NETWAS UGANDA

Market Study on Demand for Use of Wastewater, Excreta and Faecal Sludge and Other Related By-products

Final Report

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LIST OF ACROYNMS

BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
CIDI	Community Integrated Development Initiative
CSTW	Conventional sewage treatment works
ECOSAN	Ecological Sanitation
GTZ	German Technical Corporation
KCC	Kampala City Council
MAAIF	Ministry of Agriculture Animal Industry and Fisheries
MUK	Makerere University Kampala
NEMA	National Environment Management Authority
NETWAS	Network for Water and Sanitation
NGO	Non Government Organisation
NOGAMU	National Organic Movement of Uganda
MWE	Ministry of Water and Environment
NWSC	National Water and Sewerage Corporation
SEI	Stockholm Environment Institute
SSP	Sewage Stabilisation Ponds
UBOS	Uganda Buear of Standards
WHO	World Health Organisation

EXECUTIVE SUMMARY

Background

Uganda's urban population currently stands at 20% and is growing, due to rural urban migration. This trend has led to an increase in the production of wastewater from households and the growing manufacturing industry. The majority of urban dwellers in Uganda depend on on- site sanitation and untreated sludge from these facilities is usually disposed off in unsuitable places, leading to environmental pollution. However, a market for wastewater sludge and other waste products which are rich in nutrients, has been created among farmers of flowers and fruits around urban centres. The Ecological Sanitation Research (EcosanRes 2) knowledge node in Uganda, hosted by Network for Water and Sanitation (NETWAS) Uganda, plays a role in closing the knowledge gaps, influencing attitudes; researching and demonstrating sustainable sanitation promotion approaches and technology options including re-use of by products; improving access to information and knowledge and building the capacity to promote sustainable sanitation solutions in Uganda with the possibility of increasing outreach to other countries of East Africa. It is against this background that NETWAS commissioned a market study on demand for use of wastewater sludge and other related by products in Uganda.

The study was aimed at determining the available market and the extent of re-use of wastewater sludge and other related by products in and around urban centers in Uganda. Specific objectives of the assignment were to: (i) generate knowledge on the market demand for wastewater sludge and its related by-products in Uganda; investigate potential market for wastewater sludge, and related by products for agriculture use; document and analyse the legal framework for wastewater sludge use and disposal in Uganda; develop a databank of potential market for wastewater sludge; private operators and farmers in an effort to link buyers to sellers; determine the knowledge, attitudes and views of using wastewater sludge as fertilizer for crop production; and, document existing best practices and/or successes around wastewater sludge management, marketing and use among private operators and farmers.

Methodology

The study was carried out in 8 towns in the 4 regions of Uganda, including Kampala and Mityana in the Central Region, Jinja and Busia in the Eastern Region, Mbarara and Rukungiri in the Eastern Region, and Gulu and Adjumani in the Northern Region. The towns were selected based on regional representation, an equal number of towns with and without a sewer system, and those that would provide lessons on effective wastewater sludge management for other towns in the country. Data were collected from government officials in central and local governments, non- governmental organizations, generators of wastewater sludge, users of wastewater sludge as well as transporters of waste products.

Key findings

Wastewater sludge, a product of municipal wastewater treatment, can be used for a variety of purposes, including land application, either as a source of nutrients for farming or for soil remediation; as a source of fuel for incinerators; as landfill cover or for mine waste rehabilitation; as a construction materials for making cement, bricks, pumice and artificial aggregate and as a raw material for manufacture of compost or minimized dry pellets.

The Government of Uganda has put in place policy and legal instruments for discharge of wastewater but there is no provision for use of wastewater products like sludge. However, law enforcement regarding wastewater discharge is still a challenge, leading to pollution of water bodies by industries and on- site sanitation facilities. The re- use of wastewater and its related products would contribute to reduction in environmental pollution. Most urban authorities still regard urban agriculture as an illegal activity, apart from KCC which has developed a set of agricultural ordinances that provide guidelines on urban agriculture but prohibit the use of untreated human waste. MAAIF is also in the process of developing an Urban Agriculture Policy that will provide guidelines on use of wastewater sludge.

The larger towns with higher populations and wastewater treatment facilities are able to produce large amounts of sludge. However, only farmers in Kampala were using this sludge, mostly for non- food crops. Other products available for use in agriculture include effluent from wastewater, urine and faecal sludge from ecosan toilets and untreated sludge from abattoirs. There is still a lot of untapped potential for using the sludge to improve agricultural production among urban and peri- urban farmers. However, most of the waste from on- site sanitation facilities and industrial wastewater in Uganda is not disposed of properly, and is therefore not available in the form of sludge and has led to environmental pollution.

Although wastewater and related products have nutrients that can improve agricultural productivity, they also bear a risk of contamination by pathogens and heavy metals from industries, which can affect both users and consumers of products. The NWSC treatment facility in Kampala is the only one that produces sanitized sludge (Class A sludge). However, NWSC authorities restrict its use to farmers engaged in the production of non- food products due to the presence of heavy metals from industries. Sludge from small towns with few or no industries could also be safe for use if it was sanitized to kill off pathogens. Urine is considered pathogen free and is safe for use in agriculture after storage of one week, while faecal sludge in Uganda is usually sanitized through composting. There is need to sensitse farmers on ways to reduce the risk of safely using wastewater products as well as consumption of agricultural products.

The NWSC treatment facility in Kampala is the only one that produces sanitized sludge (Class A sludge), whose use is restricted to producers of non- food products due to the presence of heavy metals from industries. However, sludge from small towns with few or no industries could also be safe for use if it was sanitized. Urine is considered pathogen free and is safe for use in agriculture after storage of one week, while faecal sludge in Uganda is usually sanitized through composting.

Demand for wastewater sludge was highest in Kampala where there was treated sludge, mostly among people growing non- food crops. However, some farmers were also using untreated sludge from ditches and canals. There was more demand for urine than for faecal matter from urine diversion ecosan toilets, although there was concern about attitudes of consumers of their products. Demand for industrial waste was identified in most towns, specifically slaughter waste from abattoirs which was used for crop production, piggery and biogas production.

There was a general lack of knowledge among the local government staff technical and the general public concerning the value of wastewater sludge to agriculture. On the other hand, the more knowledgeable technical staff were concerned about the health risk of using sludge. Knowledge about urine and facal material from ecosans was more widespread, although farmers were more willing to use urine than the faeces. There was also a general acceptance of using slaughter sludge among farmers.

Increasing the amount, efficiency and safety of sludge for agriculture requires a chain of services including delivery of wastewater from towns and parts of towns without a sewer network, wastewater treatment, sanitization of sludge and other products, transportation of sludge to the farmer and technologies for application of the sludge. Services required include hygienic sanitation facilities, cesspool emptier, efficient treatment plants, on-site treatment facilities, trucks for transporting sludge, urine and other products, skilled extension service providers and an informed market for produce.

Cesspool emptier operators play an important role in the disposal of waste from households, institutions and industries, to wastewater treatment facilities. However, the smaller towns lack these services, leading to high costs of emptying on- site sanitation facilities. The majority of clients of these operators are mostly institutional, while collection in informal settlements is limited by lack of access to the facilities or to poor design of latrines for suction by emptiers.

With the cost of buying, transporting and applying sludge estimated at UGX 70,000/= for a two- ton truck, it is considered a worthwhile investment for increasing agricultural production by utilizing the nutrients and improving water holding capacity of soils. However, these benefits should be weighed against the costs of ill health among the users and consumers if nothing is done to minimize their effects.

There was a general lack of knowledge among the local government staff technical and the general public concerning the value of wastewater sludge to agriculture. On the other hand, the more knowledgeable technical staff were concerned about the health risk of using sludge. Knowledge about urine and facal material from ecosans was more widespread, although farmers were more willing to use urine than the faeces. There was also a general acceptance of using slaughter sludge among farmers.

Strategies for marketing wastewater sludge and related products need to address the issues of public awareness about the value and safety of using sludge, as well as the technical challenges like the limited technology for sanitizing sludge and removal of heavy metals to make it safer for use on food crops and aquaculture. Improving on awareness among the public would go a long way in making these products acceptable among farmers and consumers of their products.

Recommendations

Based on the above findings, the following recommendations are made:

It is recommended that Government of Uganda develop legal instruments for regulating the use of wastewater sludge and related products, by building on the draft Urban policy and localizing the WHO guidelines on use of wastewater in agriculture and aquaculture.

It is also recommended that MWE and its agencies ensure that industries producing organic waste are complying with the wastewater discharge regulations in order to protect farmers using abattoir and brewery waste.

It is recommended that regular hazard assessments be carried out to determine the potential content of the different chemical, microbial and other factors that may occur in the different waste products and develop a risk mitigation framework

It is recommended that an awareness campaign be launched for local government technical staff and the general public about the value of sludge to agriculture in order to improve urban agriculture production and reduce environmental pollution. It is further recommended that lessons could be drawn from the process undertaken by KCC in making ordinances and supporting urban farmers.

It is further recommended that the capacity of agricultural extension workers be build to support the urban and peri- urban farmers interested in using wastewater sludge including selection of appropriate crops and hygiene maintenance.

It is recommended that the capacity of the NWSC sewerage treatment plants in the towns with high population be improved to process more and produce sanitized sludge and remove heavy metals where there are industries.

It is recommended that an incentive be put in place for the private sector to invest in adding value to wastewater sludge to make it more marketable to a wider range of farmers.

It is also recommended that pre- harvest and post- harvest hygiene be promoted among urban farmers in order to reduce the transmission of contaminants on the surface of crops like vegetables. It is also recommended that urban areas be provided with clean water in areas where urban produce is sold, to reduce the health risk to consumers.

It is recommended that municipal and town councils encourage urban farmers not connected to the sewer to put up urine diversion toilets in order to generate urine at household level to increase agricultural yields without the additional costs of acquiring and transport the urine.

It is further recommended that farmers be guided on the appropriate crops to grow on wastewater sludge and related products in order to minimize the risk of contamination.

It is further recommended that a systematic assessment of the costs involved in the promotion of use of WWS and urine be done at the user level.

1.0 INTRODUCTION

1.1 Background

The urban population in Uganda is growing very fast and currently stands at about 20% of the overall population of Uganda which is about 30 million, with rural migration on the increase. Urbanization comes along with release of huge amounts of waste, one of them being wastewater from industries and homes. The manufacturing sector in Uganda has grown by 15% to a total of 209 individual manufacturing units (UBOS 2008a), these units include processing facilities like; breweries, abattoirs, paint processors, tanneries and soft drink factories. Industries discharge untreated or partially treated wastewater into water bodies, soil or into air.

> Wastewater sludge is one of the products from wastewater, and refers to the material removed from wastewater treatment plants designed to treat predominantly domestic wastewater and includes the following products; raw or primary sludge from a primary clarifier, primary sludge from an elutriation process, anaerobically digested sludge, oxidation pond sludge, septic tank sludge, surplus or waste activated sludge, humus sludge, pasteurized sludge, heat treated sludge, lime stabilized sludge and composted sludge.

Access to sanitation stands at 73% of households who usually construct VIP lined pit latrines, open pit latrines; pour flush latrines linked to a septic tank etc. The untreated sludge from the toilets is usually disposed off in areas that are unsuitable including wetlands, storm water drainage channels, natural water courses, manholes and undeveloped plots (SPR, 2009). This has greatly contributed to the observed poor water quality in many surface water bodies around these urban areas (SPR 2009). Recent research by GTZ 2009 shows that farmers of flowers, bananas etc have recognized the value of human excreta or wastewater. They use sludge as an alternative to chemical fertilizers. These practices, although unsafe in some ways have provided a market for the wastewater sludge.

The private sector through the cesspool emptier and "scavengers" have provided the sludge to farmers at a small cost. At the dumping grounds, compost material is also sold out to farmers. However, all these are pockets of success that need to be explored to determine the available market and the extent of re-use of wastewater sludge in urban dwellings.

This study aimed at filling the gap of a market study carried out by GTZ which focused on re use of urine and faecal matter. It will seek to analyse the policy environment and looks at the sources of sludge and its available market for reuse by farmers.

Network for Water and Sanitation (NETWAS) Uganda, with support from the Stockholm Environment Institute (SEI) is hosting the Ecological Sanitation Research (EcosanRes 2) knowledge node in Uganda. The EcosanRes 2 is an international environment and development program on ecological sanitation, with a mission to develop and promote pro-poor sustainable sanitation on the ground through capacity development and knowledge management. The Ecosan-Res knowledge node is a network of information, knowledge and expertise in sustainable sanitation.

In line with the overall mission of EcosanRes 2, the Uganda knowledge node plays a role in closing the knowledge gaps, influencing attitudes; researching and demonstrating sustainable sanitation promotion approaches and technology options including re-use of by products; improving access to information and knowledge and building the capacity to promote sustainable sanitation solutions in Uganda with the possibility of increasing outreach to other countries of East Africa.

It is against this background that NETWAS commissioned a market study on demand for use of wastewater sludge and other related by products in Uganda.

1.2 Objectives of the Study

The overall aim of the study is to generate evidence on the market demand for wastewater sludge and other related by-products, its cost and affordability in Uganda. Specific objectives of the assignment are:

1. To generate knowledge on the market demand for wastewater sludge and its related by-products in Uganda.
2. To investigate potential market for wastewater sludge, and related by products for agriculture use.
3. To document and analyse the legal framework for wastewater sludge use and disposal in Uganda.
4. To develop a databank of potential market for wastewater sludge; private operators and farmers in an effort to link buyers to sellers.
5. To determine the knowledge, attitudes and views of using wastewater sludge as fertilizer for crop production.
6. To document existing best practices and/or successes around wastewater sludge management, marketing and use among private operators and farmers.

The detailed terms of reference for the study are in Appendix 1 of this document.

1.3 Methodology

1.3.1 Document review

The study team examined relevant documents and reports mainly to assess the current situation on the use of wastewater sludge in Uganda which included policies, laws and regulations from the 3 key ministries of Water and Environment, Health and Agriculture and reports from NGOs that are promoting sanitation and hygiene in Uganda. Document review focused on analyzing the best practices in the management and use of wastewater sludge in Uganda and elsewhere. To complement document review, the study team collected relevant information from internet websites.

1.3.2 Area covered by the study and sample selection

The study was carried out in the four regions of Uganda. In collaboration with the Client, a sample of 8 towns; 2 towns representing each region was selected based on a number of criteria, namely: regional representation, an equal number of towns with and without a sewer system, and towns that will provide lessons on effective wastewater sludge management for other towns in the country. Kampala City Council and Mityana Town Council were selected from the central region, Gulu and Adjumani from the Northern Region, Busia and Jinja from the Eastern Region and Mbarara and Rukungiri from the Western Region. Kampala, Mbarara, Gulu and Jinja were selected on the basis of having a sewer network while the others did not have sewerage services. Table 1 presents the list of selected towns and the criteria for their selection.

Table 1: Selected towns covered by the study

Region	Selected town	Selection criteria
Central	Kampala City Council (KCC) and surrounding areas of Mukono and Wakiso	Major producer of municipal wastewater in Uganda Has a sewer system
	Mityana	Does not have a sewer system Has innovative solutions to sludge management
North	Gulu	Major town in the region Has a sewer system
	Adjumani	Does not have a sewer system Has innovative solutions to sludge management
Eastern	Busia	Does not have a sewer system Has innovative solutions to sludge management
	Jinja	Major town in the region with big institutions and industries Has a sewer system
Western	Mbarara	Major town in the region Has a sewer system
	Rukungiri	Does not have a sewer system

1.3.3 Data collection

Data were collected from a number of wastewater sludge stakeholders, including generators of wastewater sludge, users of the sludge and other related products, as well as the middlemen who connect users and generators of the sludge. In addition, information was collected from experts on sanitation and agriculture from central government ministries and their agencies, district local governments and town / municipal councils and NGOs involved in sanitation and urban agricultural production. Government ministries and their agencies included Ministry of Water and Environment (MWE), Ministry of Health (MOH), Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) and Ministry of Education and Sports (MoES), NWSC, National Environment Management Authority (NEMA), Makerere University Kampala (MUK). NGOs involved were GTZ, Community Integrated Development Initiative (CIDI) and NOGAMU.

Data collection was carried out using document review, key informant interviews and focus group discussions. Instruments for data collection included interview schedules, checklists for focus group discussions, checklist for price survey and for observation as attached in Appendix 2 of this document.

The key informants/respondents were purposively selected in collaboration with the Client. Information collected included the policies/regulations on wastewater sludge, views about sludge use on the different kinds of crops and for other production activities, key constraints to wide spread use of wastewater sludge and the social, economic and human risks involved with its use.

1.3.4 Data compilation and analysis

All data was analysed manually to identify common practices and variations in the management and use of water waste sludge, perceptions on use of the sludge, perceptions on consumption of crops grown on the sludge, affordability and willingness to pay for sludge, safety of using sludge, as well as the potential of using it for production in the near future. The economics of using the sludge was not undertaken because there were hardly any users of wastewater sludge in other towns other than Kampala. On the other hand, all users interviewed lacked records.

1.4 Study limitations

- Limited documentation on wastewater sludge use in Uganda.
- Limited knowledge/information on the wastewater sludge by the respondents.
- Limited users of wastewater sludge.
- Lack records by the users of the wastewater sludge on how much they use per a given period of time and the actual benefits in terms of quantity. The cost benefit analysis on use of wastewater sludge was not done because of this.

1.5 Report Outline

This report presents findings of the market study on demand for use of wastewater sludge and related by products. The report is divided into 3 sections; the foregone Section 1 presents the study background, scope of the study and the methodical approach adopted by the study team. Section 2 presents the key findings of the study while section 3 presents the conclusions and recommendations for the various stakeholders.

2.0 KEY FINDINGS

2.1 Terminology

In order to distinguish between the various wastewater related products, it is important to first define what is meant by wastewater, wastewater sludge and fecal sludge.

What is wastewater?

Wastewater can mean different things to different people with a large number of definitions in use. The UN- HABITAT has defined wastewater as "a combination of one or more of: domestic effluent consisting of black water (excreta, urine and faecal sludge) and grey water (kitchen and bathing wastewater); water from commercial establishments and institutions, including hospitals; industrial effluent, storm water and other urban run-off; agricultural, horticultural and aquaculture effluent, either dissolved or as suspended matter.

Wastewater and excreta consist of water, micro-organisms (including human pathogens), and organic and inorganic substances including nutrients. The microbial pathogens (bacteria, helminths, protozoa, and viruses), heavy metals (in municipal and industrial wastewater), nutrients, and organic compounds contained in wastewater and excreta pose a potential threat to human health and the environment. However, it also contains valuable nutrients that can be used to fertilize crops and fish ponds.

Waste needs to be treated to remove or inactivate pathogens before it can be safely reused or disposed of. This can be done through on-site waste disposal methods where the excreta is treated by storing it for enough time to kill the pathogens. Off-site strategies (and some onsite systems) require wastes to be treated at a centraliesd facility before it can be safely used or released into the environment.

Treated wastewater is wastewater that has been processed through a wastewater treatment plant up to certain standards in order to reduce its pollution or health hazard; if this is not fulfilled; the wastewater is considered at best as partially treated (IDRC website).

What is wastewater sludge?

Wastewater sludge is one of the products from wastewater treatment, and refers to the material removed from wastewater treatment plants designed to treat predominantly domestic wastewater and includes the following products; raw or primary sludge from a primary clarifier, primary sludge from an elutriation process, anaerobically digested sludge, oxidation pond sludge, septic tank sludge, surplus or waste activated sludge, humus sludge, pasteurized sludge, heat treated sludge, lime stabilized sludge and composted sludge (Water Research Commission, South Africa, 2008).

Wastewater sludge is a product of screening, sedimentation, filtering, pressing, bacterial digestion, chemical precipitation and oxidation; primary sludge is produced by sedimentation process and secondary sludge is the product of microbial digestion. It can be beneficially utilized as soil amendment and fertilizer. It should however be treated to reduce organic content, volume and pathogens and the vector attraction potential.

Bearing in mind that wastewater sludge in Uganda is only available in municipal and town councils, this study focused on the town/ municipal councils and the surrounding peri- urban areas where the sludge was most likely to be applied.

What is faecal sludge?

Faecal sludge is the general term for the undigested or partially digested slurry or solid that results from the storage or treatment of blackwater in so-called on-site sanitation systems such as septic tanks, latrines, toilet pits, dry toilets, unsewered public toilets and aqua privies (IDRC website).

2.2 Reuse of wastewater and sludge

In both developed and developing countries, sludge disposal is an issue growing in line with the increase in the volume of wastewater treated. Historically, sewage sludge has been considered to be waste that is to be disposed of at the least possible cost. As a result, it has traditionally been dumped in landfills, holes, any unoccupied surface and drainage systems. However, faecal sludge, excreta and biosolids are increasingly being applied on land in low- and middle-income countries due to the high cost of modern landfills that meet all environmental requirements, the difficulty of finding suitable sites for landfills and the benefit of recycling plant nutrients and enhancing soil characteristics. Their main use worldwide (greater than 60%) is to fertilize agricultural fields or green areas. This practice solves a problem for municipalities, helps farmers to decrease their organic and mineral fertilizer costs and preserves or improves soil fertility. Another important use of sludge is to improve degraded soils at mining sites, construction sites and other disturbed areas (UNHSP, 2008).

The Water Research Commission of South Africa outlined a number of ways in which wastewater sludge could be used, including land application, either as a source of nutrients for farming or for soil remediation; as a source of fuel for incinerators; as landfill cover or for mine waste rehabilitation; as a construction materials for making cement, bricks, pumice and artificial aggregate and as a raw material for manufacture of compost or fertiliser dry pellets.

Advantages

The advantage of wastewater and sludge reuse is their nutrient content. Wastewater is rich in nutrients, including nitrogen (N), Phosphorus (P) and Potassium (k) as wells as trace elements like zinc, important for plant growth. In addition, the organic matter in sludge can improve the water retaining capacity and structure of some soils, especially when applied in the form of dewatered sludge cake (FAO website). Biosolids, sludge and excreta in particular, provide numerous micronutrients such as cobalt, copper, iron, manganese, molybdenum and zinc, which are essential for optimal plant growth. It is estimated that 1000 cubic metres of municipal wastewater used to irrigate one hectare can contribute 16–62kg total nitrogen, 4–24kg phosphorus, 2–69kg potassium, 18–208kg calcium, 9–110kg magnesium, and 27–182kg sodium. It therefore can reduce the demand for chemical fertilizers, i.e. make crop nutrients more accessible to poor farmers. In light of the global phosphorus crisis, excreta and wastewater can be critical sources of phosphorus. On the other hand, excessive concentrations of nitrogen in wastewater can lead to over-fertilization and cause excessive vegetative growth, delayed or uneven crop maturity and reduced quality. Excessive concentrations of some trace elements may also cause plant toxicity and sometimes become a health risk for crop consumers. In Guanajuato, Mexico, the estimated saving arising from using wastewater to supply the required nitrogen and phosphorus for crops was US$135 per hectare (Keraita et al., 2008). A study comparing vegetable production using freshwater and untreated wastewater in Haroonabad, Pakistan, found that the gross margins were significantly higher for wastewater (US$150 per hectare), because farmers spent less on chemical fertilizer and achieved higher yields (van der Hoek et al., 2002).

While farmers and their families are direct beneficiaries, there are also indirect beneficiaries along the supply chain including farm labourers, transporters, vendors, processors, input suppliers and consumers (Buechler et al., 2002). With low investments and quick returns, this practice is lucrative and enables many farmers to leap over the poverty line (Danso et al., 2002). In many West African countries, it is especially attractive to poor migrants looking for jobs in the city (Faruqui et al., 2004).

The land application of wastewater, sludge and excreta for agricultural use constitutes a low-cost disposal method and a land-treatment system that uses the soil to attenuate contaminants. If carried out under controlled conditions, it can also be safe. Wastewater use can also recharge aquifers through infiltration or reduce the impact on surface-water bodies, as wastewater is ‘treated’ before reaching them (Jiménez, 2006). Several wastewater constituents are subject to processes that remove them or significantly reduce their concentration. Reduced costs to society are also noteworthy, in view of reducing the use of fossil fuels to produce fertilizer.

Disadvantages

Among the disadvantages of using untreated or partially treated wastewater, sludge or excreta, the most obvious are the health risks from pathogens. Diseases are linked to the nature of the pathogen in the wastewater and thus vary locally following the local public-health pattern. Risks are not limited to farmers, but can be observed in: agricultural workers and their families; crop handlers; consumers of crops or meat and milk coming from cattle grazing on polluted fields; and those living on or near the areas where wastewater, sludge or excreta is used. Within these groups the most vulnerable sections of the population are children and the elderly.

Pathogens contaminate crops mainly via direct contact, though some cases of uptake by plants have been recorded. However, contamination can be reduced considerably if the wastewater sludge and its products are applied in long term crops and in tall crops where contact between the soil and the products is minimized. According to Thor Axel Stenström (2006), contamination is minimal in the following cases:

- Slow growing crops, for example pineapples. Application should be at the time of planting as the growth cycle is approximately 18 months. There is very low product contamination risk (due to the long time). However, in cases where such long term crops produce fruits that are likely to be picked from the ground, e.g. mango, passion fruit, oranges, it is important that the sludge be applied early in the growth cycle to ensure that pathogens no longer exist at the time of fruit maturity.

- Ornamental flowers, garden plants and trees: The major risk is to the workers, necessitating the use of protective wear.
- High growing crops not picked at the ground level and with "cover": For example maize and banana. There is no or very little contact between eating parts and the ground, thus low product contamination risk.
- Grain crops processed before eating, for example millet, rice and sorghum. There is therefore lo product contamination risk.
- Hanging plants not in direct contact with the ground and not eaten raw, e.g. egg plants. There is low-medium contamination risk.
- Leafy crops on the ground that is not eaten raw, i.e. cooked, for example, kale (sukuma wiki). The risk for contamination is low and handling practices are more likely to affect contamination than the sludge.

Thor Axel Stenström (2006) further outlines high contamination risk cases where use of sludge should be restricted, including:

- Hanging plants partly or fully in contact with the soil and eaten raw, for example tomatoes. Farmers should adhere to early application of fertilisers in the growth cycle.

- Root crops that are eaten raw, for example carrots, as survival of microorganisms longer below the soil surface is long. It is recommended to wash these crops after harvesting. However, root crops that are eaten cooked e.g. potatoes and cassava are less restrictive.

- Leafy crops eaten raw, for example lettuce, cabbage. Ensure safety of applied fertilising product and that a withholding time is adhered to, as well as washing in clean water after harvesting.

Beside pathogens, wastewater and sludge can also be a source of high levels of heavy metals and organic toxic compounds. Contamination can occur, in the case of metals and some organic chemicals, through absorption from the soil, which strongly depends on the location (possible contamination sources), the environmental conditions (particularly the soil), bio-availability (in the case of some contaminants), type of plant and agricultural practices (quantity of water applied and irrigation method). For both developed and developing countries, the content of heavy metals in wastewater, excreta and sludge from domestic sources is generally low enough to allow their use for crop fertilization (WHO, 2006). However, there are always cases where care has to be taken, for example, close to tanneries or mining areas.

As described above, the use of wastewater, sludge and excreta implies benefits but also risks. Frequently, experts recommend simply banning this unsafe practice and 'properly' treating wastewater, sludge and excreta. Such recommendations, besides being nearly impossible to implement in most developing countries for both economic and social reasons, would also result in the removal of components from these 'waste' products that are not acting as pollutants but, conversely, are beneficial. Therefore, in practice, there has to be a trade-off between the advantages and disadvantages and the best solution for each situation should be sought, even if this is considered unconventional, especially from a developed country perspective. From a technical point of view, the solution will basically consist of finding a way to supply soils and crops with water, nutrients and organic matter. This should take advantage of the assimilation capacity of the soil, so that pathogens or heavy metals do not cause harm, while putting in place additional measures to deliver safe food to consumers.

Wastewater sludge, a product of municipal wastewater treatment, can be used for a variety of purposes, including land application, either as a source of nutrients for farming or for soil remediation; as a source of fuel for incinerators; as landfill cover or for mine waste rehabilitation; as a construction materials for making cement, bricks, pumice and artificial aggregate and as a raw material for manufacture of compost or fertiliser dry pellets (Water Resource Commission, South Africa, 2008). However, use of these products for agriculture carries risk of contamination by pathogens and heavy metals. There is therefore need for processing the wastewater, as well as restricting its use to crops which have limited contact with the wastewater related products.

2.3 Policies, Legal Framework and Strategies for management of wastewater

The Government of Uganda has put in place a number of policy and legal instruments regarding environmental protection. The **National Environment Act,** 2000 with its accompanying regulations: **Environmental Impact Assessment Regulations** 1998; The **National Environment (Standards for Discharge of Effluent into Water or on Land) Regulations** 1999, and the **National Environment (Waste Management) Regulations** of 1999 were put in place to ensure sustainable use of environment and natural resources across the country (MWE, 2010). The Water (Waste) Discharge Regulations, 1998 provide for the regulation of wastewater discharge through the use of permits. Discharge of effluent or waste is prohibited on land and into the aquatic environment contrary to established standards and without a discharge permit. The regulations also provide for the general obligation to mitigate pollution by installation of antipollution equipment for the treatment of effluent and waste discharge emanating from an industry. They also provide for sampling of effluent and waste water analysis.

However, there are other legal and policy provisions that relate to waste pollution and to promote the safe storage, treatment, discharge and disposal of waste which may pollute water or otherwise harm the environment and human health, namely:

- The **Water Statute** whose one objective is "to control pollution and to promote the safe storage treatment, discharge and disposal of waste which may pollute water or otherwise harm the environment and human health".
- The **National Environmental Health Policy** of 2005, whose mission statement is "*the achievement and maintenance of healthy living conditions in rural and urban areas.*"
- The **National Water and Sewerage Corporation Statute**,1995 establishes the NWSC as a Water and Sewerage Authority and gives it the mandate to operate and provide water and sewerage services in areas entrusted to it on a sound commercial and viable basis.
- **The Local Government Act**, 1997: The Local Government Act defines roles for different levels of government in provision and management of water and sanitation related activities. The Act stipulates that provision of water and maintenance of facilities is a role of Local Governments in liaison with the Ministry responsible for Water Affairs. The Act empowers the different levels of government to plan and implement development interventions according to identified local priorities.
- The **Land Act**, 1998: The Land Act vests all rights to water resources in the Government. It empowers the Minister responsible for water to regulate the management and utilization of such water. The Act allows for reasonable use by the occupier or owner of a piece of land, of water for domestic and small-scale agricultural purposes. It also provides that the government or local government holds land in trust for the people and protects

environmentally sensitive areas such as natural lakes, rivers, groundwater, natural ponds, natural streams, wetlands, forest reserves, national parks and any other land reserved for ecological and tourist purposes for a common good of the citizens of Uganda.

According to MWE, the use of wastewater sludge is guided by the World Health Organisation (WHO) Guidelines but these have not been localized. In other words, the guidelines have standards which are too high for Uganda to meet, therefore the Government of Uganda has to incorporate them into the relevant policies with relatively reasonable standards that can be observed by the generators and users of WWS and related by products.

However, there is a gap in the current laws regarding re-use of wastewater and its related products. At the local government level, Kampala City Council (KCC) is the only urban local government has developed ordinances including the Urban Agriculture Ordinance, 2006, and the Solid Waste Management Ordinance, 2000; to regulate activities in the city in order to have a life worth living. The Urban Agriculture Ordinance has a clause on human waste which prohibits people from using untreated human waste as manure for agriculture purposes. Urban agriculture is still illegal in other municipalities in Uganda.

Currently, MAAIF, in collaboration with KCC and other stakeholders, is in the process of developing a national policy on Urban Agriculture in Uganda. This policy is still in a draft form but has a provision on sludge use. MWE and KCC carried out a desk review on the policy gaps and conflicts and among the recommendations made was on wastewater sludge. These recommendations will be fed into the Urban Agriculture Policy which will then be fed into the national Agriculture Policy. The Urban Agriculture policy is among the areas to be worn the Development Strategy and Investment Plan for MAAIF (2010 /11 -2015/16 (pg 96 /97) which will then feed into the National Development Plan. The first draft of the Urban Agriculture Policy was developed in 2007 and was widely circulated to stakeholders for comments. However, although still ongoing, the process has been hampered by the lack of funds to continue with consultations (Muwanga, personal communication).

Government policy and legal instruments and especially the Wastewater Discharge Regulations, provide for discharge of wastewater but there is no provision for use of wastewater products like sludge. Only KCC, among all town councils and municipalities in Uganda, has developed ordinances to guide urban agriculture, one of which prohibits the use of untreated human waste. However, MAAIF is in the process of developing an Urban Agriculture Policy that will provide guidelines on use of wastewater sludge.

2.2.1 Law enforcement practices in Uganda

Discussions with key informants in the municipal and town councils, as well as with central government officials, revealed that laws relating to wastewater were mostly concerned with wastewater production, treatment and disposal. Therefore law enforcement is concerned with ensuring compliance regarding wastewater discharge permits as well as treatment of industrial waste. For water development, compliance involves carrying out an environmental impact assessment and obtaining an extraction permit on order to avert pollution.

- According to MWE (2010), enforcement of the water laws is still a challenge, which has led to pollution of water resources. Studies carried out by MWE revealed that the quality of wastewater sampled from a selected number of discharge points was poor, against the waste discharge standard various standards. Only 15% of all samples taken from final effluent points complied with the National Standard for Effluent Discharge for BOD5 of maximum 50 mg/l, 43% of the samples checked complied to the total suspended solids standard of 100 mg/l, and, 52% complied with the faecal coliforms standard of 5,000CFU/100mL. This has led to high pollution of water bodies. For example MWE (2010) reports that Lake Victoria which has been the main recipient of municipal, industrial and urban run- off from Kampala for 40 years is highly polluted, leading to changes in water color and the growth of algae. However, it is important to note that High BOD which is a disadvantage in receiving water bodies, may be an advantage in soil application/crop production, whereby this is a way to release the aquatic burden.

Compliance with the law is still a challenge. According to MWE (2011), as of October 2010, of the 89 Companies, Institutions and Organisations that had been issued with waste water discharge permits, only 39 had valid permits. Although these companies are operating within the law many are not fully complying with some permit conditions such as measuring and recording waste water discharges, installing waste water treatment facilities, payment of annual fees etc. These together with those whose permits have expired are being followed up to ensure that they fully comply with the law. For example, in 2010, 20 illegal water users were identified in Jinja and Iganga Districts, all of whom were waste discharge potential permit holders who were flouting the Water Resources Regulation and Water (Waste) Discharge Regulations in the year 2009/2010 (MWE, 2010). As a result, the quality of water bodies is at stake.

It is important to note that the re-use of wastewater and its products including sludge would not only increase farm productivity but also contribute to reducing the burden of nutrients in the country's water bodies.

> Law enforcement regarding wastewater discharge in Uganda is challenging, as polluters do not comply with the law, leading to pollution of water bodies by industries. The re- use of wastewater and its related products for soil application and or agricultural production would reduce the aquatic burden of this pollution.

2.3 Production and management of wastewater sludge in Uganda

2.3.1 Wastewater sludge production and availability

As already mentioned, wastewater sludge is a by- product of wastewater treatment. In Uganda's urban areas, wastewater is treated either at centralized sewage treatment plants operated by the National

Water and Sewerage Corporation (NWSC) or by industries before it is released into the environment. NWSC currently operates in 23 towns in Uganda but only 17 of these have a sewer system and wastewater treatment plants. However, sewer coverage is still low in these urban centers, with only 6.4% of the urban population connected to the sewer (MWE, 2010). According to NWSC (2010), while the total number of water connections by 30th June 2010 stood at 246,259, there were only 15,561 sewer connections in Uganda's urban centers.

According to MWE (2007), sewerage extensions and connections in the NWSC operational areas are constrained by a number of factors, namely: high cost of new sewer systems at US$ 2 per cubic meter of sewage compared to US$ 0.3 per cubic meter of water produced; poor urban planning; and, existence of alternative sanitation systems like VIP latrines and septic tanks. NWSC makes an average of only 6 km of sewer connections per annum. In addition, some of the wastewater from the on-site facilities is disposed off by cesspool operators at the NWSC sewerage treatment plants. According to Kyambadde (2009), the wastewater treatment capacity in Uganda has not grown in tandem with the growing population and industralisation. So the majority of the urban population uses on- site sanitation facilities including pit latrines or water- borne toilets connected to septic tanks. Hence, the discharge of raw urban sewage, industrial process effluents, and agricultural wastes into lakes (especially Lake Victoria) in un-gazetted areas is a major problem.

Of the eight towns visited during this study, the towns of Kampala, Jinja, Mbarara and Gulu had a sewer system and facilities for wastewater treatment, managed by the NWSC. The towns of Mityana, Adjumani, Rukungiri and Busia depended on on- site sanitation, including pit latrines and water borne toilets with septic tanks. However, the towns of Adjumani and Mityana had put in place mechanisms for treatment of faecal sludge from on- site facilities, by constructing lagoons.

Sludge production at NWSC treatment facilities

The amount and frequency of sludge production varied from town to town. This difference was attributed to the amount of wastewater produced from the sewer system as well as other wastewater disposal by cesspool emptier from latrines and septic tanks. It was only in Kampala that the wastewater sludge was produced on a daily basis. The other towns with wastewater treatment plants produce limited amounts of sludge as de-sludging takes place less frequently, as shown in Table 2.

Table 2: Generation of sludge in study towns with NWSC treatment facilities

Town	**Generates wastewater Sludge**	**Amount of wastewater sludge generated (per year)**	**Remarks**
Kampala	Yes	Data not available, but sludge is produced daily. Raw sewage received daily is 10,000 – 16,000 m3 through sewer lines and about 300 m^3 from on-site facilities by cesspool emptiers.	Sold by NWSC to users at Bugolobi site. Sludge from City Abattoir used directly by farmers
Gulu	Yes	Data not available, de-sludged once in 8 years	Used by compound designers
Jinja	Yes	4,800 m^3 every 3 years	Site workers/staff use it but not farmers.
Mbarara	Yes	42 – 120 tons	Sludge is buried after de- sludging, but sludge from abattoirs is used as pig feed.

Sludge at the NWSC treatment plants was only available for use by farmers in Kampala, Jinja and Gulu. According to the Sewage Manager at the Bugolobi treatment plant in Kampala, the facility is the only one in the country that sanitises the sludge to make it fit for re-use. However, due to the presence of heavy metals, the sale of sludge is restricted to specific types of users, namely; foresters, compound designers and flower nursery operators, meaning food crop farmers are not encouraged to use it. As a result, there is a still a lot of unsold sludge at the Bugolobi and at Wankoko site (located in Kampala district) where it is disposed off but kept under guard. Bugolobi treatment plant management employs guards at the disposal site to guard against any illegal users. Figure 1 presents sludge which has been scooped off at the Bugolobi NWSC treatment plant. With the launch of the Kampala Sanitation Master Plan that is intended to rehabilitate and expand the sewer network as well as rehabilitate Bugolobi Treatment Works and construction of new faecal treatment plants, the supply of wastewater sludge in Kampala is due to increase considerably.

Figure 1: Scooped sludge from one of the drying beds at NWSC Bugolobi treatment plant, Kampala

Although the management of Jinja NWSC treatment plant at Kimaka informed this team that the sludge was free to farmers who wanted it, discussions with the communities in Jinja MC revealed that they were not aware of its availability and use for agriculture. It was revealed that only staff of NWSC were using it for agriculture and heaps of it were seen on site by this team, with grass growth indicating that it had been lying idle for long, except for a few scoops seen as in Figure 2. It should be noted that this sludge is untreated and deemed not suitable for farming.

Figure 2: Heaps of sludge at Jinja NWSC waste treatment plant

In Mbarara MC, the amount of sludge produced was very limited (42- 120 tonnes per annum), and communities were not aware of the potential use of the sludge from the NWSC treatment plants. According to the NWSC Engineer in Mbarara, the sludge is buried so it is not available for use by farmers. Similarly, sludge in Gulu MC was only removed from the wastewater facility once, this year, 8 years after construction of the lagoons. Although the sludge was free to anyone who needs it, nobody has been known to take it. Even if there was demand, the supply is very limited as the interval of de-sludging is too long, implying no effective supply. In addition, one private operator in Gulu who was involved in on-site wastewater collection and treatment had heaps of sludge on site but did not have a market for the product.

Discussions with farmers in Kampala however revealed that some use wastewater and sludge that runs in channels in the city. This is most likely sludge that is released into the environment from pit latrines in slum areas, a common practice due to either lack of access to the latrines by cesspool emptiers or lack of funds for hiring them. Some cesspool operators in Kampala revealed that they have ever been requested by farmers and gardeners for unprocessed feacal material which they delivered. This implies that some farmers are using untreated sludge, exposing themselves and consumers of their produce to disease causing pathogens.

At the NWSC treatment plants in Kampala and Jinja, the supply of sludge was said to be greater than the demand and unsold sludge is disposed into landfills. The supply of wastewater sludge from NWSC treatment plants therefore depends on the frequency of de-sludging. In Kampala, due to the high population, de-sludging is carried out daily and sludge is almost always available. In smaller towns or where other means of sanitation are more prevalent, the intervals between de- sludging is longer, implying that even if a market for sludge existed, the supply would not be adequate. It is the view of the study team that the supply of sludge is only reliable in Kampala and in Jinja due to the high population in these towns.

Sludge production in towns without NWSC treatment facilities

Of the four towns without a sewer system, two (Mityana and Adjumani) had put in place mechanisms for treating wastewater. Both town councils have constructed lagoons on the outskirts of town for disposal of wastewater from pit latrines and septic tanks. According to MWE (2010), Mityana TC has started a public- private partnership where the TC and individual households pay part of the cost of cesspool emptying of septic tanks and latrines. The TC also opened up service lanes to ensure access to septic tanks and latrines. It has also put in place a requirement that all new constructions in areas with access to water should include water borne toilet facility. The town council has further plans to acquire a cesspool emptier and to ensure that new buildings in areas with access to water have only water borne toilets. However, this study revealed that currently, cesspool operators are sourced from Kampala and they do not dispose the wastewater in the Mityana lagoons but at Bugolobi NWSC plant in Kampala. The sludge is therefore not available to the people of Mityana. In Adjumani TC, some wastewater was disposed at the lagoons for a short time but this stopped due to the unnavigable road leading there. Private cesspool operators are hired to do the emptying. By the time of this study, the lagoons had not yet been de-sludged so there was no sludge available. Adjumani Hospital has its own wastewater system which also uses cesspool operators who remove wastewater from staff houses and the hospital septic tanks to large holding tanks for treatment.

The Busia and Rukungiri TCs did not have any wastewater treatment facility and thus had no sludge. Untreated waste from both towns was said to be disposed of into water bodies or bushes. In Busia in particular, the sanitation situation was particularly pathetic and wastewater was observed flowing openly in parts of the town. Manual labour was also said to be used in Busia to empty latrines and the waste just dumped into another pit or in the bush. Cesspool services for Busia were hired from Mbale or Tororo, while those for Rukungiri were obtained from Mbarara.

Table 3: Generation of sludge in study towns without NWSC treatment facilities

Town	Generates wastewater Sludge	Amount of wastewater sludge generated (per year)	Remarks
Adjumani	Yes	12 tons per week, not yet de-sludged	Town council constructed wastewater lagoons but not functional due to poor roads. Adjumani hospital has a sewage system with huge septic tanks
Busia	No	-	No sewer system and no other mechanism in place. Wastewater management is poor
Mityana	Not yet	-	Town has lagoon, but wastewater is collected and dumped at Bugolobi in Kampala. Sludge from slaughter houses is used by farmers.
Rukungiri	No	-	On- site wastewater removed by cesspool emptiers from Mbarara. Some farmers use sludge from abattoirs for crop and pig production and biogas

With Uganda's urban population growing at 4.8% per annum, the amount of wastewater and faecal matter produced daily is expected to increase. However, capacity to produce treated sludge in the current wastewater treatment plants is not likely to match the production, as the extension of the sewer system is not increasing at the same pace. This implies that there will be much more unprocessed wastewater and faecal matter, posing danger to the urban residents, especially the urban farmers and consumers of their products.

Sludge production by industries

Although the responsibility of treating effluent discharges in Uganda rests with NWSC, it is not in position to handle all the industrial wastewater. Beside the limited capacity of the treatment facilities, the efforts of industries to connect their effluents to NWSC sewer lines are hampered by the high connection costs involved which industries are supposed to foot. Thus the small and medium-scale industries opt to discharge untreated wastewaters into the environment (Kyambadde, 2009). A few industries have tried to put in place mitigation measures to evade environmental pollution. These systems primarily reduce chemical oxygen demand (COD) and suspended solids but nutrient removal is still a major problem and hence do not meet the required discharge standards. According to Kyambadde (2009) the following industries have pre- treatment of wastewater: breweries, oil and soap, battery production, some soft drinks plants, some fish processing plants and Kasese Cobalt Ltd. Industries without any pre- treatment include abattoirs, meat processors, dairy firms, galvanizing industries, paint manufacturers and pharmaceuticals.

In Mityana, Kampala, Mbarara and Rukungiri, it was learnt that untreated wastewater and sludge from abattoirs was reused for a number of purposes, namely feeding of pigs, crop production and for biogas. In Kampala, feed manufacturers were also using the blood as a feed ingredient. All these products were free to the public. The City Abattoir in Kampala actually has to pay the KCC to take away the solid waste including the dung produced in the facility. It should be noted that sludge from abattoirs contain high levels of pollutants.

However, this study established that a pilot research project on wastewater treatment has been set up at the City Abattoir in Kampala by BIO EARN[1] and Makerere University. The facility includes tanks for treatment of wastewater and an artificial wetland to process the effluent before it is released into Lake Victoria (see Figures 3 and 4). A study by Kansiime and Nalubega revealed that the overall removal of N, P and *E.Coli* from wastewater that passes through swamps before entering L. Victoria, is estimated at 56%, 40% and 91%, respectively. The plant produces sludge which is yet to be re-used. However, the facility is only able to process 30% of the wastewater produced by the abattoir, leaving the rest of the untreated water to flow to the lake untreated.

Figure 3: Tanks of pilot wastewater treatment facility at City Abattoir, Kampala

Figure 4: Artificial wetland for cleaning effluent at City abattoir Kampala

Ecological sanitation products

[1] BIOEARN stands for the East African Regional Programme and Research Network for Biotechnology, Biosaftey and Biotechnology Development

As already mentioned, the majority of urban dwellers in Uganda depend on on- site sanitation, mainly pit latrines. However, according to MWE (2010), many of these latrines are in a poor state and or shared, forcing people to use "*flying toilets"*, i.e. people defecate in polythene bags and throw them in the surrounding area. The government, NGOs and development partners have therefore been prompting the use of ecological sanitation (ecosan) toilets which use a natural biological process to break down human waste into a hydrated, odourless, compost like material that can be used for agriculture. The urine diversion ecosan technologies that separate urine and feaces are the ones that have been promoted in the poor urban areas where conventional water borne systems are not affordable and evacuation by cesspool emptiers by lack of space and finances. These facilities have been set up in a number of towns including Kampala, Kabale, Kisoro, among others.

The two products of urine diversion ecosan toilets, i.e. urine and faecal sludge can both be used for agriculture. According to Nuwagaba (personal communication) urine has the most nutrients necessary for crop growth, including nitrogen and phosphorus, while the faecal sludge has the most pathogens but limited nutritive value. These ecosan facilities were available in all the towns visited during this study. In 2006, Kampala City Council, in conjunction with the National Agricultural Research Organisation (NARO), carried out research on reuse of ecosan products in the Kampala peri-urban areas of Kyanja and Makindye, over a period of 4 seasons. The KCC would transport urine and faecal sludge from the slum areas which had the ecosan latrines to farmers in the two areas. The research revealed that the use of urine was found to increase production of maize and leafy vegetables considerably a shown in Table 4. Discussions with one of the farmers who took part in the research showed that although KCC no longer provides the urine, farmers have continued to use urine generated from their own households. This implies that farmers found the use of urine profitable to them.

> The production of wastewater sludge depends on the frequency of de-sludging. The larger towns with higher populations and wastewater treatment facilities are able to produce large amounts of sludge which are available for use. However, only farmers in Kampala were using this sludge, mostly flower nursery operators, compound designers and foresters. Poor farmers in informal settlements use untreated sewage and or effluent to grow crops for home consumption or income generation. Other products available for use in agriculture include urine and faecal sludge from ecosan toilets and untreated sludge from abattoirs. However, most of the waste from on- site sanitation facilities and industrial wastewater in Uganda is not disposed of properly, and is therefore not available in the form of sludge and has led to environmental pollution.

Cesspool operators

In all the 8 towns, services of cesspools emptier operators were required for emptying the on- site sanitation facilities like septic tanks and latrines. In some of the towns with wastewater treatment plants, the operators are charged a fee for dumping, either per trip or for a specific period of time. Providers of these services include KCC which had a total of 19 trucks and the Private Emptiers Association which in Kampala had 35 trucks (GTZ, 2010). The towns of Mityana, Busia and Rukungiri did not have any cesspool operators and had to get these services from other towns.

Emptier operators were charged a fee by NWSC for discharging into the plants in Kampala and Jinja, varying from 5,000/= to 20,000/=. On the other hand, the NWSC treatment plants at Gulu and Mbarara were said not to charge any fee. In the case of Adjumani and Mityana town councils that were operating treatment lagoons, the charge for discharge into the lagoons was 60,000/= and 30,000/= respectively. It was however noted that Mityana TC had put in a public/private partnership where it would meet some of the emptying costs. However, as noted earlier, the cesspool operators obtained from Kampala to provide services to Mityana were not discharging the waste at the Mityana lagoons but transporting it to Kampala and the Adjumani site was not accessible due to poor roads. However, it is also possible that the disposal costs at both places were a hindrance to the emptier operators. The table below shows the charges that cesspool operators pay to the relevant authorities.

Table 4: Operations and disposal charges for cesspool operators in the study towns

Name of Urban authority	**Body responsible for wastewater treatment facility**	**Cesspool operator charges**
Kampala	NWSC	5,000 – 10,000/= every time they dispose at site, depending on capacity of cesspool
Jinja	NWSC	15,000 – 20,000/=
Gulu	NWSC	None
Mbarara	NWSC	None
Adjumani	Town Council Adjumani Hospital	60,000/=
Mityana	Town Council	30,000/=
Busia	Not available	NA
Rukungiri	Not available	NA

The major demand for cesspools services was found to be schools, hotels, hospitals, institutions and households. Although there are potential customers in the slum areas where the majority of people use latrines, there are some factors that make this market untenable, namely: a lack of access to some of the latrines, as slum areas are not planned to leave access roads; poor construction of latrines which cannot be emptied by suction, lest they collapse; and high poverty levels among slum dwellers. As a result, these latrines, which are usually elevated due to the high water table, are emptied into open sewers, posing health risks to the slum dwellers. To address this issue, the NWSC piloted a small cesspool emptier to access the hard to reach slum areas, as presented in Fig. 5, known as UGAVAC technology.

Fig. 5: Small cesspool emptier for collecting sewage from informal settlements (Source: NWSC, 2010)

Cesspool operators revealed that they face challenges of bad odour of untreated sludge, the high operational costs (fuel, labour and maintenance) and presence of plastic materials that make suction difficult. They also revealed that transportation of urine is particularly very messy, which most likely translates into higher charges for their services. It was also noted that the private operators compete with public institutions that have emptier trucks like the Police Fire Brigade and the UPDF, yet do not incur some costs like taxes.

Cesspool emptier operators play an important role in the disposal of waste from households, institutions and industries, to wastewater treatment facilities. However, the smaller towns lack these services, leading to high costs of emptying on- site sanitation facilities. The majority of clients of these operators are mostly institutional, while collection in informal settlements is limited by lack of access to the facilities or to poor design of latrines for suction by emptiers.

2.2.2 Safety of wastewater sludge and other by-products

Any form of human waste, whether solid or liquid contains micro-organisms or pathogens that are dangerous to humans and livestock. According to Banadda et al (2009), the poor disposal of large quantities of both solid and liquid domestic sewage and industrial wastes in Kampala, into the relatively small water streams that eventually join and drain into Murchison Bay aggravates water pollution problems. It is estimated that pollution sources around Kampala City amounting to about 6.34 tonnes of Biological Oxygen Demand (BOD), 1.5 tonnes of nitrogen and 1 tonne of phosphorus are discharged daily to Lake Victoria, while 2 tonnes of BOD, 0.25 tonnes of nitrogen and 0.13 tonnes of phosphorus are discharged daily from 124 fishing shoreline settlements with a total population of 92,000; additionally, fishing shoreline settlements have less than 20% of pit latrine coverage, and hence most human waste is discharged directly into Lake Victoria.

Quality checks carried out on a monthly basis by NWSC in the FY 2009/ 2010 revealed that 32% of all samples taken from all final effluent points complied with the National Standard for Effluent for BOD of maximum 50mg/l; 43% of the samples checked complied to the total suspended solids standard of 100 mg/l; and 52% complied with the faecal coliforms standard of 5,000CFU/100mL. Cases of discharge of effluents of quality that did not meet the standards were due to design inadequacy, operation & maintenance inadequacy, storm water ingress into sewers, disposal/dumping of waste water from industrial and other non-domestic origin to NWSC sewerage systems. It should be noted that the urban poor use this effluent for irrigation of a variety of crops for home consumption and for sale. Studies carried out in Kampala revealed that the levels of pathogenic microorganisms in the water and soils on UA sites using sewage water were high, resulting in contamination, both on the surface and tissue of crops.

Centralised wastewater treatment

According to the Wastewater Regulations, sludge is supposed to be treated before is it disposed of. The NWSC treatment plants at in Kampala (Bugolobi) and Masaka use the conventional sewage treatment works (CSTW) system. In a CSTW there are four main stages/units of sewage treatment, namely: (i) preliminary sewage treatment involves the removal of big materials, e.g. plastic bottles; (ii) primary treatment involves separation of liquid from solids (sedimentation); (iii) secondary sewage purification, which involves treatment by bacteria for both solids and liquids; (iv) tertiary treatment which is a natural treatment by plants in the wetland. Wastewater sludge comes from the secondary treatment and involves digestion and drying. Important to note is that the Bugolobi treatment plant is the only one in the country that produces treated/digested sludge referred to as "Class A sludge". The rest of the treatment plants using lagoons do not have a provision for treating sludge and produce "Class B", which according to the KCC Health Inspector is not suitable for agriculture as it still has some pathogens and is therefore risky in terms of health.

According to MWE (2008), WRMD tests of effluent on NWSC treatment facilities found that only electrical conductivity values were always within the quality standard whereas other parameters like TSS, BOD and COD were not.

Figure 6: Wastewater treatment tank NWSC Bugolobi

In other NWSC towns with treatment plants, as in the case of Jinja, Mbarara and Gulu; treatment of wastewater involves the use of a series of lagoons or sewage stabilization ponds (SSP). The SSPs are a low cost system that uses bacterial activity to remove organic matter, nutrients and microbes in sewage. Most of the ponds used by NWSC for SSP are usually three in series comprising of anaerobic, facultative and maturation ponds in the same order. The sewage treatment occurs through anaerobic digestion in the first pond followed by aerobic degradation in the second pond and finally algal activity and death of microbes in the third pond. The ponds are occasionally de-sludged when there is sludge accumulation (after 2 or 3 years).

Figure 7: Maturation pond at NWSC treatment plant, Jinja

The sludge from the facilities in these towns is not treated and is thus not suitable for use in agriculture. After treatment, sludge is dried in drying beds, which were observed at Bugolobi and Jinja, as shown in Figure 7.

Figure 8: Sludge drying beds at NWSC sewage treatment plant, Bugolobi, Kampala

However, it was noted that this sludge was being used by staff of the NWSC plant at Jinja, in spite of the fact that it was not sanitised. It was also noted that although the sludge at Bugolobi was treated biologically for removal of pathogens, the treatment does not remove heavy metals which come from industries. According to the Sewage Services Manager of NWSC, wastewater in Kampala is both municipal and domestic and chances of containing heavy metals are very high. For example, wastewater from lather tanning has chromium which causes cancer in humans (Odong, personal communication). On the other hand, chromium in soils strongly attaches to soil particles and as a result it will not move towards groundwater. Crops contain systems that arrange the chromium-uptake to be low enough not to cause any harm. But when the amount of chromium in the soil rises, this can still lead to higher concentrations in crops. (http://www.lenntech.com/periodic/elements/cr.htm) This implies that wastewater sludge in Uganda is therefore not suitable for use in agriculture, either due to pathogens or due to heavy metal. NWSC therefore does not encourage farmers to use it for growing food crops but it is given to flower nursery operators, foresters and gardeners. However, according to WHO (2006), the content of heavy metals from domestic sources is generally low enough to allow their use for crop fertilization especially if source4s like pit latrines are not used as dumping site for paints, pharmaceuticals and other waste product. This implies that sludge from small towns in Uganda with few or no industries would be suitable for agricultural use if it was sanitized to free it of pathogens.

Faecal sludge

Regarding faecal sludge from latrines, studies by Dr. Niwagaba of Makerere University revealed that it takes time for pathogens in faecal sludge to die off, especially the helminths which form cysts. On the other hand, urine was found to be relatively free of any pathogens and one week storage was found to be adequate for killing off any pathogens. However, (SEI 2010-1) states that a withholding period between the last urine application and the harvest is a barrier that provides time for pathogen die-off. Risk calculations have shown that a 1 month withholding period results in substantial risk level reduction and combined with the other barriers in the multiple barrier approach the result will be a risk far below 10-6 DALY for pathogenic bacteria, viruses and parasitic protozoa (WHO 2006). Therefore, a withholding period of 1 month between last urine fertilization and harvest is always recommended. The withholding time is based on the die-off of organisms due to external factors like drying, temperature and UV-light on the surface of leafy plants. Recommended faecal treatment methods are presented in Box 1. It was noted that with the urine diversion ecosan facilities available in Uganda, faecal sludge is sanitised using the composting method.

Industrial wastewater

Inventories carried out in Kampala from 1990 up to 2006 show that most industries do not have proper methods for disposing of expired chemicals and/or chemical wastes (Banadda et al, 2009). A case in point is the coffee processing factories that emit between 1–25 mgm, much higher than the World Health Organization permissible level of 0.2 mgm. Other sources of pollution include car battery repair, reconditioning and manufacturing, traffic, and electric welding using lead coated arc, copper and chromium attributed to electric pole treatment, and zinc from paint factories, to mention but a few. Industrial wastewater composition depends largely on the type of industry and whether onsite pollution control measures have been taken. Industrial water demand and wastewater production are sector-specific. Industries may require large volumes of water for cooling, processing, cleaning, product transport and flushing wastes. Both flow and pollutant load fluctuations of industrial wastewater discharged in a municipal sewer system have a potential deteriorating effect on the functioning of a wastewater treatment plant.

According to Urban Harvest and Makerere University (2008), plants growing in a polluted environments can accumulate trace elements at high concentrations, causing serious risks to consumers. Studies carried out in Kampala revealed that industry was the major source of heavy metal contamination of wetland, with concentrations above those recommended for use in agriculture, posing potential health risk. The areas with the highest concentrations were those at battery assembling facilities which included lead, copper and zinc. The studies also suggested that the uptake of metals was higher when plants are grown in soil contaminated by wastewater containing industrial effluents than those grown on municipal solid waste dumps. The roots of wetland plants accumulated the highest concentrations of metals, with lower concentrations in leaves. The widespread dispersion of sewage in Kampala's wetlands and agricultural areas therefore represents considerable risks to human health. It is therefore important that chemical contaminants be treated distinctly from biological contaminants in policy, regulation and management, as treatment at of wastewater in Uganda only deals with pathogens.

Effluent

Effluent from wastewater treatment facilities and from other sources, is also used for farming but is not considered safe. According to ADB (2008), all treated and untreated waste effluents in Kampala (sewage, faecal sludge and Nakivubo Channel) are finally discharged through the Nakivubo Channel into the Inner Murchison Bay. The Nakivubo Channel has become a surrogate open sewer and extends almost right through the wetland and into the Inner Murchison Bay. Much of the rest of the wetlands has been 'canalised' by farmers, who drain land so as to be able to grow food crop. The potential of the Nakivubo wetland to provide some natural pre-filtering has been almost lost entirely. The quality of raw water in Inner Murchison Bay has steadily deteriorated over the years. This implies that farmers are using untreated effluent for farming.

Measures for reducing contamination

The risks of contamination can be reduced in a number of ways, including:

- Wastewater treatment to reduce the pathogen load.
- Crop restriction to those crops that have no direct contact with the ground, take long to mature or where roots are cooked.
- Wastewater application techniques that minimize contamination, e.g. drip irrigation
- Storage of faecal matter at low moisture content to reduce micro- organisms to die due to allow pathogens to die off before application
- Composting of faecal matter which generates heat that kills off the micro- organisms
- Withholding products to allow pathogens to die off after the last wastewater application
- Washing, disinfection and cooking of produce
- Hygiene practices at food markets and during food preparation
- Health and hygiene promotion among users and consumers
- Chemotherapy and immunization among users.

- Use of urea which on producing ammonia penetrates the feaces, killing off all micro-organisms, including helminths
- Incineration which requires low water content in the substrate. However, this makes it unavailable for farming.
- Restricting the use of wastewater and related products.

> Although wastewater and related products have nutrients that can improve agricultural productivity, they also bear a risk of contamination by pathogens and heavy metals from industries, which can affect both the users and consumers of products. The NWSC treatment facility in Kampala is the only one that produces sanitized sludge (Class A sludge). However, NWSC authorities restrict its use to farmers engaged in the production of non- food products due to the presence of heavy metals from industries. Sludge from small towns with few or no industries could also be safe for use if it was sanitized to kill off pathogens. Urine is considered pathogen free and is safe for use in agriculture after storage of one week, while faecal sludge in Uganda is usually sanitized through composting. There is need to sensitse farmers on ways to reduce the risk of safely using wastewater products as well as consumption of agricultural products.

2.3 Demand for wastewater sludge and related products

2.3.1 Demand and application of wastewater sludge

Apart from Kampala and surrounding areas, and to a smaller extent in Jinja and Gulu municipal councils, there was virtually no demand for wastewater sludge in the towns visited. This was due to three factors, namely; (i) the lack of awareness about the use of wastewater sludge; (ii) the limited production of wastewater sludge in the small upcountry towns; and, (ii) the absence of wastewater treatment in the towns that do not have a centralized sewer system. However, untreated sludge from slaughter houses was said to be used by farmers in and around the towns of Rukungiri, Mityana, Mbarara and Kampala. In Kampala City Council, the major users of wastewater sludge were found to be the operators of flower nurseries. Most flower nursery operators in the Kibuli – Mukwano area and Nakasero buy sludge from the NWSC treatment plant. Prices ranged from UGX 20,000/= for a 2 tonne truck to UGX 40,000/= for a 7 tonne truck.

However the Sewage Manager at the NWSC Bugolobi treatment plant in Kampala disclosed that farmers are strongly discouraged from using the sludge for food crop production because it is possibly not safe and can cause health hazards. This was echoed by the KCC Health Inspector. The major customers at NWSC are the flower nursery operators, foresters and gardeners. The nursery operators in Kampala requested for free sludge from NWSC as well as training in proper handling and use.

Table 5: Users and uses of wastewater sludge

Town	Users of sludge	Uses of sludge
Kampala	Available	Flowers, lawns, forests
Mityana	None	Slaughter sludge
Gulu	Some few farmers	Crop gardens, compounds
Adjumani	None	Not applicable
Busia	None	Not applicable
Jinja	Only staff at site	Vegetables, bananas, Cassava, S/pots
Mbarara	None	Slaughter sludge
Rukungiri	None	Not applicable

Alongside sludge, the nursery operators use compost manure too. The study revealed that sludge does well on trees and some flowers like sisal and Aloevera while compost manure is mainly used on flowers. This could be a research area for NETWAS. However, all flower nursery operator respondents preferred to use compost manure because it is easy to handle and does not pose any health risks. Compost manure too does not increase weed growth like sludge.

Some users said that they get sludge from trenches and most probably this is untreated sludge or effluent. According to Makerere University & Urban Harvest (2009), about 49% of Kampala households were involved in farming within the city boundary, most of whom were the poor that have settled in wetlands near wastewater drainage channels that discharge water from the city down to Lake Victoria. For example farmers in Banda were observed to grow cocoyams for income as well as food, and kept poultry and cattle for income generation. They also grew green vegetables, beans, maize and bananas for food. There is little sanitation or clean water and several industries discharge waste into the channels, which floods during rains, spreading industrial and other pollutants into the area used for farming. There is therefore more use of wastewater and its products by urban farmers than the numbers that buy the treated wastewater sludge from the treatment plants.

2.3.2 Demand for and application of ecosan products

In all the 8 towns of this study, it was revealed that some farmers were using urine from urine diversion ecosan toilets on their crops especially vegetables, bananas and maize. In Kampala, a good number of farmers were using urine after a KCC/ NARO research project that promoted its use in Kyanja and Makindye. KCC informed the study team that urine was used on maize and leafy vegetables like kale (*sukuma wiki*), spinach and cabbage and that its use over a period of 4 seasons increased the rate of growth of these crops and the number and size of cobs on maize. At the time of the experiment, KCC supplied urine to some of the big farmers from Kifumbira in Kamwokya where it constructed urine diversion ecosan toilets. However, the challenge KCC is facing in supplying urine to her farmers is transportation. The trucks for hire are not willing to carry urine but KCC's wish was to acquire a small emptier for urine to improve this service. Although farmers in Kyanja are no longer accessing the urine from Kifumbira and Kamwokya, they continued using urine generated at the household level. Discussion with one of the farmers from Kyanja revealed that he was applying the urine on vegetables and bananas. He noted that if urine is applied on a vegetable like nakati, the growth of leaves is not only vigorous but the period of production also increases. On maize, the use of urine was said to double the number of cobs per plant. Apart from urine, the farmer said that he was also using urine from cows as well as compost manure. According to this farmer, human urine performs better than cow urine.

A farmer from Kyampisi Sub County in Mukono District (Agnes Kario) gave her experience on using urine during a workshop organized by NETWAS. This farmer uses urine on pineapples and passion fruits which improved the performance and yield of her crops and realized increased income. The urine is bought at UGX 5000= per a 20 litre jerrican from Bina Primary School in Luzira – Kampala district which is quiet a distance. Her challenges were: the distance as there was no known source in Mukono, the vigorous growth of weeds and unwillingness of village mates to buy her produce. In Busia, farmers were using urine for growing of vegetables, fruits and flowers. On the other hand no farmer or nursery operator was found to be using faecal sludge on crops or flowers.

The uptake of human waste for farming seemed to still be hampered by attitudes of the community. According to the farmers from Mukono and Kyanja in Kampala, most of their neighbours shunned their produce on learning that they were using urine for growing agricultural produce.

An earlier study by GTZ (2010) revealed that small scale farmers who cannot afford to buy commercial fertilizer would be willing to use excreta and urine, provided they didn't have to incur transport costs. The medium scale farmers were also willing to use faeces and urine but considered the collection process tiresome and would prefer a distribution scheme or company to do it. On the other hand large scale farmers did not think it was economically viable to use human waste and would prefer to use commercial fertilizer due to the high ratio of nutrients to weight, except for organic farmers and flower farmers. However, there was concern about quality and consumer attitudes.

2.3.3 Demand for industrial waste

People in all the eight towns were using untreated slaughter slab/sludge from slaughter houses. The slaughter sludge is mainly used for crop production, feeding pigs and in some cases poultry. This sludge is free and farmers only meet the transport costs which were reported affordable by respondents. Feeding pigs on slaughter slab improves pig growth and production. Farmers interviewed had used slaughter sludge for 2 – 6 years. Pigs raised are for sale and respondents revealed that their customers do not know that pigs are fed on this sludge. Treatment of sludge before use and sensitizing other farmers on slaughter slab was raised as one of the issues that need to be addressed by the municipal council authorities. It was also learnt that waste from breweries (brewery waste) was also used by farmers for pig production.

Demand for wastewater sludge was highest in Kampala where there was treated sludge, mostly among people growing non- food crops like flowers, trees and grass for compounds. However, some farmers were also using untreated sludge from ditches. There was more demand for urine than for faecal matter from urine diversion ecosan toilets, although there was concern about attitudes of consumers of their products. Demand for industrial waste was identified in most towns, specifically slaughter waste from abattoirs which was used for crop production, piggery and biogas production.

2.4 Level of awareness and perceptions about sludge and related products

While technical staff from central ministries and national NGOs were aware about the value of wastewater sludge in agriculture, this awareness was lacking among most Local government officials. This was even so among the agricultural technical staff. The LG officials however had knowledge about the Ecosan products mainly about urine use by farmers on crops. All technical staff were however cautious about the safety of using sludge and thus did not support its use on vegetables and food crops that are eaten raw/uncooked. Reasons given are that leafy vegetables are usually not fully cooked which leaves some pathogens like E.coli, alive and can be dangerous to human health. On the other hand, experts recommend sludge use on non- food crops like trees, tree plants, flowers and long time crops like bananas.

Most farmers in other districts other than Kampala were not knowledgeable about the wastewater sludge and this was probably the major reason they were not using it. For instance, the focus group discussion in Jinja revealed that they had not heard about it despite presence of heaps of sludge at the NWSC disposal sites at the time of the study. This shows that the would-be buyers/users of this sludge are not aware of its importance, source and availability. This calls for sensitization of the public about this product, just like the Ecosan and most importantly its safety since Jinja produces "Class B Sludge". However, raising awareness must go hand in hand with ensuring that the treatment plants are treating the sludge to make it safe for use by farmers without putting them at risk.

Farmers' perceptions about re-use of faeces/faecal sludge/wastewater sludge were extremely negative. Culturally and socially, re-use of faeces is not acceptable by many people because they take it as something dirty. On the other hand, the use of urine was to some extent acceptable among those farmers who had adopted it, though there was still a poor attitude among the consumers. As a result, those using it were not willing to disclose the fact, for fear of losing out on the market for their products. There is thus a need for creating awareness among the general public regarding the safety of using urine for agriculture.

GTZ and CIDI on behalf of Fitchner (a German NGO) carried out studies on marketing of human excreta and feacal sludge re-use (2009) respectively. In both cases, the sanitation experts interviewed reported that results were not so positive due to the low content of nutrients per volume of feaces/feacal sludge and the market is not readily available. It was also revealed that, if it is not competitive in terms of nutrient content and plant availability, handling/management efforts/costs and product price, a fertilizer will not be purchased by farmers.

There was a general lack of knowledge among the local government staff technical and the general public concerning the value of wastewater sludge to agriculture. On the other hand, the more knowledgeable technical staff were concerned about the health risk of using sludge. Knowledge about urine and facal material from ecosans was more widespread, although farmers were more willing to use urine than the faeces. There was also a general acceptance of using slaughter sludge among farmers.

2.5 Affordability and willingness to pay and marketability of wastewater sludge and other products

In the towns of Jinja and Gulu where it was available, wastewater sludge was free, attributed to the fact that there was effectively no demand for it. The only cost to farmers would therefore be the cost of transportation. In Kampala, the costs for wastewater sludge from NWSC at UGX 40,000= for a 7 ton truck and UGX 20,000= for a 2 ton truck. Transportation costs to either Kibuli – Mukwano road or Nakasero was on average UGX 15,000=. Of the 6 users interviewed, 2 were accessing raw wastewater sewage from trenches while the rest were buying sludge from the NWSC. Of these four, two asserted that the cost of the sludge was affordable and the other 2 felt that it was too costly.

Regarding urine from ecosan toilets, there is some degree of acceptance among the farmers. While some use urine generated from their own households, rural farmers are willing to pay for it at a cost of UGX 5,000/= for a 20 liter jerry can. Considering the fact that urine is rich in Nitrogen and Phosphorus which are good nutrients for growing crops, this cost is affordable to small scale farmers who cannot afford commercial fertilizer, if the source of the urine was near the farm, requiring limited transportation. According to cesspool emptiers who have transported urine, the smell is quite offensive, which would probably lead to higher transport costs for taking the risk.

On the other hand, according to a study carried out by GTZ (2010), large scale farmers were not willing to use urine due to the bulk and associated costs of transporting it, in comparison to commercial fertilizer, with the exception of organic farmers. Willingness to use faecal sludge from ecosan toilets is still poor, attributed to the negative attitude to faecal waste among both farmers and consumers. In addition, application of the materials to farmers within the urban slums is limited due to lack of land for farming. This has cost implications to farmers, which is another incentive for using it for farming.

From the point of view of NWSC officials, wastewater sludge is not easily marketable, as was evidenced by the heaps of sludge observed during this study. The same applies to use of faecal sludge from ecosan latrines, despite the fact that it can be made safe through composting and storage. This lack of marketability could be attributed to a number of factors, namely:

- Sludge is produced in urban areas and urban farming in Uganda is still on a small scale but not yet intensive, thus requiring few inputs.
- The cost of transporting the sludge from towns to rural areas where large scale farming is more prevalent is high, considering that there are other alternatives like compost and farm yard manure.
- The limited awareness about the value and safety of using sludge for enhancing agricultural productivity.
- The limited use of commercial fertilizer in Uganda (at 3% only) due to the belief that it is not affordable or that the soils are fertile and do not require supplementation.

- Poor attitude towards using human faeces, which is seen as a taboo among many cultures in Uganda.

> Strategies for marketing wastewater sludge and related products need to address the issues of public awareness about the value and safety of using sludge, as well as the technical challenges like the limited technology for sanitizing sludge and removal of heavy metals to make it safer for use on food crops and aquaculture. Improving on awareness among the public would go a long way in making these products acceptable among farmers and consumers of their products.

2.6 Cost/ benefit analysis

The lack of records kept by farmers who use wastewater sludge and related products makes it difficult to arrive at a proper cost/ benefit analysis. Although respondents could recall costs incurred, they could not tell the increase in yields or income as a result of using the waste products. However, based on the fact that only 3% of Ugandan farmers use commercial fertilizer, most of whom are large scale farmers, wastewater products are most likely to be used by small scale farmers who would not normally buy commercial fertilizer. This implies that any gains in yields would be attributed to the use of the waste products. For small scale farmers, the extra costs associated with using, compared to not using the waste would include: (i) cost of the waste product, (ii) cost of transport, (iii) cost of application to a given crop. In the case of piggery which was mentioned in most towns, the cost of application would not count as the farmer would have spent the same time providing an alternative feed. It should however be noted that both this study and the KCC/ NARO research revealed that small scale farmers were more comfortable with generating urine at household level, which means the cost of the waste product and its transport would be eliminated.

In the case of wastewater sludge, three scenarios are considered. One is the case where the sludge is free of charge from a wastewater treatment facility. In this case, the major cost would be transport (about UGX 20,000/= within a 5 km distance) and application of the sludge to the crop, which can be estimated at 4 man- days for a 2- ton truck of sludge. At an average of 5,000/= per manday, total labour costs would be 20,000/=. With a total expenditure of UGX 40,000/=, the farmer would improve yields due to the NPK in the sludge.

Another scenario is the case where the farmer buys the sludge from a wastewater treatment facility. The major costs include the cost of the sludge (UGX 20,000/= for 2- tone truck), transport (UGX 20,000/= within 5 km. radius) and labour for application (4 days at UGX 5,000, amounting to 20,000?/=. The total cost in this case would be UGX 60,000/=, much less than a bag of NPK from the open market.

The last scenario, although not recommended due to the health risk involved, is the case where the farmer obtains sludge or effluent from a ditch and uses it for agriculture, which is more common among urban farmers, especially in Kampala's slum areas.. The only cost here would be the labour for application, estimated at UGX 15,000/= since the semi- liquid can be channeled to the crops and so need very limited manpower for application.

It should also be noted that apart from the nutrients, the sludge in all the above cases also improves the water holding capacity of the soil, thus protecting the crop from possible water stress.

In the case of urine application from urine diversion ecosan toilets, two scenarios present themselves for consideration. One is the case where urine is generated by the farm household, implying no cost for the urine and its transportation. The major cost here would be the labour for application to the crop, which can be estimated at UGX 10,000/=.

Another scenario is where the farmer buys urine from an institution like a school and takes it to apply on farm. The major costs in this case include urine (UGX 5,000/= per 20= liter jerrycan), transport (UGX 20,000/=) and labour (for application. However, the transport costs would depend on the distance from the farm.

Data from research conducted by NARO, Makerere University and KCC indicates that the there is a big difference in incomes for various vegetables and maize between using and not using the urine at recommended levels. Applications were 20 litres of urine/ water mixture applied per week on each plot. The table below presents a comparison of gross income between the control (i.e. no urine applied) and that from plots with recommended urine proportions applied once a week for 10 weeks.

Table 6: Comparison of gross incomes from crops with and without urine applications

Crop	**Recommended urine application levels**	**Gross income without urine (control) (UGX)**	**Gross income with urine/ ha (UGX)**	**Percentage change in GM**
Kale (*Sukuma wiki)*	20%	6,258,000/= /ha	13,421,000/= /ha	114.5%
Spinach	20%	5,119,400/= /ha	23,247,400/= /ha	354.1%
Nakati (local leafy vegetable	10%	4,323/= /plot	17,115/= /plot*	395.9%
Maize	30%	2,019,000/= /ha	8,000,000/= /ha	296.2%

*This is gross margin i.e. Revenue – Variable costs

From the above comparison, it can be assumed that even after factoring in variable costs, the profits would still be adequate to warrant application of the urine to all the crops above. The increases in gross margin (GM) for all the crops were over 100%. There is therefore scope to increase production of vegetables at household level, for both home consumption and for sale, since urine is easy to collect and apply on a small scale. Application of urine on a large scale may require specialized instruments which would increase costs. However, bearing in mind the large increase in GM, investment in such machinery would require assessing the costs of such machinery, availability of urine from large facilities like ecosan toilets, as well as costs of transporting it to the farm.

Currently, the only scenario for using slaughter sludge is obtaining it at no cost from an abattoir. The major costs in the case of crops would be transport and labour for application. In the case of livestock (pigs) the major cost would be the transport of the sludge.

With the very low levels of fertilizer use in Uganda, urban farmers could increase their yields by applying wastewater sludge and related products, with a maximum estimated costs at 60,000/= for a buying, transporting and application of 2- tons of sluge, which is more than the cost of NPK fertilizer. However, use of these products not only contributes to income and food security, but also serves the purpose of safely removing these wastes from the environment, thus reducing on pollution. Use of urine has been found to increase benefits, especially in various leafy vegetables and maize, up to over 300% in GM in spinach and *nakati*.

2.7 Inventory of wastewater sludge and related product stakeholders

The study team compiled a list of stakeholders involved in wastewater sludge and related products in one way or another. The inventory consists of producers and users of wastewater sludge, as well as researchers and other promoters of urban sanitation solutions and innovations. The inventory is however not exhaustive as the study team was not able to visit all the urban areas of Uganda. It is therefore recommended that NETWAS continues updating the inventory, attached in Appendix 2. On the other hand, the database for potential markets was not was not developed as expected, however the study found out that small scale florists, foresters, gardeners and livestock farmers were the major users of wastewater sludge and slaughter sludge respectively. This gives a proposition that the flower factories, organisations and projects promoting afforestation and re-forestation and feed millers would be potential markets for these products. However most of them are either not aware of the values of this product (wastewater sludge) or could be aware but their attitudes towards using sludge is negative and fear that their products may not be marketable. Either way, these potential users need to be mobilized and sensitized.

2.8 Best practices in management and use of wastewater sludge

From the above findings, the consultant has identified a number of best practices undertaken by different institutions which promote better disposal methods, handling and use of feacal matter and wastewater products. Among these are use of biogas toilets, use of ecosan toilets at household level and in schools, construction of low cost wastewater treatment facilities and waste compositing. These practices can be used to promote marketability of wastewater sludge and related products. The technologies used and other aspects regarding their operation and maintenance are presented below.

Biogas toilets: Faculty of Technology, Makerere University Case

Apart from proper disposal of faeces, biogas toilets provide direct benefits to users through the production of biogas, an incentive for investment into such a facility, especially in an urban setting. This has advantages over Ecosan toilets where products have to transported off site as there is limited land for using it in urban areas. The Faculty of Technology has set up a biogas toilet as one of the renewable energy technologies demonstrated in Kakiri, Wakiso districts.

Description of the technology: A pour flush latrine was constructed with a pipe behind it, leading to a bio-digester, where bacteria digest the waste matter, releasing biogas. The gas is kept in a dome at the top of the digester and released through a pipe feeding gas to a stove in the kitchen. The system requires water for flushing the toilet which is also necessary for the digestion to take place. An inlet was provided for addition of cow dung to the system as the faeces produced are not adequate. Water from the bathroom next to the toilet is also directed to the bio-digester. Water used is collected by rainwater harvesting from the roof. An important by-product of bio-digestion is the bio-slurry, a high nutrient organic fertilizer that can replace many types of mineral fertilizer for agricultural production.

Operation and maintenance of the facility: The feeder has to be periodically fed with the substrate, in this case faeces. Cow dung is first mixed with water before it is added to the system. The slurry is periodically removed and applied to a garden just next to the biogas system, as well as on tower gardens that have been set up at the centre. (Slurry comes out of the dome in the left hand bottom centre of Figure 1).

Fig 1: Latrine, biodigester (below ground), gas holder & pipe

Fig.2: Inside the pouflush toilet

Number of toilet users: 3 (2 caretakers and a spouse to one of them).

Benefits of the technology: The system produces cooking gas (Figure 3), offsetting the cost of cooking fuels like charcoal. The slurry is used for crop production, contributing to increased production, even in peri-urban areas where garden towers can be set up. In an urban setting, a landlord with many tenants can have access to tenants' faeces to produce gas adequate for his household needs, while also eliminating the cost of emptying latrines or septic tanks. In this respect, similar facilities at the household and community level have been introduced in the slums of Bwaise by an NGO, Sustainable Sanitation and Water Renewal Systems. Biogas is also cleaner to use, reduces indoor pollution and cooking takes a very short time, compared to firewood or charcoal.


Fig.3: Using the gas in kitchen

Challenges of the system: Production of feaces adequate for production of biogas for an average household is the major challenge. However, this can be overcome by either supplementing with other substrates or collecting feaces from the neighbourhood. In a school setting like Namilyango High School, production of feaces was limited by two factors: (i) girls were not using the facility due to fear of throwing in sanitary towels; (ii) most of the students were not boarders at the school. The amount of gas produced was therefore very little, just enough to boil drinking water only and the school still has to buy firewood for its kitchen. The school can overcome this by introducing cow dung or collecting faeces from nearby schools in order to further reduce on firewood costs.

There is still an issue of attitudes towards using products of human faeces for cooking, as expressed by students of Namilyango High school. However, this can be changed by setting up demonstrations, as happened in Bwaise area after bio- toilets were introduced by Sustainable Sanitation and Water Renewal Systems.

Using Ecosan products to grow crops: A case of farmer John Serwanga of Kyanja, Kampala

Mr. John Serwanga used to be a farmer in Kyanja village, a peri-urban area of Kampala City Council (KCC). John was introduced to the use of ecosan products (urine and faeces) through a research project, involving KCC and other institutions. He was part of a group of 20 farmers which later grew to over 50.

Practice: With support from KCC, farmers were able to access urine and later faecal sludge for application on their crops. He says that KCC introduced the idea in 2005, trained the farmers, transported urine and faecal sludge to the village and took farmers for study tours. Mr, Serwanga used the urine on vegetables, sweet corn and bananas while the faecal sludge was used on bananas only. He said that he also uses other organic soil conditioners including compost manure, cow dung and cow urine. He sometimes combined these products, for example, when planting, he would use compost and boost it with urine. The urine is kept in a jerrycan for 2 weeks, diluted with water and mixed with red pepper and ash before it is applied.

Although the project has ended he has moved away from Kyanja, John has continued using human urine, collected from members of his household. He gets more urine during the holidays when all his children are at home.

Benefits: According to John, the urine was more beneficial than the feacal sludge, which he has stopped using. He also asserts that it was better than cow urine. He says the quality of green vegetables improved a lot, as well as the quantity, with the production time being longer. The banana bunches were also bigger and he would sale each bunch between UGX 10,000 and 20,000. Regarding sweet corn, the use of urine led to production of 2 cobs per plant instead of one cob per plant without the urine. He is now using the urine to grow other fruits like passion fruit.

Attitude: While his family has no problem with eating the products of urine, John says that some neighbours refused to buy his products once they learnt that he uses urine. As a result, he no longer broadcasts the fact that his crops are grown on human urine.

Construction of low cost wastewater treatment facilities in small towns: Adjumani TC case

Town councils without NWSC wastewater treatment facilities can construct low cost facilities for treatment of wastewater and faecal waste like the case of Mityana and Adjumani town councils, in order to reduce the hazards of improper disposal in most of Uganda's towns. In the case of Adjumani TC, such a facility was constructed at a cost of UGX 9m/= only, with support from GIZ.

The technology: The facility in Adjumani uses vertical flow artificial wetlands followed by irrigation of the effluent on agricultural land. The sludge derived from pit latrines and septic tanks is dried and decomposed in three wetlands with a capacity of 20 m^3 each. The sludge rests for one year and is then disposed of on adjacent agricultural land.

Fig. 1: Construction of wetland series

Fig.2: Facility after use

Benefits: Benefits of this technology are two-fold, namely:

- proper disposal of latrine and septic tank sludge
- use of nutrients and waste products for food production on agricultural land

Operation: The facility is operated by a private operator who charges UGX 10,000/= per load, and who is required to maintain the facility. The operator is also allowed to grow crops on the adjacent agricultural land that is part of the facility.

Issues in operation and maintenance of the facility: Operation and maintenance is a crucial aspect of the facility. Great care must be taken to select a reliable and trustworthy operator. In the case of Adjumani, the new operator is the only pit emptier who is stationed in Adjumani and who thus has a personal interest in the success of the project and in the maintenance of the facility.

Environmental safety: The facility is constructed in in-situ clay, with minimal threat to ground and surface water. The isolated location of the facility minimizes the smell at the time of off-loading the waste.

Implications for use of sludge and effluent for agriculture

- The use of processed sludge and effluent on land adjacent to the facility reduces the cost of transportation from the facility to the area where sludge is needed.
- The resting period of one year would be adequate to kill off the micro organisms to make the sludge safe enough for use for agriculture.
- The issue of too much manure on the same piece of land is eliminated as it takes several years before the next removal of the humus-like residue, by which time the nutrients would have been exhausted.
- The danger of toxicity of crops by heavy metals is very minimal in the small towns as there are limited industrial activities.

Challenges: The road to the facility is in a poor state, making disposal at the site difficult, especially during the wet season.

Contributions to this case by Hanns Andre Pitot Beaujardiere, GIZ Technical Advisor, Adjumani Town Council, are acknowledged

Household level composting in Kitgum Municipality (insert pictures from rossa)

ROSA (Resource-Oriented Sanitation concepts for peri-urban areas in Africa); implemented a composting project in Kitgum, N. Uganda, with the following objectives:

- Using composting in order to develop practical operation and management strategies for peri-urban areas
- Demonstrating safe resource reuse by sanitising food waste mixed with source-separated faeces using different composting techniques.

Technology: Two technologies were used, namely piling and windrow composting. The piling technology involves putting organinc matter like food residues, leaves and weeds; and leaving them to decompost. The composting takes 6 months to 2 years and compost is ready when materials have turned blackish. In the windrow method, a mixture of feed stock materials is placed in a long, narrow pile. The pile is turned or mixed on a regular basis to provide oxygen throughout the pile. Frequency of turning is determined by several factors including temperature, moisture level and porosity of the pile. The advantages of the windrow composting process include thorough mixing of materials. The compost is ready in about 4 months.

Operation and maintenance (O&M): O&M involves acquisition of household domestic wastes that are placed in piles or windrows and left for decomposition. The decomposed organic matter is applied in gardens. Cow dung is sometimes being added to supplement the nutrient level of the other wastes. Households that have UDDTs often apply source-separated faeces to the compost pit.

O&M is mainly done by women with the assistance of children. Some people prefer windrows while others prefer the use of pits, especially where the spatial extent has to be minimised. Thus, the costs of O&M may be kept minimal or reduced to zero when done by the household members. Otherwise, it is estimated to cost less than EUR 10 per composting period. The costs include the turning of the compost, as well as spreading the compost on the garden.

Impacts: Overall, more than 50 households were trained in hands on courses on how to make compost for their gardens. By January 2010, the total number of households performing on-site composting had grown to 100. All households who were trained on composting are doing it at their homes, producing compost for their gardens.

Acceptability:

- Many homes, whose members have been trained, started composting their organic waste. Most of them have prepared small gardens within their compounds where they are now applying manure and growing their crops.
- By involving people from various villages in the sensitisation workshops, the knowledge about composting could be disseminated extensively.

Lessons learnt:

- Only few members of the community were willing and/or had the capacity to pay for their solid waste collection by private operators. The majority of them opted for composting to manage their organic wastes and apply the compost in their urban farmland while the few nonbiodegradable wastes were taken to collection points were a Town Council truck collects them.
- The quantity of wastes generated at household level in the peri-urban areas of the Town Council is small, compared to those produced by households in urban areas.
- Many private operators are sceptical about the people’s willingness to buy the final compost manure considering the product as too expensive.

Sustainability

With regards to long-term impacts of the project, the main expected impact of the project is improved cleanliness of the area as well as increased productivity through the use of compost.

Challenges:

- Many households in peri-urban areas only produce small amounts of organic waste. This makes the

Industrial Wastewater treatment: Pilot wastewater treatment at City Abattoir in Kampala

Wastewater from industries in Uganda’s towns is usually left to flow into open waters, leading to environmental degradation. At City Abattoir in Kampala, a pilot research project on wastewater treatment has been set up by BIO EARN and Makerere University.

The Technology: The facility includes tanks for treatment of wastewater and an artificial wetland to process the effluent before it is released into Lake Victoria. The plant also produces wastewater sludge.

Operation and maintenance: The wastewater is first pumped into the processing tanks where it is kept for … It is then piped through the artificial wetland to remove any other waste before the effluent is discharged into an open channel. Wastewater sludge is kept in a container at the facility where farmers are supposed to collect it from.

Fig 1: Treatment tanks at the wastewater facility

Figure 2: Artificial wetland for cleaning effluent before disposal

Benefits: The wastewater is treated to free it of industrial pollution that would be harmful to the environment. The resultant effluent and sludge are safe for use in agriculture. Swamps are efficient in removing nutrients from wastewater, making it safe for disposal or reuse.

Challenges: However, the facility is still small and is only able to process 30% of the wastewater produced by the abattoir, leaving the rest of the untreated water to flow to the lake untreated.

3.0 CONCLUSIONS AND RECOMMENDATIONS

3.1 Conclusions

Wastewater sludge, a product of municipal wastewater treatment, can be used for a variety of purposes, including land application, either as a source of nutrients for farming or for soil remediation; as a source of fuel for incinerators; as landfill cover or for mine waste rehabilitation; as a construction materials for making cement, bricks, pumice and artificial aggregate and as a raw material for manufacture of compost or minimized dry pellets.

The Government of Uganda has put in place policy and legal instruments for discharge of wastewater but there is no provision for use of wastewater products like sludge. However, law enforcement regarding wastewater discharge is still a challenge, leading to pollution of water bodies by industries and on- site sanitation facilities. The re- use of wastewater and its related products would contribute to reduction in environmental pollution. Most urban authorities still regard urban agriculture as an illegal activity, apart from KCC which has developed a set of agricultural ordinances that provide guidelines on urban agriculture but prohibit the use of untreated human waste. MAAIF is also in the process of developing an Urban Agriculture Policy that will provide guidelines on use of wastewater sludge.

The larger towns with higher populations and wastewater treatment facilities are able to produce large amounts of sludge. However, only farmers in Kampala were using this sludge, mostly for non- food crops. Other products available for use in agriculture include effluent from wastewater, urine and faecal sludge from ecosan toilets and untreated sludge from abattoirs. There is still a lot of untapped potential for using the sludge to improve agricultural production among urban and peri- urban farmers. However, most of the waste from on- site sanitation facilities and industrial wastewater in Uganda is not disposed of properly, and is therefore not available in the form of sludge and has led to environmental pollution.

Although wastewater and related products have nutrients that can improve agricultural productivity, they also bear a risk of contamination by pathogens and heavy metals from industries, which can affect both users and consumers of products. The NWSC treatment facility in Kampala is the only one that produces sanitized sludge (Class A sludge). However, NWSC authorities restrict its use to farmers engaged in the production of non- food products due to the presence of heavy metals from industries. Sludge from small towns with few or no industries could also be safe for use if it was sanitized to kill off pathogens. Urine is considered pathogen free and is safe for use in agriculture after storage of one week, while faecal sludge in Uganda is usually sanitized through composting. There is need to sensitse farmers on ways to reduce the risk of safely using wastewater products as well as consumption of agricultural products.

The NWSC treatment facility in Kampala is the only one that produces sanitized sludge (Class A sludge), whose use is restricted to producers of non- food products due to the presence of heavy metals from industries. However, sludge from small towns with few or no industries could also be safe for use if it was sanitized. Urine is considered pathogen free and is safe for use in agriculture after storage of one week, while faecal sludge in Uganda is usually sanitized through composting.

Demand for wastewater sludge was highest in Kampala where there was treated sludge, mostly among people growing non- food crops. However, some farmers were also using untreated sludge from ditches and canals. There was more demand for urine than for faecal matter from urine diversion ecosan toilets, although there was concern about attitudes of consumers of their products. Demand for industrial waste was identified in most towns, specifically slaughter waste from abattoirs which was used for crop production, piggery and biogas production.

There was a general lack of knowledge among the local government staff technical and the general public concerning the value of wastewater sludge to agriculture. On the other hand, the more knowledgeable technical staff were concerned about the health risk of using sludge. Knowledge about urine and facal material from ecosans was more widespread, although farmers were more willing to use urine than the faeces. There was also a general acceptance of using slaughter sludge among farmers.

Increasing the amount, efficiency and safety of sludge for agriculture requires a chain of services including delivery of wastewater from towns and parts of towns without a sewer network, wastewater treatment, sanitization of sludge and other products, transportation of sludge to the farmer and technologies for application of the sludge. Services required include hygienic sanitation facilities, cesspool emptier, efficient treatment plants, on-site treatment facilities, trucks for transporting sludge, urine and other products, skilled extension service providers and an informed market for produce.

Cesspool emptier operators play an important role in the disposal of waste from households, institutions and industries, to wastewater treatment facilities. However, the smaller towns lack these services, leading to high costs of emptying on- site sanitation facilities. The majority of clients of these operators are mostly institutional, while collection in informal settlements is limited by lack of access to the facilities or to poor design of latrines for suction by emptiers.

With the cost of buying, transporting and applying sludge estimated at UGX 70,000/= for a two- ton truck, it is considered a worthwhile investment for increasing agricultural production by utilizing the nutrients and improving water holding capacity of soils. However, these benefits should be weighed against the costs of ill health among the users and consumers if nothing is done to minimize their effects.

There was a general lack of knowledge among the local government staff technical and the general public concerning the value of wastewater sludge to agriculture. On the other hand, the more knowledgeable technical staff were concerned about the health risk of using sludge. Knowledge about urine and facal material from ecosans was more widespread, although farmers were more willing to use urine than the faeces. There was also a general acceptance of using slaughter sludge among farmers.

Strategies for marketing wastewater sludge and related products need to address the issues of public awareness about the value and safety of using sludge, as well as the technical challenges like the limited technology for sanitizing sludge and removal of heavy metals to make it safer for use on food crops and aquaculture. Improving on awareness among the public would go a long way in making these products acceptable among farmers and consumers of their products.

Recommendation	**Stakeholder(s)**
Develop instruments for regulating the use of wastewater sludge and related products, by building on the draft Urban policy, based on the WHO guidelines on use of wastewater in agriculture and aquaculture.	MAAIF, MoH, MWE, Town/ Municipal councils, CSOs
Ensure that industries producing organic waste are complying with the wastewater discharge regulations in order to protect farmers using abattoir and brewery waste, as well as consumers of their products	MWE, NWSC
Create awareness about the value of sludge to agriculture among the technical staff of local governments and the public in order to use improve production and reduce environmental pollution. It is further	MAAIF, MWE, CSOs

Recommendation	Stakeholder(s)
recommended that lessons could be drawn from the process undertaken by KCC in making ordinances and supporting urban farmers.	
It is further recommended that farmers be guided on the appropriate crops to grow on wastewater sludge and related products in order to minimize the risk of contamination.	MAAIF, NAADS. CSOs
It is also recommended that pre- harvest and post- harvest hygiene be promoted among urban farmers in order to reduce the transmission of contaminants on the surface of crops like vegetables.	MAAIF, NAADS. CSOs
It is also recommended that urban areas be provided with clean water in areas where urban produce is sold, to reduce the health risk to consumers.	UWAs, NWSC, CSOs
Upgrade the capacity of the NWSC sewage treatment plants in the towns with high population to process more and produce sanitized sludge and remove heavy metals where there are industries.	NWSC
Encourage the private sector to invest in adding value to wastewater sludge to make it more marketable to a wider range of farmers	MWE, NSWC
Build the capacity of agricultural extension workers to support the urban and peri- urban farmers interested in using wastewater sludge including selection of appropriate crops and hygiene maintenance.	MAAIF, CSOs
Promote urine diversion toilets among the urban farmers and generate urine at household level to increase agricultural yields without the additional costs of acquiring and transport the urine.	Municipal/ town councils, CSOs
It is recommended that regular hazard assessment be carried out to determine the potential content of the different chemical, microbial and other factors that may occur in the different waste products and develop a risk mitigation framework.	MWE, NWSC
It is further recommended that a systematic assessment of the costs involved in the promotion of use of WWS and urine be done at the user level.	MWE, CSOs

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Appendices

Appendix 1: Term of reference for undertaking the assignment

Terms of reference for conducting a market study on demand for use of waste water sludge and other related by products

BACKGROUND

The urban population in Uganda is growing very fast and currently stands at about 20% of the overall population of Uganda which is about 30 million, with rural migration on the increase. Urbanization comes along with release of huge amounts of waste, one of them being waste water from industries and homes. The manufacturing sector in Uganda has grown by 15% to a total of 209 individual manufacturing units (UBOS 2008a), these units include processing facilities like; breweries, abattoirs, paint processors, tanneries and soft drink factories. Industries discharge untreated or partially treated waste water into water bodies, soil or into air.

> Waste water sludge is one of the products from waste water, and refers to the material removed from waste water treatment plants designed to treat predominantly domestic waste water and includes the following products; raw or primary sludge from a primary clarifier, primary sludge from an elutriation process, anaerobically digested sludge, oxidation pond sludge, septic tank sludge, surplus or waste activated sludge, humus sludge, pasteurized sludge, heat treated sludge, lime stabilized sludge and composted sludge.

Access to sanitation stands at 73% of households who usually construct VIP lined pit latrines, open pit latrines, pour flush latrines linked to a septic tank etc. The untreated sludge from the toilets is usually disposed off in areas that are unsuitable including wetlands, storm water drainage channels, natural water courses, manholes and undeveloped plots (SPR, 2009). This has greatly contributed to the observed poor water quality in many surface water bodies around these urban areas (SPR 2009). Recent research by GTZ 2009 shows that farmers of flowers, bananas etc have recognized the value of human excreta or wastewater . They use sludge as an alternative to chemical fertilizers. These practices, although unsafe in some ways have provided a market for the waste water sludge.

The private sector through the cesspool emptier and "scavengers" have provided the sludge to farmers at a small cost. At the dumping grounds, compost material is also sold out to farmers. However, all these are pockets of success that need to be explored to determine the available market and the extent of re-use of waste water sludge in urban dwellings.

This study will aim at filling the gap of a market study carried out by GTZ which focused on re use of urine and faecal matter. It will seek to analyse the policy environment and looks at the sources of sludge and its available market for reuse by farmers.

Network for Water and Sanitation (NETWAS) Uganda, with support from the Stockholm Environment Institute (SEI) is hosting the Ecological Sanitation Research (EcosanRes 2) knowledge node in Uganda. The EcosanRes 2 is an international environment and development program on ecological sanitation, with a mission to develop and promote pro-poor sustainable sanitation on the ground through capacity development and knowledge management. The Ecosan-Res knowledge node is a network of information, knowledge and expertise in sustainable sanitation.

In line with the overall mission of EcosanRes 2, the Uganda knowledge node plays a role in closing the knowledge gaps, influencing attitudes; researching and demonstrating sustainable sanitation promotion approaches and technology options including re-use of by products; improving access to information and knowledge and building the capacity to promote sustainable sanitation solutions in Uganda with the possibility of increasing outreach to other countries of East Africa.

It is against this background that NETWAS would like to hire a consultant to conduct a market study on demand for use of waste water sludge and other related by products.

Overall objective of the consultancy is to;

Generate evidence on the market demand for waste water sludge and other related by-products, its cost and affordability in Uganda.

Specific objectives of the assignment;

1. To generate knowledge on the market demand for waste water sludge and its related by-products in Uganda.
2. To investigate potential market for waste water sludge, and related by products for agriculture use.
3. To document and analyse the legal framework for waste water sludge use and disposal in Uganda
4. To develop a databank of potential market for waste water sludge; private operators and farmers in an effort to link buyers to sellers.
5. To determine the knowledge, attitudes and views of using waste water sludge as fertilizer for crop production.
6. To document existing best practices and/or successes around waste water sludge management, marketing and use among private operators and farmers.

SPECIFIC TASKS OF THE CONSULTANT.

In collaboration with the NETWAS (U) team, the consultant will;

1. Implement preparatory activities for the study including but not limited to (5 days)
2. Meet with NETWAS (U) team for initial briefings and discussions around the activity.
3. Review existing literature/ information around the issue at hand
4. Develop and submit an Inception concept and draft tools for collecting of the data as per understanding of the assignment.
5. Coordinate/undertake subsequent activities in terms of collection of data from the identified stakeholders
6. Analyze data in collaboration with NETWAS knowledge node team and produce a draft report for discussion.
7. Prepare and submit the final study report in both hard and soft copy to NETWAS (U).
8. present results to the National sanitation working group and or the advisory committee

1.0. DELIVERABLES.

The following deliverables are expected from the consultant;

1. Final study report
2. Data bank of sludge private operators; sellers and buyers with their contact details
3. 2 fact sheets on best practices

2.0. GOEGRAPHICAL COVERAGE.

The survey will be a national study in which samples of small towns will be logically selected as deemed fit or at the discretion of the consultant.

3.0. TIMELINE

It is expected that the assignment at hand will take a maximum of 20 man days commencing September to October 2010.

4.0. TARGET GROUPS FOR THE SURVEY

The survey will sample small towns in Uganda targeting; private sector stakeholders, farmers and institutions.

5.0. PAYMENT TERMS

The total compensation will be based on the available budget and also negotiable, and payment will be disbursed as follows:

- 30% upon delivery of Inception concept
- 60% upon delivery of final completed reports
- 10% upon delivery of final fact sheets

6.0. REQUIRED COMPETENCIES

- A sound and comprehensive understanding of the Ugandan Water and Sanitation sector and its policy framework at various levels.
- A good understanding of the fundamentals of sustainable sanitation.
- A sound understanding of dynamics of the WATSAN sector in Uganda in context of cross cutting issues as gender, HIV/AIDS, PWDs among others.
- Ability to communicate and analyze situations, as well as professionally documenting lessons and excellent report writing skills.
- Proven track record and/or experience conducting research and particularly baseline surveys.

7.0. REPORTING

At the end of the fixed period, the consultant will submit to NETWAS Uganda Program manager draft copies of both hard and soft versions of the study report and best practice documentations for review before a final report is submitted.

Appendix 2: Database of wastewater stakeholders

Name	Role	Contact
Central Government Institutions		
Directorate of Water Resources Management, Ministry of Water and Environment	Implementation of the provisions of the Water Act related to regulating water abstraction and discharge of waste water into the environment.	Commissioner, Water Resources Planning and Regulation Tel: +256 – 0414 – 4323558 /320914/321342
National Water and Sewerage Corporation	Supply of drinking water and treatment of sewage in the big urban centers	Mr. James Miiro Maiteki Sewerage Services Manager/ NWSC Kampala Tel: +256 0772 486350
Mr. Allan Kawezi	Senior Engineer/ NWSC Gulu branch	0717315445/ 0702224111
Mr. Kiza Samanya	Distribution Overseer/ NWSC Mbarara Branch	
Mr. Fredrick Etedinal	Area manager/ NWSC Jinja Branch	
Urban Water Supply and Sanitation Department, Ministry of Water and Environment	Supervision of Urban Water Authorities and provision of technical support to utility management through drafting of private operators' performance contracts and performance assessment. Planning, design and development of urban water and sewage systems countrywide. Regulation. Regulation of urban water supply and sanitation service development	Eng. Commissioner, Urban Water and Sanitation Tel: +256 0772412853
National Environment Management Authority (NEMA)	Coordinating, monitoring, regulating and supervising environmental management in Uganda. Spearheads development of environmental policies, laws, regulations, standards and guidelines; and guides Government on sound environmental management in Uganda.	Mr. Isaac Ntunju Environmental Inspector Tel: +256 0772 699828
Ministry of Agriculture, Animal Industry and Fisheries	Supporting, promoting, guiding and regulating the production of livestock, fisheries and crops in order to ensure improved quality and quantity of the produce and their products for local consumption, food security and export.	Directorate of Crop .. and Directorate of Animal Resources T
National Agricultural Advisory Services (NAADS)	To give farmers, particularly the poor, access to the agricultural advice they need from private sector service providers. Recently reviewed to include urban agriculture.	NAADS Secretariat Plot 39A Lumumba Avenue Mukwasi House, 2nd Floor P.O Box 25235, Kampala Tel: 0414 345440; 0312345060/1/2 Fax: 0414 347843
Ministry of Education and Sports	Responsible for hygiene promotion and sanitation in primary schools. Works to ensure that schools have the required sanitation facilities and provide hygiene education to pupils	Commissioner, Primary Health Department
Ministry of Health	Contribute to the attainment of a significant reduction of morbidity and mortality due to environmental health and unhygienic practices and other environmental health related conditions	Assistant Commissioner, Environmental Health Division Plot 6 Lourdel Rd,

Name	Role	Contact
		Wandegeya Tel: 256-414-340884 Kampala Uganda
National Sanitation Working Group	Coordinate ministries responsible for sanitation; coordinate sanitation promotion activities in sector	
Research Institutions		
Makerere University	Provide teaching and research services	Department of Civil Engineering, Faculty of Technology Dr. Charles B. Niwagaba Tel. +256 0772335477
National Agricultural Research Organisation (NARO)	The National Agricultural Research Organisation (NARO) is the apex body for guidance and coordination of all agricultural research activities in the national agricult ural research system in Uganda.	
Local Government agencies		
Kampala City Council	Law enforcement and provision of sanitation services at the local level	Mr. Lule, Principal Health Inspector Ms. M. Azuba, Senior Agricultural Officer
Adjumani TC	Law enforcement and provision of sanitation services at the local level	Mr. Samuel Lagu, Town Clerk, 0772361490
Rukungiri TC	Law enforcement and provision of sanitation services at the local level	Mr. Vincent Byamukama, Urban Water Officer
Mbarara MC	Law enforcement and provision of sanitation services at the local level	
Gulu MC	Law enforcement and provision of sanitation services at the local level	Mr. Richard Nyadero, PHI
District Water and Sanitation Working Groups	Coordinate sanitation promotion activities at the district level	Chaired by representative of the sector donor group. Environmental Health Division of MOH provides the secretariat.
NGOs / CBOs		
Community Integrated Development Initiatives (CIDI)	Contribute to the general development objective of improving living conditions of the poor both in rural and urban area. In urban strategic focus is on people living in informal settlements (Slums). Specialises in water and Sanitation, Sustainable agriculture and Micro credit.	Mr. Samuel Lukanga, Senior Programme Officer 0772314075
Environmental Alert	Promotes food security, natural resource management and community empowerment, to improve livelihoods of vulnerable communities	Program Officer, Environment and Natural Resource at Environmental Alert, Land, Land use and Soils Program.

Name	Role	Contact
		Tel: 0414510215;
Sustainable Sanitation and Water Renewal Systems (SSWARS)	Promote sustainable sanitation promotion, utilization and recycling of resources…which reduces risks of exposure, incidence of diseases and disease prevalence accruing from inadequate sanitation and hygiene and contaminated or use of unclean water.” social marketing and waste recycling programs.	
Uganda Domestic Sanitation Services (UGADOSS)		
Action for Slum Health and Development (ASHD)		
ACODE		
Development partners		
GIZ	Supports urban water and sanitation sub-sector to improve access to clean drinking water and sewage systems.	
UNICEF	Contributes to improvement of water supplies and sanitation facilities in schools and communities, and to promote safe hygiene practices.	Mr. Semakula, Water and Sanitation Hygiene Specialist/ UNICEF Tel +256 0772820528
Producers of wastewater		
Mr. David Mutebi Musisi	Quality controller, Kampala City Abbatoir	0784648244
Users of wastewater		
Ms. Julie Namuwaya	Nursery operator, Kibuli, near Mukwano	
Mr. Davison Okumu	Nursery Attendant, Bugolobi Kampala	0774308982
Ms. Josephine Namukasa	Nursery operator, Nakasero, Kampala	
Ms. Mary Mutesi	Nursery operator, Yusuf Lule Rd, Kampala	
Mr. John Bosco	Nursery operator, Kibuli, near Mukwano	
Mr. Deo Kibuuka	Nursery operator, Kibuli, near Mukwano	
Mr. John Serwanga	Farmer/ Kyanja, Kampala	0782401089
Musaanya Rose	Farmer/ Kevina Farm	0772354815

Name	Role	Contact
Kampala Farmers Association		**0772884689**
Muwanga Silvia	Farmer, Kampala	0782804858
Rose Yiga	Farmer, Rubaga, Kampala	0782868873
Rose Musanya	Farmer, Kawempe, Kampala	0772354815
Besigire- Omugisha	Farmer, Nakawa, Kampala	0712961832
Kato Douglas	Farmer, Kampala	0782080807
Muhwezi Albert	Farmer, Kampala	0782321142
Mary Modedu	Farmer, Mbale	0752450380
Marion Tukahirwa	Farmer, Wakiso	0772413380
Adeka Alfred	Farmer	0772820554
Kamya Prossy	Farmer, Buziga, Kampala	0712419920
Wastewater sludge transporters		
Mr. Jaffer Matovu	General Secretary, Private Emptiers' Association	0772 665410
Mr. Yosam Muguzi	Cesspool operator, Bugolobi, Kampala	
Okello	Cesspool Operator/ UPDF, Gulu	
Mr. David Bashakara	Cesspool Operator/ Kamukuzi, Mbarara	0753577100
Mr. Christopher Lubwolwa	Cesspool operator, Bugolobi, Kampala	
Mr. George kirimani	Cesspool operator, Kizungu Mbarara	0772641207