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Capacity strengthening in sanitation: benefits of a long-term collaboration with a utility and research institute

M. Bassan and L. S. Strande, Switzerland

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Sanitation investments in Africa have largely failed to meet the Millennium Development Goals. Many, sewer-based wastewater treatment plants provide inadequate treatment, and faecal sludge from onsite treatment in urban areas is largely untreated. The National Office of Water and Sanitation in Burkina Faso and the Department of Water and Sanitation in Developing Countries in Switzerland are involved in a collaboration designed to increase institutional aptitude, and develop sustainable long-term wastewater and faecal sludge management solutions. The developed approach evaluates and fills gaps in existing infrastructure, operational ability, local knowledge, and institutional procedures. The continuous communication between the partners has resulted in a synergy and increased level of commitment. This paper presents results and future plans of this utility - research approach that has resulted in training and capacity development plans and a much greater understanding of sanitation management. The lessons learned are transferable to other countries, institutes and sectors.

Introduction

Sanitation and wastewater treatment investments in Sub-Saharan Africa (SSA) have failed to meet the Millennium Development Goals (MDGs) for sanitation, leaving 580 million people without access to "improved" sanitation (Anand, 2006)(UNICEF, 2008). Many existing wastewater (WW) treatment plants are not operational due to a lack of financial and technical resources (Koné, 2002 and 2010). In urban SSA, the majority of people with access to sanitation are served by onsite systems, not WW sewer and treatment plants. Faecal sludge (FS) from onsite systems (e.g. pit latrines and septic tanks) is frequently dumped untreated directly into the environment. FS dumping results in environmental contamination, and ultimately means that sustainable sanitation goals are not met, even if there is access to "improved" sanitation. WW and FS management is especially problematic in cities with rapidly increasing, unplanned development (Strauss and Montangero, 2002). There is a great need for appropriate WW and FS treatment technologies that are cost efficient, do not have large energy demands, are robust, and achieve adequate levels of treatment (Kayombo et al., 2004)(Kengne, 2006).

Facing challenges of public health and sustainability of environmental resources, the National Utility of Water and Sanitation (ONEA) in Burkina Faso adopted a National Sanitation Strategy in 1996 (Vezina, 2002), becoming one of the first West African utilities to adopt a strategic plan that includes management of WW and FS. The strategy defines global principles for sanitation, and their application has led to the planning and implementation of WW and FS management. Construction of a sewer network and wastewater stabilization ponds (WSPs) was completed in 2004 in the capital Ouagadougou, with reclamation of the WSP effluent in agriculture. Water reclamation has great potential to reduce disease burden in West Africa, where currently 50 to 90 % of vegetables consumed in urban areas are cultivated with polluted water (e.g. WW) (Ouédraogo et al., 2008)(Drechsel et al., 2010). However, ONEA has experienced problems with operations and maintenance (O&M) of their WW infrastructure. By 2012 ONEA plans to implement treatment of FS from onsite systems at two treatment facilities in Ouagadougou. Thus, ONEA is faced with the challenge of effectively managing the existing WSPs, as well as the construction of FS treatment facilities for the population served by onsite sanitation systems. ONEA has demonstrated their willingness to try novel approaches for WW and FS management, but is lacking an adequate institutional framework to ensure the success of implemented solutions. A three year collaborative partnership facilitated by The French Agency for Development (AFD) has been established to address this. The project is led by ONEA, in collaboration with the department of Water and Sanitation in Developing Countries (Sandec) at the Swiss Federal Institute of Aquatic Research (Eawag). The mandate includes strengthening of institutional and technical capacity in design, construction, operation, and scientific monitoring of the WSP and planned FS treatment plants.

The goal of the project is to develop a holistic approach to fulfil sanitation goals that addresses unique local conditions through continuous collaboration with stakeholders. This paper presents realized and potential future benefits in Ouagadougou of the first long-term project of this type in West Africa. ONEA has demonstrated that they can be a leader in sanitation solutions in West Africa through their commitment to this novel approach and the resulting solutions that are being developed. The lessons learned can be expanded to other countries and applied to other sectors, for example drinking water and energy.

Materials and methods

Burkina Faso is a land-locked country in the centre of West Africa, in the Soudano-Sahelian region. The population of the capital Ouagadougou is 1’475’233, (INSD, 2008). It is served by an international airport, has food and textile industries, and is experiencing growth due to immigration from surrounding rural areas. The annual rainfall is 500 - 900 mm, with the majority of the rain in July and August (Sou, 2009).

Wastewater

The WSPs in Ouagadougou were designed for 100’000 population equivalents (Dodane et al., 2006), with the flow diagram presented in Figure 1, which also shows the planned area for the FS treatment plant. The treated effluent is used for irrigation in a 10 hectare agricultural area (AFD, 2010). In addition to domestic wastewater, a large amount of the influent is industrial from a brewery, a slaughterhouse and a tannery. Some of the important parameters in the National Discharge Standards for industrial discharge into the sewer and for wastewater discharge into surface water are presented in Table 1 (DGPE, 2001).

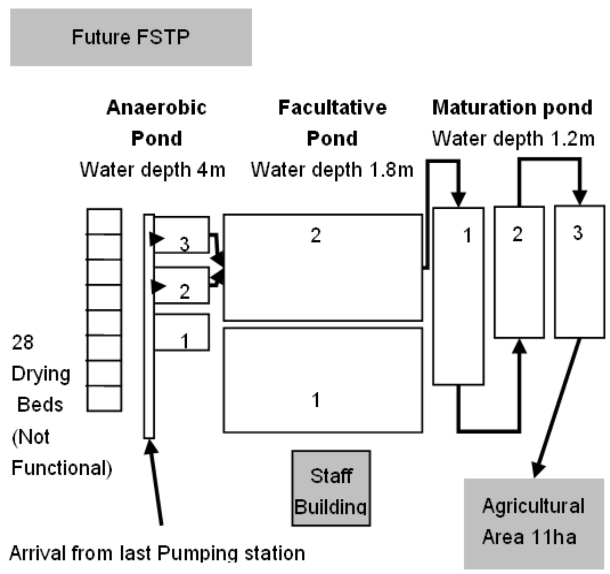

Figure 1. WW treatment plant flow diagram in Ouagadougou and site of future FS treatment plant

Faecal sludge

88% of Ouagadougou is served by onsite sanitation systems, and FS production from these systems is estimated to be 500 - 1’000 m^3/day (Somda, 2006)(Koanda, 2006)(Pöyry, 2010). Initially, ONEA plans to construct two FS treatment plants consisting of unplanted vertical flow drying beds, each being designed to treat 125 m^3/day. Effluent from the drying beds will be treated in WSPs along with WW (described above) and solids dried for six months to ensure removal of pathogens. Following construction and operation of the two FS treatment plants that will treat half of the city faecal sludge, the lessons learned will be used in the design and implementation of further FS treatment plants. The possibility of increased performance with planted versus unplanted drying beds will be evaluated through field studies using two of the planned drying beds. FS characteristics are variable, and a comprehensive characterization of FS in Ouagadougou has not yet been carried out. Also, little is known about the organisation and capacity of the entrepreneurs that empty and transport FS ("emptiers"). FS characterization and formalizing the FS emptying sector are therefore included in the project.

Stakeholders

Stakeholders that have been regularly engaged in the project include employees of ONEA, FS emptiers, local universities (University of Ouagadougou, 2iE), and NGOs (CREPA, Water Aid). Stakeholders that are involved in annual workshops include: Ministries in charge of water, wastes, and health; local municipalities; AFD; and journalists.

Areas of research focus

Research for the three year programme was developed around the following three central areas. They were selected to identify weaknesses, stakeholders and appropriate solutions:

1. Assessment and optimisation of the existing WW treatment
2. Filling knowledge gaps to achieve adequate FS management
3. Ensuring value-added treatment by-products.

Assessment and optimisation of the existing wastewater treatment

To aid ONEA in identifying reasons for their WW operation and maintenance difficulties and provide adequate solutions, studies have been and are conducted to understand the operating conditions. A study focused on industrial discharge will evaluate existing pre-treatment technologies, industrial WW characteristics, and treatment options. This is being done through literature reviews, site visits, laboratory analyses and interviews. Another study focused on the design, treatment performance and monitoring procedures of the WSPs. This was done through interviews, site visits, review of documents and lab analysis. Physical (pH, T°, Conductivity, TSS, TVS), chemical (COD, BOD_5, Nitrate, Total Phosphorus, Orthophosphate) and microbiological (E. Coli and Total Coliform) parameters were analysed according to AFNOR standard methods. Samples were taken at 10 AM and 15 PM two days per week from the 12th of July to the 18th of August 2010 and then combined for analyses. The final goal was to provide ONEA with recommendations for both design and monitoring plans.

Filling knowledge gaps to achieve adequate faecal sludge management

Prior to the design of the FS treatment plant, studies will be conducted to characterize FS throughout the city and provide ONEA with an overview of FS emptying and transport. Following construction of the FS treatment plant, studies will be conducted to evaluate and optimize the drying bed performance and assess the financial and institutional viability of the operation. This evaluation will be based on studies that were previously conducted in Dakar, Senegal (Mbeguere and Koné, 2009). The goals are to optimize technical operation (e.g. truck circulation, screener waste removal, bed load, drying time and removal of dried sludge), to ensure effluent quality of the new FS treatment plants through weekly laboratory analyses and to provide ONEA with financial and institutional operation plans.

Ensuring value-added treatment by-products

Value-added treatment by-products that are marketable to local agriculture and industry could provide a way to help finance the entire sanitation service chain, and reclaim valuable nutrients and organic material. Studies have been conducted to evaluate the market demand for by-products of FS and WW treatment processes. Interviews were conducted with local farmers who are currently using the WSP effluent for irrigation to assess their working conditions (availability of sanitary infrastructure and potable water, type and frequency of water-borne diseases, income level, and difficulties encountered). Results of laboratory analyses were compared to the WHO Guidelines for the Safe Use of Wastewater, Excreta and Greywater in Agriculture (WHO, 2006). The feasibility of selling plants from FS drying beds for animal fodder was also evaluated. This was done through a literature review, interviews, identification and characterisation of suitable plants that are already used locally for fodder, and a market demand study. Once the FS treatment plants are constructed, the optimal FS loading rate to ensure plant acclimatisation and treatment performance will be evaluated on two of the drying beds.

Collaborative capacity strengthening and procedure optimisation

To ensure that there is an ongoing and close collaboration between ONEA and Sandec, workshops, training sessions and frequent meetings are held to capitalise information. Needs analyses are employed to assess the strengths and weaknesses of sanitation, laboratory, operation and maintenance services at the material, technical, human resource, internal and external procedure levels. This has involved several interviews with employees, as well as document consultation and site visits. The needs analyses resulted in the identification of priority needs for capacity strengthening in infrastructure operation, maintenance, and monitoring. Quality plans were discussed to answer these priority needs and have already been applied. They will be regularly assessed and optimised through monthly meetings in order to ensure the process sustainability, also following the end of this project. In addition to the training sessions, workshops are organised internally with employees of ONEA to capitalise research study results, and the information on internally led activities to define optimisation strategies. This increases the understanding for ONEA employees of FS and WW related issues and provides ONEA with stronger management capabilities. Other workshops have been organised with local stakeholders to ensure that their needs are being satisfied, and to share information on the WW and FS institutional setup.

Results and discussion: research results, collaborative capacity strengthening and procedure optimisation

Assessment and optimisation of the existing wastewater treatment

Evaluation of the WSPs in Ouagadougou revealed significant degradation due to poor maintenance and inadequate consideration of the local context during design. The soil around the WSPs was not adequately protected against intense seasonal rains resulting in furrowing of the dams, and increasing the possibility of leaching from the WSPs. In addition, reptiles and rodents have dug extensive galleries in the dams, and there is uncontrolled plant growth around the edges of WSPs, and throughout unused ponds. The WSP effluents did not meet national standards for pH, COD, TSS and orthophosphates. The results of important parameters monitored are presented in Table 1, together with the National Discharge Standards.

Table 1. Mean, extreme and performance of analysed parameters of WSPs in Ouagadougou, and National Discharge Standards

Parameter	Standard for discharge into sewer(1)	WSP influent(2)	WSP effluent(2)	WSP % removal(2)	Standard for discharge into environment (1)
pH (-)	6.4-10.5	8.3 (6.0-11.7)	8.4 (7.0-8.6)	-	6.4-10.5
Total suspended solids (mg/l)	100	266 (99-671)	110 (73-142)	59%	200
COD (mg/l)	2000	810 (285-1240)	254 (128-346)	44%	150
Filtered BOD_5 (mg/l)	800	504 (372-700)	21 (13-25)	96%	50
Nitrate (NO_3) (mg/l)	90	3 (0-6)	2 (0-7)	17%	50
Orthophosphates (mg/l)	50	29 (15-51)	26 (7-38)	13%	5

sources: (1) DGPE, 2001; (2) Ouédraogo, 2010

It appears that one of the main problems that ONEA has in meeting National Discharge Standards is the lack of industrial pre-treatment, and influent variability based on industrial activity (Kiemde, 2006)(Dodane et al., 2006). For example, the pH of the WSP influent varied from pH 6 to pH 11.7. Both extremes could be responsible for hindering the operational performance of the WSPs. A 44% removal efficiency of COD is also low compared to typical WSPs, which are normally in the range of 60-80% (Conseil Général de Seine-et-Marne, 2008).

Figure 2 shows the results of the monitoring plan in this study, compared to the ongoing ONEA monitoring plan. Significant differences were observed for TSS as the gravimetric method was employed in this study, and a DR2010 spectrophotometer by ONEA. Other differences are most likely explained by the different sampling regimes. This study took samples twice daily, whereas ONEA only sampled once each week on Mondays. Sampling regimes that take into account variable loadings from households and industries are more representative of the actual operating performance. Loadings reached a peak mid-day and mid-week, and COD, TSS and nitrates were nearly double on Thursdays as they were on Mondays (for material reasons, BOD5 was only analysed on Monday for both monitoring plans) (Ouédraogo, 2010). Important recommendations included protection of the WSP boundaries with masonry coverage, improved maintenance, and composite sampling throughout the week in the monitoring plan.

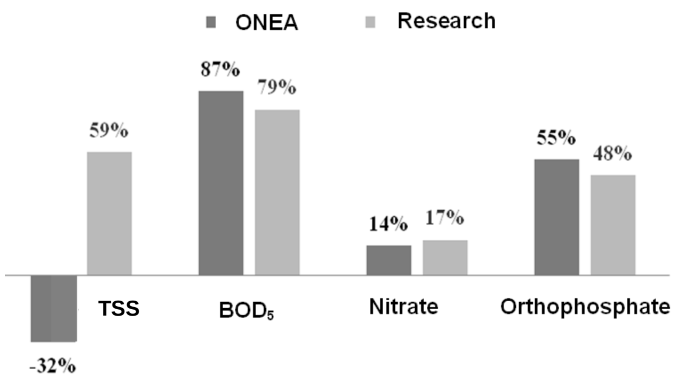

Figure 2. Analysis results difference between ONEA and study monitoring plans

Source: Ouédraogo, 2010

Ensuring value-added treatment by-products

Interviews were conducted with 50 farmers with a history of working in the agricultural area located next to the WSPs. Results revealed poor working conditions and poor plant growth rates. Based on these conditions, many farmers that had been allocated a parcel of land had ended up leaving the area. 96% of the interviewed farmers blamed poor water quality for the low production rates. This observation has been confirmed by results of Sodium Absorption Ratios (SARs) analyses of 14, which exceed the maximum accepted value for irrigation (Sou, 2009). Results of microbiological analyses confirmed that Food and Agriculture Organisation (FAO) standards of less than 1000 Faecal Coliform / 100 ml are being achieved (FAO, 1992). However, the sanitary conditions at the effluent reclamation agricultural area are not good, with 85% of the farmers reporting not washing their hands after contact with irrigation water, and 27% complaining of itching. This is due to the lack of potable water and sanitation services, as well as the inadequate irrigation techniques that do not provide barriers for human health protection (e.g. most farmers are directly exposed to reclaimed water). Potable water, hand washing facilities, showers, irrigation equipment, and adequate protection need to be available for the famers in a secured area to avoid vandalism. Further studies should be conducted to determine solutions for improved productivity and sanitary conditions with water reclamation. Tilling and addition of organic matter should be investigated for areas where the soil has become too compacted. Other solutions to be considered include timing of irrigation to reduce evaporation and SAR, dilution, improved treatment of suspended matter, and culture of saline tolerant cereals or trees (Sodré, 2010).

Results of the evaluation of optimal plants for potential planted FS drying beds, and the market potential for fodder plants, highlighted the importance and viability of the fodder market in Ouagadougou. There are four cattle markets and five locations where cattle fodder is sold. The revenue potential for fodder plants is at its greatest during the dry season. Interviews revealed that 90% of fodder sellers were interested in plants cultivated in drying beds and 86% of cattle owners were interested in purchasing them. 70% of cattle owners said they would accept paying for the plants up to the normal market price. In order to limit transport expenses and optimize capital received from sales, the transactions should be limited to a few larger-scale cattle operations. Two species of plants were selected for evaluation in the planted drying bed trials that are already sold in the local fodder market: Sporobolus pyramidalis and Echinochloa pyramidalis. Both of these species grow well in wet environments, reproduce by cutting or rhizomes, and have strong root development (Somé, 2010).

More means set up to answer the needs of sanitation services

The needs analyses revealed the following areas that need to be addressed to increase ONEA's abilities to plan, design, operate, maintain, monitor, and capitalise upon knowledge and experience:

1. Human resources
2. Specific knowledge for management of future projects and existing infrastructures
3. Internal and external procedure to ensure institutional efficiency in these activities
4. Material and equipment for operation, maintenance and monitoring
5. Information capitalisation procedures.

These five points were discussed with employees of ONEA during individual meetings, training sessions and workshops, and their importance was confirmed during this process. To fulfil these needs, a quality plan for O&M and monitoring, and training and human resource development plans were elaborated, and their future success will be ensured through the following educational planning and workshops, as well as monthly meetings to monitor and optimise the plans implementation.

Educational planning and workshops

The training plan was designed to strengthen the overall knowledge of WW and FS management within ONEA. The first training session for ONEA employees was held in October 2010, the topic was the overall WSP infrastructure, operating principles, and effective monitoring programs. During this training, clear tasks and objectives were defined for employees responsible for O&M of the infrastructure, and an analysis plan and monitoring sheets were discussed. Positive results of this educational session have been further demonstrated by the commitment of employees that request implementation of the defined monitoring tools. Topics of future training sessions will include the determination of helminth eggs and viability, and the management and monitoring of sewer networks. There will also be a training session held in Dakar Senegal, to learn from the FS treatment experiences there, and a final session in Ouagadougou on operational principles and procedures following construction of the FS treatment plants.

In addition to the internal ONEA training sessions, workshops have also been organized with local authorities, NGOs, academic institutions, and FS emptiers. Topics have included recommendations of the needs analyses and research studies, as well as developing an adequate institutional framework for FS management. The workshops and meetings with emptiers have led to a better understanding of their capacity, and organisational ability, and clarification of the regulations and responsibilities of ONEA, the emptiers, and local municipalities through official texts.

Mechanisms to ensure future success of sanitation infrastructure

The remaining challenge is the long-term individual and institutional commitment to implementing the developed sanitation solutions. The collaboration between ONEA and Sandec has already resulted in a strong partnership and exchange of knowledge. In addition to the strong initial commitment by ONEA with the adoption of a National Sanitation Strategy and several Strategic Sanitation Plans, many mechanisms are in place that will help to ensure future success. First of all, the collaboration is based on developing and exchanging knowledge, as opposed to a philosophy of one way knowledge transfer. This exchange is critical for developing new and innovative sanitation solutions as well as developing confidence in them. Concrete solutions and research results are also enhancing Sandec's knowledge, dissemination strategies and future approaches. The understanding and commitment to success throughout ONEA on WW and FS management is also raised through synergistic activities including Masters' theses of ONEA employees based on their work in this project. The incorporation of local stakeholders has also generated a commitment to sanitation throughout the community (e.g. FS emptiers, municipality). The project relationship will most likely continue for longer than the initially envisioned three years in order to conduct ongoing studies on optimization solutions for the new FS treatment plants, and to continue to develop both partners knowledge. Finally, the project leadership by ONEA will facilitate transition at end of the project.

Conclusions

Lessons learned to ensure the long-term sustainability of sanitation projects in other locations in Burkina Faso, as well as to other countries and sectors include:

- Investment of, and project lead by local partner,
- Importance of identifying and acknowledging internal strengths and weaknesses of each stakeholder,
- Development of sustainable plans and approaches for the long-term technical and institutional management,
- Implementation of the developed solutions for at least a year of the collaboration,
- Development of adequate laboratory capacity to ensure future success of monitoring programs,
- Development of capitalisation procedures of the knowledge and experience developed during and after the project to ensure success of design, implementation, and operation of future projects,
- Generation of value-added treatment end-products for the financial sustainability of the entire system.

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Contact details

Name of First Author: Magalie Bassan
Address: 265 rte de Malagnou, 1225 Chêne-Bourg.
Tel: +41 (0)78 743 51 64
Fax: +41 (0)44 823 53 99
Email: magalie.bassan@gmail.com
www: www.sandec.ch/

Name of Second Author: Linda S. Strande
Address: Ueberlandstrasse 133, 8600 Duebendorf
Tel: +41 (0)44 823 55 53
Fax: +41 (0)44 823 53 99
Email: linda.strande@eawag.ch
www: www.sandec.ch/