: Landfill. The arrows indicate the material flows: Grey: mixed waste, Brown: rejects, Green: biodegradable waste.



Our research partners: **University of Asmara,** the **Administration of Maakel Region** and the **Institute of Landscape and Environmental Planning** of the ETH Zurich.

analysis of the financial implications of this change in system.

Financial analysis

As reported by the municipal authorities, the annual budget of the solid waste management department amounts to about 12.3 million Nakfa (US$ 819,000), which cover the costs of solid waste collection and latrine emptying services.

The various cost items (e.g. salaries, maintenance, fuel cost, depreciation etc.) of the solid waste management system were assessed on the basis of the data provided by the sanitation unit of the Administration of the Maakel Region and own investigations. Total annual costs and cost distribution among the processes are graphically illustrated in Fig. 3. For the existing baseline situation (first column in Fig. 3), the total annual costs (fixed and variable costs) of solid waste management are about 10 million Nakfa, whereof 57 % are related to waste collection and transport. Fig. 3 also includes total costs and cost distribution of modelled alternative scenarios. The "centralised composting" scenario with one large composting plant at the landfill (180 tons per day), reveals an annual cost increase of approx. 2.5 million Nakfa. The "decentralised composting 1" scenario assumes 60 small decentralised composting plants (3 tons per day) operating throughout the city and treating all the waste generated in Asmara. The calculation reveals considerably higher costs attributed to significantly higher personnel costs, as small-scale plants are far more labour-intensive to manage and operate than large-scale plants.

Finally, the "decentralised composting 2" scenario assumes that only waste from households is treated in decentralised composting plants. The bulk waste from street sweeping is collected separately and disposed of directly on the landfill. This scenario not only reduces the number of composting sites in the city to 36 plants, but also the number of staff; the highest key cost factor in decentralised composting. Though, the skip collection costs are slightly increased by that measure, the total costs are lower than in the "centralised composting" scenario. This already indicates that decentralised composting has its advantages within a solid waste management system when implemented in selected solid waste streams.

Focus on the cost structure instead of determining total figures

Analysis of the cost structure allows a differentiated discussion on the advantages and disadvantages of decentralised composting. Although operation of decentralised composting may be more expensive than that of centralised systems, the model reveals that compared to a centralised plant, transport costs are reduced in decentralised composting. In the case of Asmara, 1.7 million Nakfa can be saved in transport costs as shown in Fig. 3 (fourth column). Half of the additional costs, which would be necessary to implement and operate the decentralised composting schemes, can thus be compensated by costs savings in transport and increased revenues through the sale of compost. This compensation would not be as significant in a centralised composting plant, as its transport costs remain unchanged.

Furthermore, decentralised composting eases the operational and financial burden from the weakest link – transport – in the solid waste management chain. Allocation of capital for waste collection trucks, their operation and maintenance (fuel, spare parts) are a great challenge for many authorities in cities of low and middle-income countries. Additionally, the lack of available land for final disposal within city reach is also of great municipal concern. The problem of limited transport capacity becomes even more acute with new landfill sites being constructed further away from the city centre.

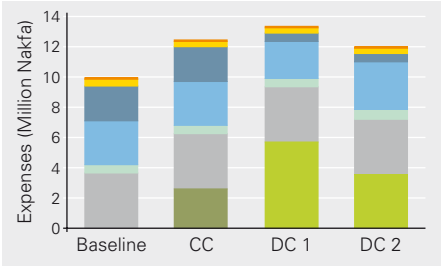
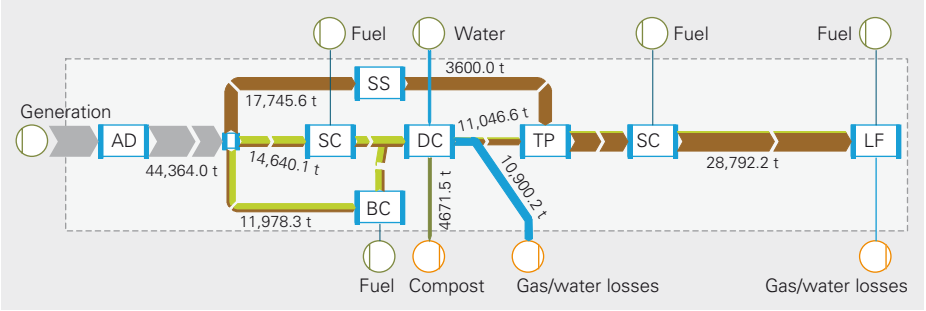


Figure 3: Process cost analysis for the baseline and different composting scenarios for Asmara, Eritrea. ■ = Administration, ■ = Landfill, ■ = Block collection, ■ = Skip collection, ■ = Transfer point, ■ = Street sweeping, ■/CC = Centralised Composting, ■/DC = Decentralised Composting

In all scenarios, improved solid waste management systems incur increasing annual costs. However, the question of how to allocate investments most efficiently remains to be discussed. The results of the presented study suggest a reallocation of necessary new investments to decentralised composting schemes so as to use existing capacities more efficiently. Instead of investing in new transport equipment and landfill extension, the investment can be channelled into decentralised composting schemes. In the case of Asmara, decentralised composting would result in freeing existing truck fleet capacity, as only 64 % of the initial waste volume has to be transported. The remaining capacity can be used to extend the SWM service to other areas, thus increasing system efficiency.

The described approach not only allows to predict the financial outcomes of potential changes in the solid waste management system, but also contributes to enhancing decision-making. To conduct a reality check, Sandec will submit the results obtained to the Eritrean and Tunisian authorities involved. Furthermore, a follow up is planned to deal with further questions arising from the current results and future plans of the stakeholders involved. ○ ○ ○

Figure 2: Processes and material flows in a future scenario comprising decentralised composting schemes in the solid waste management system of Asmara (Baseline).
See Fig. 1 for abbreviatons. Additional process DC: Decentralised Composting.



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Optimising Water and Nutrient Management in Hanoi, Vietnam

The authors have developed a tool to help analyse water and nutrient flows in environmental sanitation systems even with scarce data. On the basis of the information obtained, optimum measures and strategies can be proposed to protect the environment and recover secondary resources. Agnès Montangero

Environmental sanitation in Hanoi: A situation analysis

As a result of Hanoi's rapid urbanisation, the municipal authorities are faced with a real challenge as regards the provision of adequate water supply, sanitation and solid waste management. Significant pressure is also exerted on the environment and resource consumption. Hanoi's water supply relies mainly on groundwater; however, the city's water demand already exceeds the aquifer's recharge rate. The groundwater level is lowered by overexploitation, and the city is suffering from land subsidence. The agricultural sector is of key importance in the supply of food and provision of income to the poorest sector of the population. In Thanh Tri, a district located south of Hanoi, farmers use urban and industrial effluents as fertilisers and fish food (van den Berg et al., 2003) (Photo 1). Although this practice has reportedly led to higher yields and greater financial benefits, it is also associated with health risks.

Septic tanks are the most common urban on-site sanitation option in Vietnam. In Hanoi, septic tank effluents are mainly discharged into the sewerage and drainage network (Photo 2). However, apart from domestic black wastewater, which is pretreated in septic tanks, and a limited amount of industrial and hospital wastewater, which is subjected to preliminary treatment, all the wastewater is discharged untreated into aquatic systems draining into the Nhue and Red Rivers (Viet Anh et al., 2004). Faecal sludge collected in the urban centre is usually disposed of in a landfill. A small fraction of the sludge is co-composted with solid waste. In peri-urban areas, latrines are generally emptied by individuals and their content reused as fertiliser in agriculture or aquaculture either directly of after on-farm composting with other waste. About 70 % of the solid waste generated in the urban districts are collected and disposed of in a landfill. A small portion is co-composted with faecal sludge. The uncollected waste is discharged on open dumps or in drainage channels, burnt in the open or recycled. Lakes, ponds and canals in Hanoi are seriously affected by untreated domestic and industrial wastewater. The dissolved oxygen concentration is extremely low and the BOD_5, COD, NH_4^+, and total coliform concentrations increasingly exceed the Vietnamese National Standard "Class B" applicable to irrigation and fisheries.

Water and nutrient flow analysis: A new tool

There is a need to design a more sustainable environmental sanitation concept in Hanoi to allow recycling of valuable water and nutrients without jeopardising health and the environment. To meet this need, we used the material flow analysis (MFA) method, which studies the fluxes of resources used and transformed as they flow through a region. In industrialised countries, MFA proved to be a suitable instrument for early detection of environmental problems and development of appropriate measures (Baccini and Brunner, 1991). The question is how to render such a data-intensive method affordable to developing countries, where data may be scarce and the resources for data collection limited. A tool aiming at answering this question is currently being developed as part of a PhD study (Montangero, 2006). The tool includes a model describing water and nutrient flows within the environmental sanitation system, a database with default values for some of the model parameters and a series of plausibility criteria allowing to crosscheck some of the model outputs with values from reliable data sources. According to the recommended approach,

Photo 1: Wastewater irrigation in Thanh Tri, Hanoi.

Sandec

Le Ngoc Cau, Asian Institute of Technology Center in Vietnam, Hanoi, Vietnam.

Nguyen Viet Anh and Pham Thuy Nga, Centre for Environmental Engineering of Towns and Industrial Areas, Hanoi University of Civil Engineering, Hanoi, Vietnam.

Vu Dinh Tuan, National Institute for Soils and Fertilizers, Hanoi, Vietnam.

Hasan Belevi, Institute of Environmental Engineering, University of Innsbruck, Innsbruck, Austria.

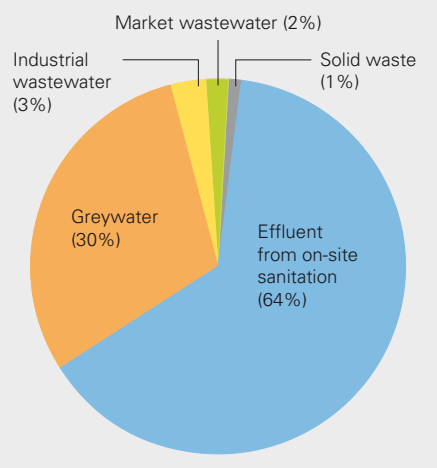

Figure 1: Origin and fraction of the different phosphorous sources in surface waters.

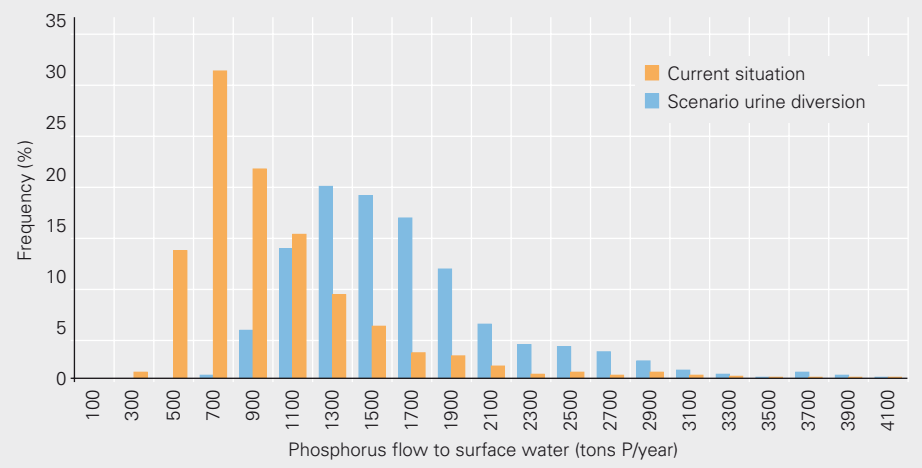

Figure 2: Frequency histogram illustrating P flow to surface water (tons P/year).

a preliminary flow assessment is carried out prior to field measurements. The model parameters are quantified on the basis of local knowledge, local reports and statistical data. Unknown parameter values are estimated by using the available database and interviews conducted with experts. Water and nutrient flows are subsequently calculated on the basis of the first estimated parameter values. Uncertainty and sensitivity analyses as well as a plausibility assessment are conducted on the basis of the outputs of the model. The parameters are newly quantified if the key variables reveal large uncertainties or if certain model outputs are not plausible. Sensitivity analysis allows identification of the parameters requiring further assessment so as to lower the degree of uncertainty of the key variables. Since this iterative approach contributes to reducing the costs required for data collection, it also renders MFA application more affordable.

Photo 2: Street drain in Hanoi city.

R. Scheidegger

Water and nutrient flows in Hanoi

Water, nitrogen and phosphorous flow were assessed in Hanoi's environmental sanitation system and the results subsequently used to discuss key issues related to water and nutrient management in Hanoi.

Application of the tool on phosphorus loads

The following example illustrates the results obtained for one of the key issues – the phosphorous load in surface waters. Liquid effluents from septic tanks as well as greywater are the main sources of phosphorous contamination of surface waters in urban and peri-urban areas (Fig. 1). According to the model, septic tanks cannot effectively retain nutrients, as merely 7–12 % nitrogen and 13–28 % phosphorous entering the septic tanks are removed with faecal sludge. The remaining nutrients leave the tanks with the liquid effluent. Unlike septic tanks, urine diversion latrines immobilise most of the nutrients either as stored urine or dehydrated faecal material. These products could be reused as fertiliser and soil conditioner in peri-urban agriculture. Assuming that the septic tanks in Hanoi are replaced by urine diversion latrines, the phosphorous load in surface waters could be reduced by 42 % or from 1,572 ± 601 to 905 ± 557 tons/year (Fig. 2). This would further lead to a reduction in phosphorous demand and, hence, in raw material consumption.

Conclusion

The developed tool aims at supporting planners and decision-makers in establishing a comparison between the different environmental sanitation options and not at modelling the flows as accurately as possible. The information on water and nutrient behaviour, acquired through use of the tool under different environmental sanitation scenarios, can be fed into discussions with the different stakeholders on appropriate environmental sanitation options during the planning process. This study only focuses on water, nitrogen and phosphorous flows. However, other factors must also be taken into account when developing environmental sanitation concepts. The fate of other materials in the system, such as organic matter and toxic substances (heavy metals, persistent organic pollutants, endocrine disrupting substances, and antibiotics), should also be addressed. Moreover, the costs of the various environmental sanitation scenarios should be estimated since they are decisive in the selection of environmental sanitation options. ○ ○ ○

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NCCR North-South Programme Phase 2

The National Centre of Competence in Research (NCCR) North-South is one of 14 long-term research programmes implemented by the Swiss National Science Foundation (SNSF) in areas of vital strategic importance for the scientific and socio-economic advancement in Switzerland.

NCCR North-South focuses on international research cooperation and promotes high-quality disciplinary, interdisciplinary and transdisciplinary research with the aim of contributing to an improved understanding of the status of different syndromes of global change, the pressures and causes of these syndromes on different resources (human, natural, economic) and the responses of different social groups and society as a whole.

Within the framework of the first phase of the NCCR North-South programme (2001–2005), Sandec was able to generate considerable knowledge in the field of environmental sanitation, though with a strong disciplinary focus. To increase the interdisciplinary and transdisciplinary relevance of its work in the second phase (2005–2008), Sandec has formalised its collaboration with the Swiss Tropical Institute (STI) to form a work package (WP) on health and environmental sanitation.

The goal of this WP is to establish – through focused research – new evidence in the fields of health, health systems and environmental sanitation to assist in attaining the Millennium Development Goals – particularly MDGs 4–7 in urban settings and semi-arid contexts, with focus on the most vulnerable population groups.

Sandec

Improving environmental sanitation to reduce health risks of the urban poor stands at the centre of work package 3 in phase 2. Poor family from Nouakchott, Mauritania.

In environmental sanitation, research emphasis will be placed on investigating and defining the keys to improving excreta and wastewater management, and developing methods to reduce health risks by improved environmental sanitation among the mobile populations and the urban poor. Specific research activities will focus on strategic sanitation planning issues, using the HCES approach, and developing further the methodology of Material Flux Analysis (MFA) as a planning and decision-support tool while extending its scope to pathogen flows and associated health risks.

The purpose of health research is to investigate and define the determinants related to health, including interventions in social systems. This will allow successful translation of research results into public health and social practice strategies by (1) monitoring and analysing the dynamic performance of health systems and (2) improving access to and use of services, treatment and health care.

For more details please visit
http://www.nccr-north-south.unibe.ch/

Composting, a Component of the Clean Development Mechanism (CDM)

The Clean Development Mechanism is designed to facilitate and render more efficient the meeting of the greenhouse gas (GHG) emission reduction targets as established in the Kyoto Protocol. Under the CDM, an industrialised nation with a GHG reduction target can invest in a project of a developing country and claim credit for the reduced emissions achieved by that project.

Waste Concern, a research partner of Sandec in Bangladesh, has succeeded in introducing composting as a CDM project component. A developed methodology credits composting of waste, which would have otherwise been landfilled. By channelling the waste to a composting plant, the project prevents methane emissions from anaerobic decomposition of landfilled waste. As composting is basically an aerobic process, methane emissions are thus replaced by less damaging CO_2 emissions.

An MSc thesis conducted at Sandec has analysed the financial aspects of the Clean Development Mechanism in decentralised waste management and wastewater treatment projects in developing countries. It comes to the conclusion that high transaction costs and risks in CDM approval favour large centralised projects. Although many decentralised projects contribute significantly to poverty alleviation and sustainable development, they cannot compete with large centralised projects, which meet the emission reduction targets at minor cost. To render decentralised projects more viable, their contribution to sustainable development should be monetised or the institutional design of the CDM altered so as to lower the hurdles for small and decentralised projects.

Further details are available from
www.sandec.ch

Decomp Database – A Platform for the Exchange of Information on Decentralised Composting in Low and Middle-income Countries

Numerous decentralised composting schemes are operated in low and middle-income countries; however, the initiators, i.e. municipalities, businesses, NGOs, community-based organisations or individuals, are often unaware of the existence of other schemes. This inaccessible expertise and know-how thus compels these initiators interested in implementing decentralised composting to go through the same trial and error phase.

The *decomp database* attempts to bridge this information gap by supporting the exchange of information and strengthening a global composting network. This Internet database contains a worldwide collection of small and medium-size composting sites with main focus on schemes in low and middle-income countries. The database contains key information on different composting schemes and provides contacts for the exchange of further information. Access and use of the *decomp database* are free of charge, and experts are invited to feed the database with their own composting initiatives. You are welcome to explore the *decomp database* at http://sandec.instanthost.ch

If you have further questions, please contact Silke Drescher or Chris Zurbrügg
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Understanding Vulnerability and Resilience in Environmental Sanitation

Understanding and enhancing local resilience to risks is increasingly regarded as an important factor in sustainable development projects. Our knowledge on the essence of resilience, the manner in which it can be described and analysed, and especially its fostering possibilities are still limited. Understanding resilience – for instance towards risks and adversities of deficient excreta, wastewater or solid waste management – draws our attention to the strengths and capacities to cope, recover and adapt, as well as on the ways in which political and civil entities can enhance or erode this strength. Such questions should not only be examined on individual or household level, but also include the community and higher levels of society. In the following 4-year phase of the NCCR North-South research programme, Sandec, in collaboration with the Swiss Tropical Institute (STI), will be committed to combining its activities and focus on determining vulnerability and resilience with regard to environmental sanitation. After exploring existing methods of situation analysis, the respective approaches will be complemented with specific tools of resilience assessment and subsequently tested in selected case studies. A multi-scale analysis of how social stakeholders manage risks may pave the way to strengthening resilience and upscaling approaches.

The Sandec Team

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The Sandec team from left to right:
Back: Stefan Diener, Antoine Morel, Roland Schertenleib, Martin Wegelin.
Middle: Silke Drescher, Regula Meierhofer, Agnès Montangero, Christoph Lüthi, Caterina Dalla Torre, Doulaye Koné, Chris Zurbrügg.
Front: Prem Gurung, Martin Strauss, Halidou Koanda, Alexandra Baumeyer, Kim Müller
Not present: Sylvie Peter, Dionys Forster, Monika Schaffner, Matthias Saladin, Christian Müller, Ives Kengne, Noah Adamtey.

New Faces

Christoph Lüthi joined the Sandec team last November and reinforces the Strategic Environmental Sanitation Planning Unit (SESP). He is an urban development planner by profession and will be mainly working in the further development and application of the "Household-Centred Environmental Sanitation Approach" (HCES). He will also be active in the Swiss-funded NCCR research programme in close collaboration with the EPFL in Lausanne, studying "Innovations in decision-making processes for sustainable urban projects".

On the Bookshelf

Apart from the publications cited in the text, we recommend the following new books and publications as key readings in the water and sanitation, solid waste management and water treatment sector:

Water and Sanitation

Community-driven development for water and sanitation in urban areas – Its contribution to meeting the Millennium Development Goal targets
Community organizations working with local NGOs have been responsible for many of the most cost-effective initiatives to improve and extend provision for water and sanitation to low-income urban households. Some have achieved considerable scale, especially where water and sanitation utilities and local governments work with them. This publication describes many such initiatives and discusses their relevance for meeting the Millennium Development Goals (MDGs) target for water and sanitation.
By Satterthwaite D., McGranahan G. and Mitlin D., April 2005. Available from
wash-cc.org/res/publications.php

Sanitation and Hygiene Promotion – Programming Guidance
This document focuses on a selection of the interventions identified by the Hygiene Improvement Framework (improved sanitation at the household level, access to soap, hygiene promotion and the enabling environment), while recognising that others (such as improved water supply, solid waste management, better drainage, school sanitation and so on) are also important if the health benefits of sanitation and hygiene promotion are to be realised.
By USAID, WSSCC, UNICEF, WHO/PAHO, WEDC, the Water and Sanitation Program (WSP) and the London School of Tropical Medicine and Hygiene, April 2005. Available from
wash-cc.org/res/publications.php

Public-Private Partnerships for Water Supply and Sanitation. Policy Principles and Implementation Guidelines for Sustainable Services
Striving for reliable and effective partnerships and good governance in water and sanitation issues, these documents – "Policy Principles" & "Implementation Guidelines" aim at supporting sound, reliable and unambiguous relationships, institutions and processes.
By SDC, SwissRE, SECO, April 2005. Available from www.partnershipsforwater.net

Biological Wastewater Treatment in Warm Climate Regions
Gives a state-of-the-art presentation of the science and technologies of biological wastewater treatment, particularly domestic sewage. The book covers the main treatment processes used worldwide with wastewater treatment in warm climate regions given a particular emphasis where simple, affordable and sustainable solutions are required. Two volumes.
By Von Sperling M., de Lemos Chemicharo CA., 2005. Available from www.iwapublishing.com

Urban Stormwater Management in Developing Countries
The purpose of this book is to disseminate contemporary knowledge and practical experiences concerning problems and solutions related to urban hydrology and drainage. Although the main focus is on developing countries, the book draws from experiences in many other parts of the world. Based upon numerous practical examples and case studies, the book provides information to assist in the management, planning and engineering design processes.
By Parkinson J., Mark O., October 2005. Available from www.iwapublishing.com

Water for Life: Making it happen
This report makes clear that achieving the target of the Millennium Development Goals (MDGs) for access to safe drinking water and basic sanitation will bring a payback worth many times the investment involved. It will also bring health, dignity and transformed lives to many millions of the world's poorest people. The humanitarian case for action is blindingly apparent. The economic case is just as strong. The International Decade for Action Water for Life provides the incentive for coordinated efforts to prevent the daily disaster of unnecessary deaths.
WHO/UNICEF, 2005, ISBN 92 4 156293 5. Available from www.who.int

Meeting the Financing Challenge for Water Supply and Sanitation: Incentives to Promote Reforms, Leverage Resources, and Improve Targeting
This paper, a review and synthesis of innovative financing in the water and sanitation sector, emphasises the critical importance of mechanisms that 1) promote and support sound policies and reform, 2) leverage more domestic resources from providers, users, and local governments, and, 3) help to improve the use of subsidies for the poor. Its main objectives are to develop a framework for a review of financing mechanisms for water supply and sanitation; provide a global review of financing mechanisms, on the development and use of innovative financing mechanisms; and, identify the directions for further research.
By Mehta M., UNDP-Water & Sanitation Program series, May 2003. Available from
www.worldbank.org

Advocacy Sourcebook: A guide to advocacy for water, sanitation and hygiene
This Sourcebook aims to compliment the approach of putting people's initiative and capacity for self-reliance at the centre of achieving the water and sanitation targets. It offers practical guidance on advocacy work related to water and sanitation and is a useful resource for anyone working involved in WASH who wants to undertake advocacy work. It aims to explain the different advocacy tools, give practical examples of advocacy work and provide information on key policy actors and processes and how to influence them at local, national and international levels.
WaterAid, WSSCC, December 2003.
Available from
www.wash-cc.org/res/publications.php

Listening – To those working with communities in Africa, Asia, and Latin America to achieve the UN goals for water and sanitation
This publication attempts to bring to an international audience the views of some of those who are too rarely heard in the international development debate – the practitioners who work with communities.
"Listening" also prepares the way for a regular People's Right to Water and Sanitation Report to be published by the WSSCC every two years, beginning in 2005 and continuing until the 2015 target year for reaching the Millennium Development Goals.
WSSCC, February 2004. Available from
www.wsscc.org

Solid Waste Management

Private Sector Involvement in Solid Waste Management. Avoiding Problems and Building on Successes
This publication presents a picture of the current state of private sector provision of solid waste management services, mainly in low and middle-income countries, by drawing on case studies and reports of experience from many diverse situations in four continents.
By Coad A., published by GTZ, 2005. Available from www2.gtz.de/dokumente/bib/05-0412.pdf
Short version available from www.cwgnet.net/documentation/skatdocumentation.2005-12-02.1545617642/file

Improvement of Sanitation and Solid Waste Management in Urban Poor Settlements
This document provides a reader's digest to a publications series on sanitation and solid waste management in urban poor settlements, which was first published in German by the GTZ between 2001 and 2004 in the context of a sectoral project financed by the German Federal Ministry for Economic Cooperation (BMZ). To make this publication available to a wider professional audience, particularly to cooperation partners in the South, it was translated into English in 2005.
By Samol F., Herrle P., Jachnow A., Vest H., El Shorbagi M., Bockelmann D. Available from
www2.gtz.de/dokumente/bib/05-0768.pdf

Water Treatment

Training Manual for SODIS Promotion
The training manual contains a description of important factors that contributed to the success of previous SODIS projects - the acceptance and sustainable application of the method. The manual contains information on the kind of aspects to consider during assessment and preparation of a SODIS project as well as a description of training approaches and participatory education tools. The information presented in the booklet will support organisations working in the field of community health education and assist them in successfully planning and implementing SODIS activities.
February 2006. Available from
www.sodis.ch/files/TrainingManual_sm.pdf