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Operation and maintenance strategies for resource-oriented sanitation systems in Nakuru, Kenya

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Maximum benefits of improved sanitation will be achieved when sanitation facilities operate continuously and to full capacity in conformity with acceptable standards of quantity and quality. However, there is a demonstrated link between long term sustainability of a sanitation system and the effective operation and maintenance (O&M) of the system. Diagnosis of O&M services in developing countries show dysfunctions leading to failure. Problems with O&M are recognized as a key constraint to sustainability. Accordingly, operation and maintenance tasks must be carried out effectively and efficiently. To achieve this, O&M of sanitation services must be seen as a holistic system, whose components include collection, storage, transportation, treatment and utilization or disposal. Considerable study has been conducted on O&M of solid waste and urban services but very little information is available on the O & M requirements for resource- oriented sanitation system (ROSA). This paper reports findings of studies whose specific objective were to develop strategies for sustainable O&M for ROSA systems in Nakuru, Kenya.

Introduction and background

The situation of sanitation system throughout Kenya is a source of concern. Most urban and peri-urban areas lack adequate sanitation, while the available facilities are misused, poorly maintained and associated with public health and environmental risks. According to the Ministry of Public Health and Sanitation, out of 34 million Kenyans, 15.64 million (46%), do not have adequate sanitation, as compared to 40% of people around the world without access to improved sanitation (WHO/UNICEF, 2006). Lack of adequate sanitation services is as a result of many factors including: insufficient water, inadequate financial resources, limited institutional capabilities, difficult soil conditions for on-site sanitation and lack of space of expansion. As cities expand and populations increase, the situation will grow worse and the need for safe, sustainable and affordable sanitation systems will be even more critical (Winblad and Simpson-Hébert, 2004).

One of the systems that have become a success story in a number of areas is the Urine Diverting Dehydrating Toilet (UDDT) system. These systems were invented in the late 1990's as a need to find a sustainable, technical and economically viable solution for household level sanitation (Bloh, 2008). Their main advantage over the pit latrine is that they are permanent structures that do not require digging and can be used on rocky grounds as well as loose ground. The system is suitable in flood prone areas and the product can be used as a source of fertilizer.

However, to reap maximum benefits of any sanitation system, the operation and maintenance (O&M) of the system must be carried out effectively and efficiently. The system should operate continuously and to full capacity in conformity with acceptable standards of quantity and quality. Moreover, there is a demonstrated link between long term sustainability of a sanitation system and the effective operation and maintenance of the system. Diagnosis of O&M services in developing countries show dysfunctions leading to failure. Problems with O&M have long been recognized as a key constraint to sustainability of water and sanitation systems and according to Brikké and Bredero (2003), statistics show 30-60% of rural water systems failure due to lack of adequate O&M.

The ROSA project

Resource Oriented Sanitation concepts for peri-urban areas in Africa (ROSA) is an ongoing EU funded project that proposes resource-oriented concepts as a route to sustainable sanitation and to meet the United Nations Millennium Development Goals (MGD's). These concepts are being applied in four pilot cities in Eastern Africa, namely, Arba Minch (Ethiopia); Nakuru (Kenya); Arusha (Tanzania) and Kitgum (Uganda). In all these cities the local project consortium comprises the municipality administration for implementation working jointly with a local university responsible for the research. In Nakuru, the local university involved is Egerton University.

One of the major research topics within the project focuses on Operation & Maintenance of resource-oriented sanitation concepts. The main goal of this study in Nakuru (Kenya) was to propose sustainable O&M management strategies by firstly assessing the existing sanitation situation and their operation and maintenance so as to build a platform from which the strategies can be developed taking into consideration the sustainability factors.

Conventional sanitation system

The current sanitation options used world wide are based on two principles namely flush-and-discharge system (water born sanitation) and drop-and-store system (Winblad and Simpson-Hébert, 2004; Esrey et al. 2001).

In a flush-and-discharge system a relatively small amount of dangerous material, human faeces, is allowed to pollute a huge amount of water. In most cases the resulting sewage is discharged completely untreated into surface waters (Winblad and Simpson-Hébert, 2004). This system is only applicable where there is piped water connection because it requires some 15.000 liters to flush away 50 liters of faeces and 500 liters urine produced by one person per year (Winblad and Simpson-Hébert, 2004). The investment in sewers network and treatment works is high and unaffordable by most municipalities. Most local authorities are not able to meet the basic demand for domestic water supply and it would be impractical to assume they would provide water for waterborne sewerage system. The underlying fact is that large number of the low income peri-urban population will not have access to any form of sewage system in many years to come.

The drop-and-store systems are much cheaper but have many disadvantages. These systems cannot be used effectively on rocky grounds and in densely populated areas where they fill up frequently and require emptying or digging new pits every few years. Where the groundwater is high or during floods, high chances of polluting water resources exist. Pit latrines constructed on loose sandy soils often collapse during flooding and when being emptied (ROSA project team, 2007).

The local authorities, managers, service providers and engineers lack adequate solutions and tools to face the challenges of peri-urban on-site sanitation. Conventional approaches to urban sanitation have proven to be unable to make a significant impact on the dramatic service backlog of nearly half of the world's population. There is a need for new approaches and scientific methods to design and develop appropriate on-site sanitation systems that offer solutions that are healthy, affordable and sustainable to the society.

Resource-oriented sanitation systems

The challenge posed by conventional sanitation can be tackled by the innovative approach based on Resource Oriented Sanitation Concepts or Ecological / Sustainable Sanitation. These systems are based on ecosystem approaches and the closure of material flow, where human excreta and grey water are recognized as resources available for re-use (Winblad and Simpson-Hébert, 2004). These concepts are a way towards a more ecological sound sanitation based on source separation and reuse which has three fundamental principles:

- Containment to prevent pollution rather than attempting to control it after pollution.
- Treatment to sanitize the faeces and the urine.
- Utilization the sanitized products for agricultural purposes.

Operation and maintenance (O&M)

O&M of sanitation systems still receives much less attention than their design and construction. Brikké and Bredero (2003) even say that in many developing countries, operation and maintenance of small community sanitation systems have been neglected. One of the reasons is that under the pressure to extend sanitation services to more people, the budget and staffing for O&M often get lower priority than for construction of

new facilities. Among the consequences are non functioning services and installations and damage to the environment and people's health.

Several studies are available on O&M of solid waste (e.g. Ahluwalia and Nema, 2006) as well as on water and sanitation service and urban services (e.g. Sohail et al., 2001). However there is lack of adequate information on O&M requirements, and cost data for different resource-oriented sanitation systems regarding collection, transport, treatment and utilization of the sanitized products (Braeustetter, 2007). Furthermore, there is no evidence of community based approaches of O&M being rolled out across a city (Sohail et al., 2001).

Implementation and O&M strategies for resource-oriented sanitation systems

Nakuru at a glance

Nakuru town is situated in Nakuru district and is headquarter of Rift Valley Province. It is the 4th largest town in Kenya. It is located 160 km North-West of the capital city of Nairobi and is linked to the rest of the country by the Trans-African Highway starting from Mombasa, through Nairobi to Western Kenya, Uganda and to Central Africa and is situated at 1859 m above sea level. The town is situated between Menengai Crater to the North and Lake Nakuru to the South. It is a cosmopolitan town hosting various races and has almost all tribes of Kenya. The population of Nakuru was estimated to be over 500,000 in 2003 and the growth rate is approximately 7% per annum. The municipal council covers a geographical area of 290 sq. km of which the town takes 102 km² while the rest 188 km² is covered by Lake Nakuru National Park.

As a result of the rapid increase in population, the demand for basic goods and services, including infrastructure such as housing, water and sanitation, street lights, roads, security, information resources centre, among others has increased. This in turn has put a strain on the available resources and it is apparent that the council can not cope with the demand since they lack the institutional, financial and human resource capacity (Nakuru Business Association, 2004).

Base line study

A base line study conducted in 2007 by the ROSA project team established that Nakuru is experiencing serious environmental and sanitation problems. Only 19% of the built-up area is sewered. Septic tanks, cesspools and pit latrines serve the other areas within the municipality. In the high-density areas, unsanitary methods namely defecating in the open, and "flying toilets" are used due to lack of adequate sanitary facilities. Other problems identified were the collapse of pit latrines due to weak soils, flooding of the pit latrine during heavy rainfall and the possibility of contamination of the ground and surface water. Filled up pit latrines were abandoned and there was lack of space to put up new ones or construct septic tanks.

In order to develop a strategy for operation and management of resource-oriented sanitation systems, it is important to understand the existing situation and current management system. A survey was conducted using structured questionnaires to assess the status quo of the sanitation options and the existing operation and maintenance practices and the stakeholders involved in this activity. The study also investigated the knowledge and willingness to adopt and operate resource-oriented sanitation systems. The questionnaire was designed with both open-ended and closed questions.

Results and discussions

Type of sanitation system used

Out of 215 respondents, 106 used simple pit latrines, 31 used VIP, 12 used pour flush, 35 used sewered connected and 25 used septic tank. Sanitation facility was not available for 6 respondents. Generally, 31% of the toilets were in good and clean conditions while the rest ranged from fair to poor.

About 60% of the respondents used toilet paper for anal cleaning while 40% used old newspapers.

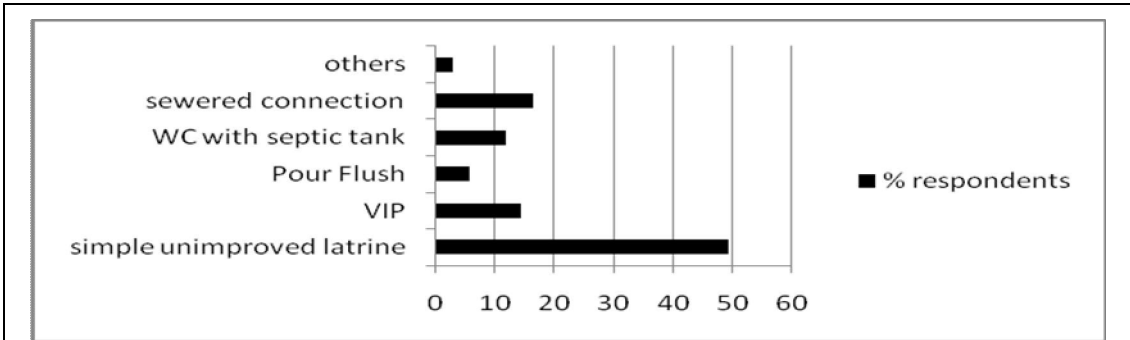


Figure 1. Type of Sanitation in Nakuru Municipality

Source: Muchiri E.W. (2007) field survey

Responsibility of operation and maintenance

There are different players involved in the operation and maintenance of sanitation facilities. The survey identified six stakeholders namely: landlords, owners, tenants, agents/caretakers, municipal council, private service providers. Their involvement is shown in

Figure 2.

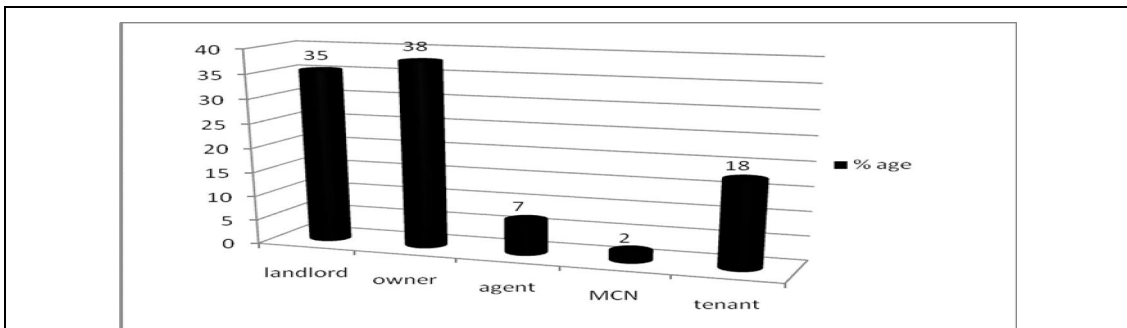


Figure 2. Stakeholders responsibility for operation and maintenance

Source: Muchiri E.W. (2007) Field survey

Knowledge of Resource-Oriented Sanitation

The survey also wanted to find out if there were any respondents who were familiar with resource-oriented sanitation systems or who had at least heard about the concept. Generally, the terms were very new to most of the respondent as is shown in Table 1. However, more than 50% of the respondents were willing to use the system and use the products.

Activity/parameter	Yes (%)	No (%)	No response (%)
Ecosan knowledge	17	83	0
Knowledge of ROSA	21	74	5
Knowledge of urine as a fertilizer	53	47	0
Use of toilet when responsible for O & M	65	34	1
Use of toilet when not responsible for O & M	86	12	2
Willingness to use urine as a fertilizer	53	44	3
Willingness to store urine and faeces	60	30	10
Willingness to use urine and faeces as a fertilizer	61	38	1

One of the crucial outcomes of the study was that 86% of respondents answered they are interested in using an UDDT toilet if they are not responsible for Operation & Maintenance. This result supported clearly the hypothesis that the development of O&M strategies, which are not based on household level only, are of utmost importance for sustainable sanitation systems.

Responsibility for cleaning toilet

The report showed some gender disparity in cleaning the toilets where only 2.0% men cleaned voluntarily. The percentage of women involve in cleaning was 31%, while respondent indicated 12.5% was done by employed house aids. However, 53.7% indicated men were paid to clean the toilets.

The study also found out that in most rental plots, there are no separate toilets for men and women and very few toilets had hand washing facilities installed (table 2). This compromises both the dignity of the users and their health.

Parameter	Yes (%)	No (%)	No response
Separate toilet for male and female	9.7	86.6	3.7
Hand washing after visiting toilet	22.9	72.4	4.7

Overview of implementation area

The ROSA project initially planned to do the implementation in the densely populated peri-urban areas located South-West of Nakuru municipality, namely Kaptembwo, Mwariki and KwaRhonda. However, this became impossible due to the insecurity situation that prevailed in the area during the post-election violence in early 2008. The project changed the implementation site to Hilton and London areas at the North-Western part of Nakuru municipality, which had similar sanitation problems. The areas were also close to the municipal solid waste dumping site where a CBO (named MAWAREMA) makes organic fertilizer from composting market organic wastes and were willing to use urine and faecal material to fortify the compost.

Finally, four sites were identified for piloting sanitation systems based on urine-diversion dehydrating toilets. They included:

- A rental residential plot: 20 households (with an average of 5 people per household) to share three UDDTs. Because of limitation of space it is not possible to construct more toilets.
- House of Fire church and nursery school
- Crater View Secondary School with a student population of 120 girls and 120 boys
- Kaptembwo Primary School with a student population of 900 pupils

Urine –Diversion dehydration toilets for the House of Fire church

The urine diversion toilets are documented in Kvarnström et al. (2006), *Morgan (2007)* and in Winblad and Simpson-Hébert, (2004)

Construction

The first pilot UDDT was constructed at a church and nursery compound to serve the church congregation of about 50 members and a pre-primary nursery school with an enrolment of 25 children handled by three teachers. The facility consists of two single vault UD dehydration toilets, one urinal with five urinal bowls (three of them are especially designed for children) and one double vault UDDT with solar drying at the back.

Storage and collection strategies

The major difference between urine diversion and other sanitation systems is that the urine diversion toilet has two outlets and two collection containers, one for faeces and the other for urine.

The faeces are collected directly in the vault underneath the toilet chamber. The material is stored in 50 litres open containers. The dimension of the vault is 1100mm (length) x 900mm (width) x 750mm (height). This space is enough to allow up to four 50 litre containers to fit in. Once a container fills, it is pushed aside to allow an empty bucket to be placed below the hole and the full one to dry. It is recommended that the filled container remains in the vault for a period greater than six months to allow pathogen die-off (WHO, 2006). Urine is collected in a 30 litres plastic container. For the mentioned facility, provision is made for discharging the excess urine through an over flow pipe into a soak away pit, with the possibility to collect the urine for a later use.



Photograph 1. Completed Pilot UDDT in Nakuru, Kenya

Source: Muchiri, E.W. (2008)



Photograph 2. Water less urinals- green ones for nursery school children.

Source: Muchiri, E.W. (2008)



Photograph 3. Inside a UDDT –note the squatting U-D pan and the bucket of ash.

Source : Muchiri, E.W. (2008)

Operation and maintenance strategies

Strategies for transportation of faeces

Transport logistics are similar to those of solid waste. Dry faeces per capita are much lighter than solid waste generation per capita and therefore more volume can be carried by the same vehicle. In plots with gardens, local reuse of the product is encouraged. Where the product can not be reused on-site, arrangement for managing the transport to the secondary treatment or for utilization elsewhere should be made. This calls for a consultative forum with stakeholders involved in transportation and treatment and an understanding on the logistics should be arrived at. The critical factors to consider at this stage are: health safety, protective clothing, type and condition of container, legal aspect, environmental impact and cost. The type of vehicle employed are described in UNCHS-Habitat (1997) and may depend on the amount of the product being transported, distance to destination, topography of the area, accessibility and financial capacity of the service provider.

For the facility constructed two different O&M strategies have been developed:

- Residential plot: MAWAREMA, a local composting NGO has committed interest in faeces collection, by charging a small fee for this service. The landlord has agreed to cover that fee for his tenants.
- House of Fire church and nursery school, Crater View Secondary School and Kaptembwo Primary School: the products (both faecal material and urine) will be used on-site and therefore only manpower will be required to lift and move the products to the treatment area and finally to the garden. Human handcart or a wheel barrow may be used.

Treatment of faeces and urine

The aim of faeces treatment is to sanitize the faeces or kill pathogens to protect public health. Treatment also enables safe reuse. Various technologies exist including: storage, composting, alkali treatment, addition of urea, desiccation, solar drying among others (Winblad and Simpson Herbert, 2004; Niwagaba 2007). Urine treatment and its utilization is also discussed in depth in Kvarnström, et al. (2006) and Morgan (2007). The treatment strategies proposed for Nakuru are:

- Alkaline treatment (pre-treatment) where ash is added to the faeces after defecation. This treatment will promote pathogen die-off through elevated pH (>9) for six months. The ash covers the faeces and therefore reduces smell and chances of flies breeding. The ash also dehydrates the faeces.
- Storage in the vaults for up to six months.

- Solar radiation, UV light for the double vault that will allow waste to be dried by solar.
- Composting (treatment). Most pathogens die at temperatures of 55-65°C. Composting process attains this thermophilic temperature and is therefore ideal to treat faeces.
- Co-composting faeces with organic matter by a CBO involved in composting

Use of faeces and urine

On-site dried and sanitized faecal material will be used as fertiliser within the institutions own gardens. Urine which has valuable supply of nitrogen and also phosphorous and potassium in smaller quantities will also be used on the garden to grow crop. Morgan (2007) explains in detail how to sanitize and use toilet compost and urine to grow crop. Currently urine is drained away in soak pits. Provision for collection is in place, but there is no demand for its use at the moment.

Up-scaling

The close cooperation with MAWAREMA shall lay the ground for a sustainable O&M strategy for UDD Toilets. The CBO is offering services for collection of both faeces and urine to the users at a small fee. And to co-compost the collected faeces and urine with organic waste at two central treatment sites. The Co-composted material will be sold by MAWAREMA to local farmers around Nakuru. It is expected that acceptance for urine diverting toilets in the peri-urban areas will increase if the users can contract MEWAREMA or other private collectors to handle and transport the faeces and urine.

Basic skills in O&M of UDDT

The users of the UDDT are main players in the O&M of the facility. Without their involvement, sustainability of the facility is not certain. It is therefore important to ensure that they know how to use the facility correctly and maintain its cleanliness on a daily basis. To accomplish this, the users will be trained on proper usage of the UDDT and thereafter a monitoring and evaluation exercise will be carried out to determine whether O&M practices are sustainable in terms of social acceptability, technical appropriateness, hygienic and cost effectiveness.

Conclusions and recommendations

Research on the operation and maintenance is still ongoing. Monitoring and evaluation exercise is on to assess the acceptability of the new pilot project and to determine need for up scaling. More pilot projects are currently under construction and will be monitored to assess the effectiveness of the current O&M strategy used. However, the lessons learned from the sanitation study indicate that operation and maintenance of UDDT's will be sustainable if users are not responsible for O&M but contract service providers to collect the faeces and urine for them. Awareness creation to the users and training on proper usage of the UDDT is done. The private collectors will be attracted to offer the service if there was a ready and profitable market for product. For the O&M to succeed, all stakeholders should get involved and should play their roles and undertake their responsibilities effectively.

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