Management of Wastewater and Faecal Sludge in Southern Africa

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Abstract: This paper deals with the trends, legislative framework and current sludge management practices in southern Africa. Recognising that a large percentage of the Southern African population is not serviced with full waterborne systems, a paper on the management of sludge in the region would not be complete without discussing the management of faecal sludge (FS) from on-site sanitation systems as well. The first half of the paper focuses on the management of wastewater sludge from waterborne sewage systems. The research papers from the region focus primarily on the impact of sludge application on land and agricultural use. The wastewater sludge disposal practices and legislative trends in South Africa are discussed in detail including an overview of the technologies that are used to stabilise, dewater and dry the wastewater sludge. The majority of plants in South Africa do not treat the sludge further than the traditional anaerobic digestion and activated sludge extended aeration. Final disposal methods are still dominated by on-site disposal methods including direct land application (dedicated land disposal) and stockpiling of the sludge on site. The second half of the paper focuses on the management of FS from on site sanitation systems. The FS, which is often contaminated with domestic waste, originating from these on-site sanitation systems requires responsible handling and disposal. The problems and challenges in FS management are highlighted as well as the recommended legislative trends.

Keywords: Faecal sludge; on-site sanitation; sewage sludge; southern Africa, wastewater sludge

INTRODUCTION

This paper has to be seen within the context that in sub-Saharan Africa only 37% of the population has improved sanitation based on the 2004 data published in the United Nation 2006 report on the Millennium Development Goals (United Nations, 2006). Currently about 300 million people in Africa do not have access to safe water and about 313 million have no access to sanitation. Most of Africa's population live in rural areas (62 percent) and yet access is lowest in the rural areas, at about 47 percent for water and 45 percent for sanitation. Low access to a safe water supply and adequate sanitation is the root cause of many diseases that afflict Africa and a contributory factor to the high infant and maternal mortality rates (African Development Bank Group, 2006).

The Sanitation coverage in the sub-Saharan Africa increased from 28% in 1980 to 36% in 1990. Sanitation coverage refers to the percentage of the population that has access to collection and disposal of wastewater, with or without treatment. Today, access to adequate excreta disposal is available to only about 35% of the population. Technologies used for the safe disposal of excreta are mostly of the individual type, mainly septic tank system and simple latrines. Communal systems, such as conventional and small bore sewers are rare and available in some urban high income areas only (UNEP – IETC, 2002).

In communities where space is lacking, or no nearby reliable water supply is available, the feasibility of water borne sewerage or even pourflush latrines becomes questionable. Households seem to be more aware of these limitations than many technical agencies. For example, in Kumasi, Ghana, more than 50% of households preferred a ventilated latrine to a water-flushed toilet, because the former does not depend on water, is simple and does not break (UNEP – IETC, 2002).

Both on-site sanitation systems and water borne systems generate a solid component which needs to be managed responsibly. It is for this reason that this paper addresses both the management of wastewater sludge originating from water borne sewage treatment systems as well as the management of the solids that accumulate in on-site sanitation systems i.e. faecal sludge (FS). Information and statistics on wastewater sludge and FS management in different countries in Africa is very limited.

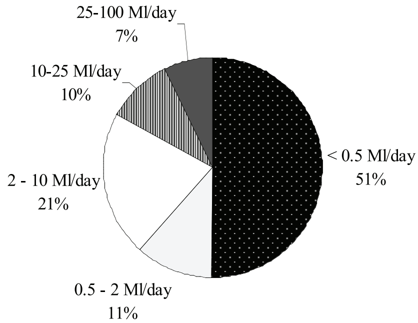

Figure 1: Size Distribution of Wastewater Treatment Plants in South Africa

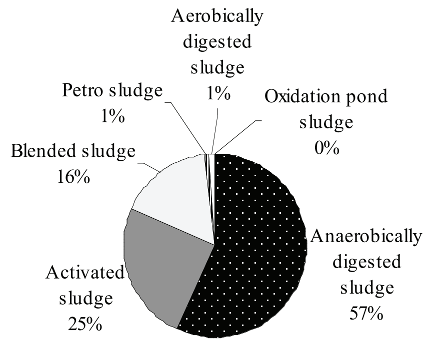

Figure 2: Sludge generated at wastewater treatment plants in South Africa (dry mass percent base)

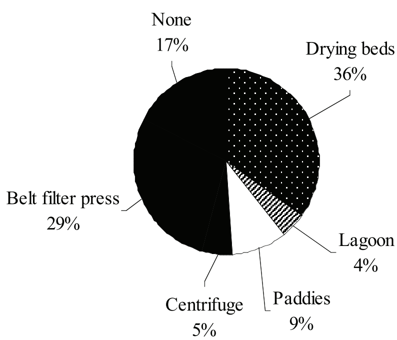

Figure 3: Dewatering technologies employed in South Africa (dry mass percent base)

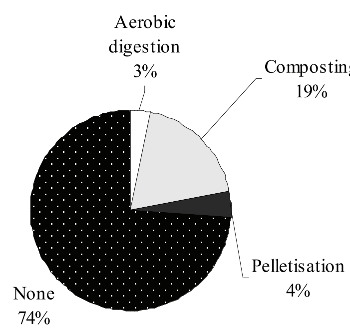

Figure 4: Tertiary treatment and additional stabilisation technologies employed in South Africa (dry mass percent base)

Figure 3 illustrates the dewatering technologies employed by the wastewater treatment plants surveyed in this study on a mass percentage basis. Most of the sludge mass is dewatered either in drying beds (36%) or mechanical belt filter presses (29%). Where no dewatering technologies are employed, liquid sludge is often used for direct land application such as dedicated land disposal and instant lawn cultivation. When comparing mechanical dewatering systems, the mass of sludge dewatered in belt filter presses exceed that of centrifuges. If the data is reworked to represent the number of plants rather than the dry mass percentage, the figures are significantly different. Drying beds are used at 45% of the plants followed by belt filter presses (15%), centrifuges (5%), paddies (9%), lagoons (4%) while 24% of the plants employ no dewatering (Snyman et al., 2004).

Figure 4 illustrates the tertiary and additional stabilisation technologies used to stabilise the sludge. Anaerobic digestion of primary and humus sludge is still employed to stabilise the majority (57%) of the sludge in South Africa (Figure 2). The majority (74%) of the sludge mass did not treat the sludge further than the traditional anaerobic digestion and activated sludge extended aeration. Composting is used by both metropolitan city councils and plants in smaller town councils while pelletisation is only employed by large metropolitan councils which is why the mass percentage is relatively high (19%). Only 9% of the number of plants surveyed composted the sludge. Aerobic digestion is employed as an additional treatment method after anaerobic digestion in one major site which contributed 3% of the mass of total sludge surveyed (Snyman et al., 2004).

MANAGEMENT OF WASTEWATER SLUDGE FROM WATER BORNE SEWAGE TREATMENT SYSTEMS

Regional trends

Limited information could be found on the management of wastewater sludge from waterborne sewage treatment systems in Southern Africa. The research papers from the region focus primarily on the impact of sludge application on land and agricultural use. Case studies related to the infrastructural development of sludge management facilities are limited to tender and media releases.

Land application and the agricultural use of wastewater sludge and subsequent effect on soil and water quality is documented for Zimbabwe, especially studies in the Harare area. Muchuweti et al. (2006) indicated a growing public concern in Zimbabwe over the illegal cultivation of vegetables on soils amended with sewage sludge or irrigated with mixtures of sewage and sewage sludge. This could be one of the driving factors for the research focus on agricultural and land application. Nyamangara and Mzezewa (1999, 2001) determined the effect of long-term sewage sludge application on clay loam soil under pasture grass in Zimbabwe. Amos et al. (2003) studied the impact of sewage sludge land disposal practice on groundwater in Harare, Zimbabwe. Due to long term irrigation with sludge and wastewater a thick humus blanket covered the farm. Ground water and soils quality show increased concentrations regarding some parameters such as ammonia, nitrates, TP, faecal coliforms and certain metals (Amos et al., 2003). Muchuweti et al. (2006) reported high metal concentrations in two of the staple dietary crops, maize and tsunga, which may affect food quality and safety. Tsunga leaves contained over 18 times more Cd, 5 times more Cu, 22 times more Pb and 4 times more Zn compared to the EU guideline limits (Muchuweti et al., 2006).

Ngole, et al. (2006) reported that sludge production in Botswana especially in Gaborone City has increased recently as a result of the rapid rate at which the city is growing and the introduction of advanced wastewater treatment techniques. In Botswana, in an effort to increase arable farming around major settlements, funding is available to small horticultural projects and the trend is to use sludge. The use of sludge is encouraged considering the fact that soils in semi-arid regions like Botswana are generally poor with low water retention capacity, and are characterized by low plant nutrient status.

The trends in South Africa and Namibia are likely to be very similar although the scales are vastly different. South Africa has approximately 900 wastewater treatment plants which treat in the order of 5000 to 7000 Ml/day (Derived from the South African Department of Water Affairs and Forestry data base).

Sludge disposal practices in South Africa

Figure 1 gives the an indication of the relative size distribution of wastewater treatment plants in South Africa, based on the data supplied by the local Department of Water Affairs and Forestry. Half of the plants treat less than 500 m3/day (< 0.5 Ml/day) and a further 11% treat between 500 and 2000 m3/day. There is little information on the sludge handling practices of these small plants, although it is suspected that most of the sludge is accumulated on site. The data presented in this section stem from the raw data collected as part of a country wide survey of 72 wastewater treatment plants (Snyman et al., 2004) which focused mainly on the plants larger than 2000 m3/day. **Figure 2** show the types of sludge generated by the wastewater treatment plants surveyed on a mass percent bases. The majority of sludge that is used/disposed is anaerobically digested sludge (primary and humus sludge). Waste activated sludge accounts for 25% of the mass. Blended sludge represents primary and activated sludge blended before or after digestion.

Final disposal methods employed by the wastewater treatment plants surveyed in South Africa are still dominated by on-site disposal methods. This includes direct land application and stockpiling of the sludge on site. The beneficial use of sewage sludge include; the use of the sludge by the local municipality or farmers, used to generate compost, used as the bottom layer for golf courses or using it to cultivate instant lawn. In some cases the sludge is sold or given to a contractor in exchange for bulking agent. The stockpiled sludge of many plants decreased over time without explanation (Snyman et al., 2004).

Sludge legislation in South Africa

The South African wastewater guidelines, of which Volume 1 and 2 were published in 2006, are now being implemented by the local authorities (Snyman and Herselman, 2006ab). The Department of Water Affairs stipulate in the authorisation of the plant that the Guidelines should be adhered to and through this process the Guidelines become legally binding. The South African guidelines will ultimately comprise of a set of 5 Volumes:

- Volume 1: Selection of Management Options
- Volume 2: Requirements for the agricultural use of sludge
- Volume 3: Requirements for the on-site and off-site disposal of sludge
- Volume 4: Requirements for the beneficial use of sludge
- Volume 5: Requirements for the thermal sludge management practices and for commercial products containing sludge.

The background and motivation for the development of these set of guidelines are detailed in Snyman et al. (2006).

Wastewater sludge classification system. A new generic wastewater sludge classification system has been adopted which is more in line with international trends. Wastewater sludge is classified according to a microbiological, stability as well as a pollutant class (Table 1).

Table 1: The South African wastewater sludge classification system

Classification class	Best quality	Intermediate quality	Worse quality
Microbiological class	A	B	C
Stability class	1	2	3
Pollutant class	a	b	c

Snyman et al. (2006) and Snyman and Herselman (2006ab) detail the limits for the each of the microbiological, stability and pollutant class.

MANAGEMENT OF FAECAL SLUDGE FROM ON SITE SANITATION SYSTEMS

The aim of this section is to create awareness of the challenges in the region regarding the management of faecal sludge. The presentation will include graphic images that illustrate the difficulty of managing this material. On site sanitation systems are often installed in densely populated and peri-urban areas as it is perceived to be a cost effective management option. However, when the pits fill up, the FS requires removal and disposal, which is challenging. Strauss et al. (2003) detail the characteristics of this material. The Swiss Federal Institute of Environmental Science Dept. of Water & Sanitation in Developing Countries (SANDEC) has published extensively on this topic based on work done in Africa and specifically Ghana. The results are directly applicable in the Southern African region.

Regional trends

The use of on-site sanitation systems, such as septic tanks, bucket latrines and pit latrines, is implemented widely in both rural and urban areas. The faecal matter, which is often contaminated with domestic waste, originating from these on-site sanitation systems requires responsible handling and disposal. Every day, several hundred thousand tons of faecal matter from either open defecation or collected from on-site sanitation installations (unsewered family and public toilets, aqua privies and septic tanks) are disposed of into the urban and peri-urban environment. The "waste" is either used in agriculture or aquaculture or discharged indiscriminately into lanes, drainage ditches, onto open urban spaces and into inland waters, estuaries and the sea, causing serious health impacts, water pollution and eye and nose sores (Strauss and Montangero, 2002). In Southern Africa, information on the extent of the problem is clearly observed and local authorities attempt to address this through links with local research groups such as the University of KwaZulu-Natal, University of the Western Cape and the CSIR. A number of encouraging initiatives for improving the management of sludge from on-site sanitation systems have been reported recently, especially in West African countries such as Senegal, Mali, Ivory Coast, Burkina Faso and Ghana amongst others. The treatment of FS includes pond based systems (Ghana, Benin and Mali), constructed wetlands (Mali), co-treatment in ponds (Burkina Faso), co-treatment with wastewater in ponds (Botswana and Tanzania) and co-treatment with wastewater in activated sludge plants (South Africa).

Challenges in managing FS

The problems and challenges in FS management rest with all the components of the FS stream – viz. pit/vault emptying, haulage, storage or treatment, and use or disposal. All aspects are involved including institutional/managerial, financial/economic, socio-cultural, and technical. Table 2 details the current FS management practices according to Strauss and Montangero (2002). These authors have accurately presented the potential problems and consequences. Southern African countries experience the similar problems. In dense settlements of South Africa, the challenges are significant.

Legislative trends

In most of Africa, including South Africa, no guidelines exist for the management of FS from on-site sanitation systems although internationally developed guiding documents such as the strategic planning of FS management developed by SANDEC, the Department of Water and Sanitation in Developing Countries (Klingel et al., 2002) are widely used and referenced. In the majority of less-industrialized countries, effluent discharge legislation and standards have been enacted. In Africa, it is common to find that performance and effluent standards are poorly controlled and enforced.

Table 2: Current FS Management Practices – Causes, Problems and Consequences (adapted from Strauss and Montangero (2002)

FS Management component and aspect	Causes	Problems	Consequences
Emptying + Collection			
Technical	Limited or no accessibility to pits Inappropriate emptying equipment Manual emptying	Overflowing pits Low emptying frequency Informal or emergency emptying of pits and indiscriminate disposal of FS	At community level, mainly: • Health hazards from openly dumped FS and through use of contaminated water • Eye and nose sores • Non-functionality of infrequently emptied septic tanks → solids carry over
Institutional / Financial	Poor service management Users' low affordability for pit emptying Lack of information (e.g. on how septic tanks work)		
Haulage			
Technical	Traffic congestion Lack of suitable disposal or treatment sites at economically viable distances	Collectors dump FS in an uncontrolled manner at the shortest possible distance from where FS was collected	At district or municipal level, mainly: • Pollution of surface and (shallow) groundwater • Eye and nose sores • Health hazards from use of contaminated water (e.g. for vegetable irrigation)
Institutional	Lack of urban planning → lack of suitable disposal or treatment sites at short distance from collection point Lack of involvement of private sector service providers Lack of suitable incentive and sanctions structure		
Financial / Economic	Collectors minimising haulage distance and time		
Treatment			
Technical	Lack of proven and appropriate treatment options	FS is used or dumped untreated	At district or municipal level, mainly: • Health hazards through use of contaminated water sources and water pollution
Financial / Economic	Where FS treatment exists: private collectors/entrepreneurs avoid paying treatment fees		
Institutional / Financial	Lack of political will to invest in treatment Lack of effective cost recovery Lack of urban planning Lack of information	Non-availability of suitable treatment sites Use or discharge of untreated FS	
Use in agriculture			
Agronomic / Institutional / Financial / Economic	Farmers in want of cheap soil amendment/fertilizer Private and public providers of FS collection + haulage services interested in generating revenue from selling FS to farmers Lack of enforcement of crop restrictions where such exist	Soils amended and vegetables fertilised with untreated FS	Potential health risks to consumers
Institutional	Lack of promotion and marketing of biosolids produced in FS treatment	Lack of incentives by producers of biosolids and by farmers to trade biosolids	Lack of knowledge result in bad practices and hence less commitment at institutional level
Health	Farmers unaware of potential health risks Lack of hygiene promotion	Lack of hygiene and health protection	Actual health hazards to farmers and consumers
Disposal			
Institutional	Lack of implementation of FS treatment schemes, of town planning and designation of suitable treatment sites Lack of adequate fee structure and incentives for haulage of FS to treatment sites Lack of promotion and marketing of biosolids produced in FS treatment	Indiscriminate dumping of untreated FS High-quality biosolids remain unused and need to be landfilled	Water pollution and risks to public health Depletion of soil organic fraction and deterioration of soil productivity

In most cases, the standards focus on wastewater treatment and effluent discharge standards related to water borne sewage treatment. FSs and products from their treatment are seldom considered. Thus, standards enacted in any particular country usually apply for both wastewater and FS treatment (Strauss and Montangero, 2002). In South Africa, this is not the case (Snyman and Herselman, 2006a).

Often, the standards are too strict to be attained in developing countries. A suitable strategy would consist in selecting a phased approach, under the paradigm that "something" (e.g. 75% instead of 95-99% Helminth egg or COD removal) is better than "nothing" (Von Sperling, 2001 according to Ingallinella et al., 2002). Ingallinella et al. (2002) argued that replicating the strict standards or limits established in industrialized countries without taking into account the local conditions is inappropriate. In many instances, the numerical values of certain parameters are established without defining locally appropriate management and treatment options. Such options would have to take into account disposal or use scenarios, type of soils on which they are spread, influence on the crops, health aspects, financial and economic factors, etc. Treatment aiming at the use of the treatment products would clearly have to meet different standards than that of final disposal or discharge. A sensible strategy for public health protection in biosolids use has been adopted by the EU. The general principle is to define and set up a series of barriers or critical control points, which reduce or prevent the transmission of infections rather than controlling numerical quality criteria which require regular monitoring. In the Southern African region, such monitoring is costly (if competent laboratories are available). Research is being commissioned in South Africa to generate good practice guidelines for the management of FS.

CONCLUSIONS

This paper focuses on wastewater sludge from water borne sewage systems as well as the management of FS from on-site sanitation systems in the southern African region. Management of wastewater sludge from water borne sewage treatment plants is often limited to on-site storage although research trends seem to encourage the agricultural use of wastewater sludge. South Africa has recently developed and adopted sludge guidelines that encourage the beneficial use of sludge while setting strict requirements for all disposal options. A much more challenging and pressing issue is the management of FS. Challenges exist throughout the entire FS management stream (viz. pit emptying, haulage, storage or treatment, and use or disposal). This includes the institutional/managerial, financial/economic, socio-cultural, and technical aspects. Researchers and policy makers are starting to address the challenges on a local level, but an all inclusive guide or policy is not yet available.

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