

## Characterization of Peri-Urban Anthropogenic Pollution in Kampala, Uganda

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*Effective improvement of the current poor environmental sanitation in peri-urban Kampala requires an understanding of pollutant characteristics (types, sources, locations and loads). As part of an on going study, this paper presents pollution characteristics in Bwaise III and challenges encountered during the period 2002-3. Findings show that pit latrines are a major source of pollution as far as pathogenic bacteria and nutrients are concerned (14.5E20 cfu TTC /yr, 41,775kgN/yr and 6,680KgP/yr). Drains on the other hand, though they have lower levels of nutrients (980kgTKN/yr and 80kgP/yr for sullage) are recipients of runoff, solid waste and faecal matter and hence a major problem in the area especially during the rains. The impact of these on the environment and community health are mutually reinforcing. Challenges encountered during the study have been overcome largely by dialogue. Management strategies and mitigation measures for these areas require the collective participation of communities, authorities and policy makers.*

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### Introduction

Increasing global urbanization poses big challenges especially for developing countries. Here, urban growth is usually associated with rapid expansion of unplanned smaller urban centres and peri-urban settlements. These areas harbour dense populations arising from both natural increases and rural to urban migration. Informal settlements lead to environmental degradation in these and surrounding areas. This is attributed to the increasing generation of anthropogenic waste and municipal authorities, which lack the capacity to ensure adequate provision for environmental health (Vernon, 2002).

Africa, though reported to be the least urbanized continent, is recognized as one where the rate of urbanization is highest (UNEP, 2002). The development of informal settlements in the peri-urban areas of the cities has been reported. In these settlements where the majority of the urban population reside: 70% in Dares-salaam (Chaggu, 2004), 77% in Blantyre, 80% in Luanda (Palamuleni, 2002) and 60% in Kampala (WSP/NWSC, 2000) to mention a few, are characterized, among other things, by poorly constructed houses, poor sanitary conditions, lack or inadequate services and lack of legal status as residential dwellings.

In Uganda, increased urbanization and industrialization in the recent years, especially in the city of Kampala, has led to an increase in the city's population and development of informal settlements. The resident population in Kampala city is estimated at 1.2 million with an annual average growth rate of 3.8% (UBOS, 2002). This population size almost doubles during the day since the city serves as a workplace for residents of several nearby areas but who go back home in the evening. The capacity of the municipal authorities to provide basic services to meet the needs of the increasing population is currently limited.

In Kampala, about 900 tonnes of solid waste are generated daily, of which only about 40% is collected and disposed of by Kampala City Council (KCC), while the rest is indiscriminately disposed of (Sikyajula, 2003). Of the total effluent from industrial and domestic sources in the city, 10% is treated and the rest is discharged untreated (NWSC, 2000). The informal peri-urban settlements in the city have a high population density, are located in valleys and wetlands with a high water table, are predominantly inhabited by the urban poor and have inadequate basic services such as water supply and sanitation (excreta, solid waste, sullage and storm water management). Environmental degradation in these areas due to anthropogenic activities is on the increase and is likely to get worse if corrective measures are not put in place.

In the informal settlements where a great majority use shallow groundwater, its quality has become a widespread concern. Recent studies carried out in these areas suggest a link between the incidence of cholera, acute diarrhoea and use of contaminated protected springs (Howard et al., 2003; MOH, 1998). In addition, due to poor sanitation, disease outbreaks (malaria, cholera, typhoid, etc) are prevalent especially during rainy seasons as a result of flooding (Plan, 2001).

Currently there are limited data and analysis of available information. Therefore pollutant characteristics, which include the types, quantities, locations and sources in Kampala, are largely unknown. Moreover, there is no basis for assessing the impact of the resultant loads on the subsurface waters in these areas. Efforts to mitigate the impacts of this pollution by policy makers are limited by, amongst other reasons: lack of a comprehensive database on pollution from domestic sources, financial constraints, land-ownership issues, and non-implementation of mitigation measures by local communities.

This paper is a result of an on-going study whose aim is to create a better understanding of the quantities and impact of anthropogenic pollution and transport in Kampala's peri-urban areas with a focus on shallow groundwater.

The paper is a presentation of the pollution characteristics (sources, locations, types and loads) in a selected informal peri-urban settlement, Bwaise III, as a case study. Presented also are challenges of the on-going study and proposed management strategies of the major pollutant sources.

This information with ongoing hydro-geological and soil attenuation potential investigations for selected contaminants will be utilized in the development of a predictive pollution management model and identification of mitigation measures. The latter will involve participation of the community, municipal authorities and policy makers.

**Study area**

Bwaise III Parish is found in Kawempe Division, Kampala District. It is located in the northern part of Kampala City approximately 4km from the city centre (Fig. 1). It is a low-lying area (mostly a reclaimed wetland) with a high water table (<1.5m) in most of the areas. The parish has an area of 57ha and is divided into six local administrative zones namely; Kalimali, Bokasa, Bugalani, St. Francis, Katoogo and Kawaala (Fig. 2). The area though mainly residential has some economic activity for the low-income residents. This constitutes mostly trading which ranges from cooking and selling food in markets to hawking and retail shops. The area is largely unplanned with lack of basic services, poor road access and deplorable housing. It has one of the highest population growth rates in Kampala District (Table 1).

**Materials and Methods**

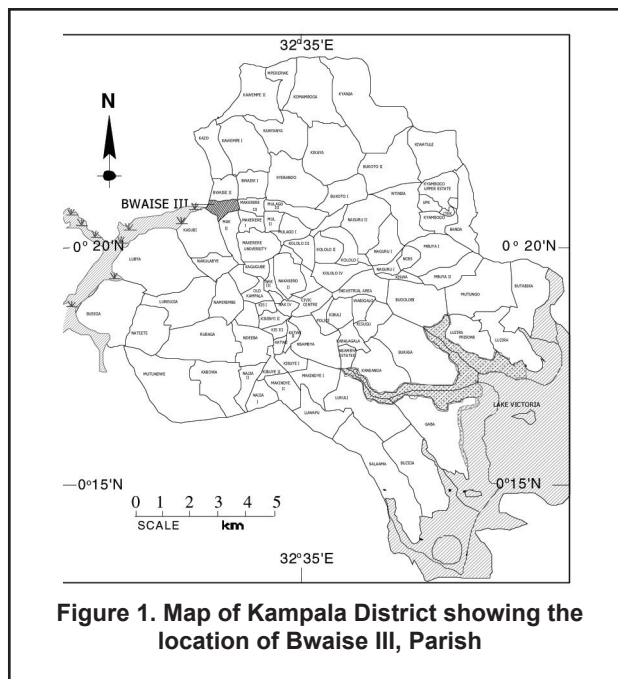
**Field surveys and consultations**

These were undertaken so as to identify and locate pollution sources, and assess the environment sanitation of the area during 2002. Record sheets were used to note the source types, location and operational status of the facilities. The latter was obtained from consultations with the residents and local authorities. These included: number of users, desludging frequency and methods (for pit latrines), and management issues (for solid waste dumps). Information on the nature of the solid waste, number of pit latrine stances, nature of sullage drains (lined or unlined, flowing or stagnant) was obtained through surveys.

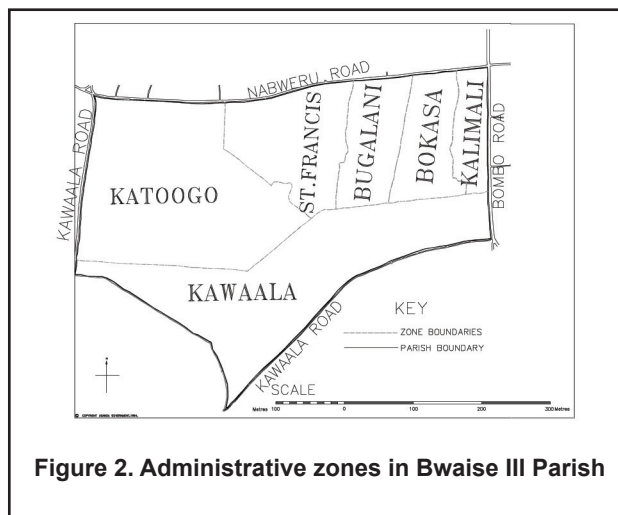
Pollutant sources were geo-referenced with a geographical positioning system (Garmin etrex vista). The resulting coordinates of the various sources were transferred to a digitized map of the study area, which was obtained from the Department of Surveying, Entebbe, Uganda. The extent of the area of the different zones was estimated from the digital map.

**Field and laboratory measurements**

These were undertaken to ascertain the seasonal variation of the sullage/wastewater characteristics within the drains.



**Figure 1. Map of Kampala District showing the location of Bwaise III, Parish**



**Figure 2. Administrative zones in Bwaise III Parish**

Table 1. Population trend for Bwaise III Parish			
Year	Population	Population density (pers/km <sup>2</sup> )	Annual growth rates (%)
1991 <sup>1</sup>	7,321	13,557	
1996 <sup>2</sup>	9,913	18,357	7.1 (1991-6)
2002 <sup>3</sup>	15,015	27,806	9.6 (1991-2002)

<sup>1</sup> 1991 Population and Housing Census Report (District Report, 1994)

<sup>2</sup> Plan international study (Lwasa, 1999)

<sup>3</sup> UBOS (2002) (Data processing centre-Household number is 3003)

Due to the intermittency of flow in most of these systems, sampling was undertaken regularly from a flowing drain (within the zone of Kalimali) in the period 2003. This was done weekly during the rainy season (March to April

& September) and dry season (July to August). In situ measurements of temperature, pH, electrical conductivity (EC) and dissolved oxygen (DO) were carried out with WTW TA 197pH/Temperature, HANNA instruments HI 9033 multi range conductivity, and Camlab Handylab OXI oxygen meters respectively. The flotation method was used to obtain the wastewater flow. Samples were collected in acid-rinsed and sterilized plastic bottles for chemical and microbiological analysis respectively. These were delivered to the Public Health and Environmental Engineering and Animal Science Laboratories of the Faculties of Technology and Agriculture respectively, Makerere University for analysis (Table 2).

Parameter	Test
Thermotolerant coliforms (TTCs)	Membrane filtration <sup>1</sup>
Total phosphorus	Ascorbic acid with persulfate digestion <sup>1</sup>
Total Kjeldahl Nitrogen (TKN)	Macro-Kjeldahl method <sup>1</sup>
Nitrates	Cadmium reduction method <sup>2</sup>
Chlorides	Mercuric Thiocyanate method <sup>2</sup>
Sulphates	Turbidimetric method (Sulfaver method) <sup>2</sup>

<sup>1</sup> APHA/AWWA/WEF, 1998

<sup>2</sup> HACH, 1997

Rainfall data for the sampling period was obtained from the Department of Meteorology, Kampala for the Makerere station located about 2 km from the study area.

## Results and Discussion

### Pollution sources

The identified anthropogenic pollution sources to shallow ground waters were found to be excreta disposal facilities, solid waste dumps, sullage drains, animal yards, car washing bays and/or garages (Fig. 3). However, it was evident that the major pollutant sources were the excreta disposal facilities (pit latrines), solid waste dumps and sullage discharged into unlined drains, which are the focus of the on-going study.

### Excreta disposal facilities

With limited coverage of the municipal sewerage in Kampala (about 9%), the rest of the population in the city utilizes on-site sanitation systems notably septic tanks and various forms of pit latrines. In Bwaise III, most of them are elevated due to the high water table (Fig. 4).

The distribution of these in the different zones in the area is presented in Table 3. More than 80% of the pit latrines are of the traditional unimproved type and do not meet the basic criteria of hygiene and accessibility to children and the disabled. Subsequently polyethene bags ("flying toilets") and spaces around the house are used for excreta disposal



**Figure 4. Typical raised pit latrine in the area, a solid waste dump and a covered sullage drain**

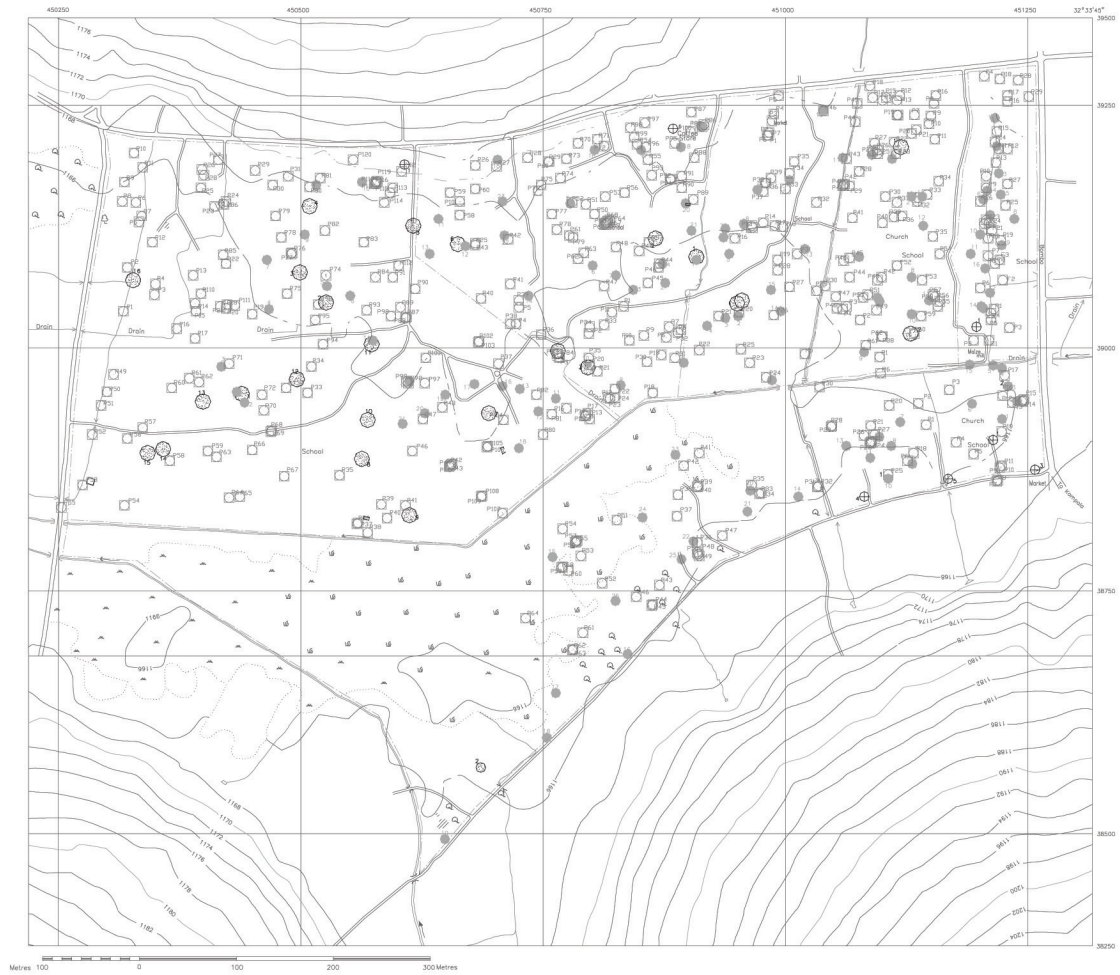
especially by the children. In these cases, the excreta disposed ends up in drainage channels and in solid waste dumps.

Due to poor access to these facilities for desludging and associated costs, most of the latrine contents are drained either into adjacent excavated pits (these are unlined) or into sullage drains (adjacent to which they are usually constructed) during the rains. Desludging is carried out at least twice a year for the majority of these systems (pers. comm with the residents). One could therefore infer that the bulk of the loading from these systems is discharged within the area, resulting into localized impact on the subsurface waters. The waste load from latrines is closely associated with the settlement density, or density of pit latrines per hectare, the number of people using each pit, and the geologic conditions (Barrett et al., 1999).

From Table 3, it can be seen that the zones of Bokasa, Kalimali and Bugalani have a high settlement density (>100 households/ha) and user numbers per latrine stance. This implies that the waste loads from the pit latrines in these 3 zones with respect to the size of the area are high. In addition, no desludging by a cesspool emptier is undertaken so all the waste generated accumulates in the environment and slowly leaches into the shallow ground water. Pollutants of health and the environment associated with waste material from these facilities are nitrates, pathogens and phosphorus. It is estimated that each person generates about 2.5kg of nitrogen and 0.4kg of phosphorus per year in Uganda based on national statistics of food supply (Jönsson and Vinnerås, 2003). According to Feachem et al. (1983), the estimated enterobacteria content based on diet for the Ugandan population, which is largely carbohydrate, is on average  $10^8$  cfu per gram of human excreta. With this in mind, the estimated loads from pit latrines for different zones are shown in Table 4. The bacteria load contains pathogenic and potentially pathogenic organisms.

**Table 3. Population and excreta disposal facility (pit latrines) distribution in the different zones of Bwaise III Parish**

Zones	Kalimali	Bokasa	Bugalani	St. Francis	Katoogo	Kawaala
Land area (ha)	2.36	3.88	4.25	6.71	17.25	16.41
No. of Households	258	451	515	580	1191	225
Settlement density (HH/ha)	109	116	121	86	69	14
Total no. of pit latrines	27	62	39	99	117	64
No. of stances	56	134	77	215	249	129
Estimated no. of users	1595	2610	2180	2870	6150	1305
Users per stance	28	19	28	14	25	10
Class 3 latrines	23 (85%)	59 (95%)	36 (92%)	81 (82%)	95 (81%)	38 (59%)
Estimated no. desludged with a cesspool emptier	-	-	-	17	10	-



**Key**

- 
- Grassy papyrus swamp
- 
- Solid waste open dumps
- 
- Pit latrines
- 
- Carwashing bays/garages
- 
- Animal feedlots/waste spreading areas

**Figure 3. Anthropogenic pollution source types in Bwaise III Parish**

Zone	Nitrogen (kg/ha/yr)	Phosphorus (kg/ha/yr)	Bacteria ( $\times 10^{14}$ cfu /yr) <sup>1</sup>
Kalimali	1690	270	815,045
Bokasa	1604	269	1,333,370
Bugalani	1282	205	1,113,980
St.Francis	1069	287	1,466,570
Katoogo	891	93	3,142,650
Kawaala	199	32	6,668,550

<sup>1</sup> Average body waste generation estimated to fall within the range 1400-1450gram/ca/d (Chaggu, 2004). Used a value of 1400gram/ca/d.

### **Solid waste dumps**

Both biodegradable and non-biodegradable wastes are generated in the area. The biodegradable wastes include peelings (bananas, cassava and potatoes) generated from homes and commercial eating places, wastes generated from the markets that sell fresh foods while the non-biodegradable include polyethene bags, plastic bottles, plastic basins and other plastic materials used in homes. Other wastes generated are from charcoal sellers, saw dust and timber pieces from carpentry workshops and waste paper and other wastes from institutions like schools. Previous studies in the area show that of the wastes generated, 80-89% are biodegradable, 0.4% metal, 2.5% plastics and polyethene bags, 1.1% wood wastes, 1.7% paper and 7.4% others (Nyenje, 2002 and Lwasa, 1999).

The area is serviced by one KCC skip, which is located at the Kawempe Division's headquarters, in a neighbouring parish. To avoid the trouble of moving long distances, most of the residents indiscriminately dispose of their waste. The municipal authority has also provided a tractor, which acts as a mobile skip for waste collection 1-2 times a week. This is inadequate and residents who can afford to pay, hire private garbage collectors who remove the waste on agreed days. Efforts by community based organizations and youth groups to improve the solid waste management in the area are frustrated by poor attitude (associated with their temporary residential status), non-payment of collection fees by residents which results in a lack of collection equipment (bins, wheel barrows, protection wear etc).

Open dumping is thus the major form of waste disposal in the area (Fig. 4 & 5). The waste is usually burnt when dry and left to decompose during the wet season. Illegal disposal of waste into storm water and sullage drains traversing the area is also practiced. Deliberate open dumping is also practiced as a way of wetland reclamation (pers. comm. with residents in Bugalani Zone). The dumps are recipients of human excreta and hence contain pathogens.

As noted above, the bulk of the waste is organic and this is generated mostly by the households in the area. The per capita generation rate for households in one of the zones



**Figure 5. Figure 5: Sullage/storm water drain in the area with solid waste dumping on the drain bank (inset)**

was estimated as 1.1kg/d (Nyenje, 2002), which is higher than the average value estimated for the city, about 0.9kg/d (Sikyajula, 2003). The waste generation rates for the different zones within the study area are depicted in Table 5 resulting in a total amount of 9,000kg/d. This amount is significant, and as has been observed, is an environment hazard necessitating proper management. Estimated phosphorus and nitrogen loads from the solid waste (Table 6), considering the organic portion (about 80%) (peelings of cassava and potatoes have trace amounts of these nutrients), are based on an average composition of 1.1% nitrogen and 0.2% phosphorus of the dry matter content (ranges between 16-18%, an average value of 17% is used in the calculations) (Nambi et al., 2004).

Zone	Average waste generation (m <sup>3</sup> /d)	Total daily production(kg/d) <sup>1</sup>
Kalimali	1.6	720
Bokasa	2.8	1260
Bugalani	3.2	1440
St.Francis	3.6	1620
Katoogo	1.4	630
Kawaala	7.4	3330

<sup>1</sup> The presented values refer to unrecycled waste with a wet density of 450kg/m<sup>3</sup>.

Zone	Nitrogen (kg/d)	Phosphorus(kg/d)
Kalimali	1.08	0.20
Bokasa	1.88	0.34
Bugalani	2.15	0.39
St.Francis	2.42	0.44
Katoogo	0.94	0.17
Kawaala	4.98	0.91

### Sullage drains

As noted earlier, the majority of the households do not use water-borne sanitation. As a result, most of the sullage water is directly disposed of into the environment via sullage drains and open spaces. Due to the high water table and dense settlement, sullage management in the area is largely inadequate. Tertiary and secondary drains are haphazardly constructed between houses and have poor gradients, which inhibit flow (Fig. 5). The water consumption rate is estimated to be in the range of 12-15l/ca/d in these informal settlements (Pers. comm with Eng. Sonko Kiwanuka, Engineer, NWSC, Kampala-Uganda). If on average the consumption is taken as 14l/ca/d and considering that no wastewater enters the sewers, the quantity of wastewater generated may be taken as 80% of the water consumption (Punimia and Ashok, 1998). Hence the amount discharged into the environment is in the region of 12l/ca/d. However, it is noted that a lot of storm water collects and stagnates in the area in these drains carrying with it lots of pollutants (e.g. TTCs, TKN, total phosphorus etc) hence the impact of these drains may actually be greater than envisaged. These drains operate as combined open sewers. This is further illustrated by the quality characteristics of the wastewater in the drains during the wet (March to April and September) and dry seasons (July to August) (Table 6).

Parameter	Wet (n=7)		Dry (n = 5)	
	Range	Average values	Range	Average values
DO	0.33-2.50	1.36±0.72	0.53-1.37	0.97±0.37
EC (µS/cm)	325-634	525±102	319-713	469±159
pH	7.31-8.04	7.68±0.29	7.63-7.85	7.73±0.09
Total-Phosphorus (mg/l)	0.74-3.28	1.77±0.88	0.83-1.81	1.19±0.38
TKN (mg/l)	0.6-35.08	18.56±13.75	6.0-31.58	13.87±10.84
Nitrates (mg/l)	1.0-11.7	6.97±3.57	3.4-9.5	6.4±2.38
Chlorides (mg/l)	36-72	51.86±13.13	34-113	64.60±29.82
Sulphates (mg/l)	0-26	3.86±9.77	0-27	10.20±11.14
TTCs (cfu/100mL)	(1-14) E6	(4.8±4.3) E6	(7.4E5-9.8E6	(2.8±3.9)E6

Recent measurements undertaken during one sampling strategy in the dry season (July 2004, this study) from three sullage/storm water drains within the area give high BOD<sub>5</sub> and COD values in the range of 76-400 and 141-977mg/l respectively. Studies undertaken on main drains traversing similar environments in Kampala show that the wastewaters carried by the drains have high BOD<sub>5</sub> and COD values (exceeding National effluent discharge standards: 50 and 100mg/l respectively) with values as high as 350mgBOD<sub>5</sub>/l and 400mgCOD/l reported (Niwigaba, 2002).

From Table 6, maximum pollutant concentrations of phosphorus, TKN, nitrates and TTCs (as seen from the ranges) are obtained during the rainy season. During the dry season the flow is very low (almost stagnant). However, after rain it ranges from 0.27m/s to about 1m/s with the latter under flooded conditions. It appears that stagnation during the dry season results in most of contaminant attenuation through processes like leaching into the subsurface, adsorption, and microbiological uptake. Using the per capita wastewater generation and population size from each zone (no of households and household size of 5 and average concentrations during the dry season with sullage being the predominant wastewater, the estimated loads are as shown in Table 7. Estimation based on wet season data is complicated by the fact that as mentioned, these drains are recipients of wastes from the neighbouring areas.

Zone	TKN (kg/yr)	Phosphorus(kg/yr)
Kalimali	78	7
Bokasa	137	12
Bugalani	156	13
St.Francis	176	15
Katoogo	362	31
Kawaala	68	6

### Impact of Pollutant Loads

The impact of the pollutant loads within the area is mutually reinforcing. Wetland reclamation by way of solid waste dumping has implications for the lithology and subsequent contaminant transport to shallow ground water as a result of rainfall infiltration. In this case, the upper zones of the unsaturated zone (<0.5m) have a high permeability (in the order of 10<sup>-3</sup>m/s, this study) and hence a potentially fast infiltration of contaminants into the subsurface. The poorly managed solid waste is a recipient of human excreta, a source for proliferation of rodents and vectors of diseases, offensive smells due to the high decay rate, blocked sullage/storm water drains leading to flooding during the rains and infiltration into the subsurface of leachate. The impact of solid waste dumps on the microbiological quality of groundwater is likely to be more localized than widespread (ARGOSS, 2001).

Due to the shallow nature of the aquifer in the area (<1.5m) aerobic conditions have been realized (dissolved oxygen>2.0mg/l) in a protected spring and observation wells installed within the area, with correspondingly high nitrate concentration levels. This implies that a significant percentage of organic nitrogen generated in the area from excreta disposal facilities, solid waste dumps and sullage/storm water drains is oxidized to form nitrates.

The sullage drains in the area, the majority of which are unlined, are poorly maintained resulting in stagnant wastewaters. These are a source of smells, poor aesthetics and are a breeding ground for malaria (pers. comm. with the residents). The situation is escalated during the rains

with flooding resulting in flow of contaminated water into peoples' houses.

High TTCs counts ( $>>E6$  cfu/100ml) and nitrate concentrations ( $>200$ mg/L) following heavy rains in the area have been measured in the observation wells and a protected spring (this study). The latter was successfully rehabilitated with community participation in the period 2000 and on-going measurements show a relatively good microbiological quality during periods of no rainfall appropriate in small community managed supplies of less than or equal to 10TTCs cfu/100ml (Howard et al., 2000). However, this source is contaminated following heavy rains. This may be attributed to 1) the relaxed maintenance of the source by the community (pers. observ.) who claim inadequate financial support for maintenance activities and new comers in the area who do not have an appreciation of the protection measures undertaken previously (pers. comm. with residents living near the spring), and 2) The recent rehabilitation of Nabweru road which has resulted into increased runoff to the spring protection area.

The poor sanitation environmental sanitation in the area has an impact on the health of these communities. Malaria, diarrhoea, typhoid and cholera epidemics are common in the area in that order especially during the rainy season (Lwasa, 1999). To address these impacts therefore requires concerted effort and support from the communities, planners, municipal authorities and policy makers as discussed in the subsequent section.

## Legal & Institutional Aspects of Pollution control

To protect natural resources from pollution and to ensure a healthy environment, various policies and legislations have been enacted by Government. Among these is the KCC Solid waste Management Ordinance, 2000; National Health Policy, 1999; National Environment Statute, 1995 and the Public Health Act, 1964. However, from observation, the enforcement of these within the area is very weak hence the current environmental degradation. The community attributes the latter to inadequate municipal authority service, poverty, absentee landlords, lack of space for construction of excreta disposal facilities and solid waste disposal, and the poor attitude of the residents associated with their "temporary" resident status (Plan, 2001). The authorities attribute their limited service to lack of resources (financial and human) and weak enforcement of planning laws. Besides this, revision of some obsolete laws is currently ongoing but is still an incomplete process. To the service providers these areas are considered illegal settlements and hence not catered for (WSP/NWSC, 2000). It is increasingly realized therefore that appropriate solutions to address the existing problems have to be integrated and multi-sectoral.

## Challenges of the study

The communities are organized in a local council system under the leadership of a Local Council (LC) chairman

which makes mobilization for awareness creation or project activities feasible. However, due to settlement in what is supposed to be a "wetland" area, the residents are very sensitive to land ownership Issues and were initially suspicious of the study. To overcome this, an introduction letter was written to the LC chairmen of all the zones explaining the study and its' intended outputs. This was followed by discussions with the LC chairmen for further clarification and to receive their permission to undertake the study within their zones. Due to the limited education that the residents have, the team has had to continually sensitize them about the purpose of the study during pursuance of fieldwork activities.

The obvious poor environmental sanitation in the area is a health threat to the study team. To overcome this, the wearing of proper protective clothing during field activities and analysis of collected samples has been critical to avoid disease infection.

Currently there is a low level of community participation in on-going efforts to improve the environmental sanitation in the area despite recurring disease occurrence. This is due to the tendency of each household not to care about the neighbourhood, an attitude that has resulted in indiscriminate liquid/solid waste disposal. To address this, some management measures have been proposed.

## Conclusions

The estimated loads generated in the area from the different sources annually are: 41,775Nkg, 6,680kgP, 14.5E20 cfu TTCs (from excreta disposal systems); 4,910kgN, 890KgP (Solid waste dumps); and 980kgTKN, 80kgP (sullage). These loads are high and problematic because the largest percentage is 'contained' within the area and impacts on the environment (incl. shallow groundwater sources), and the community's health. The major pollutant sources in the area are seen to be excreta disposal facilities and solid waste dumps. As part of this study, this information will be used in the identification of mitigation measures, in which communities and authorities are expected to participate, and the development of a predictive pollution management model.

## Recommendations

*Excreta disposal systems:* Ecological sanitation dry toilet systems should be piloted in this area especially at household level. These have the advantage of space economy, resource recovery and minimal impact on the environment including groundwater. However, successful operation is very much dependent on continuous sensitization of the community on the operational aspects of these systems as well as a support mechanism for reusing of the materials as appropriate.

*Solid waste:* Privatization of solid waste management and community participation should be encouraged so as to improve waste collection. The composition of the solid waste generated in the area suggests that it can be composted and the manure used in gardens. This requires that communities separate their waste at the source. Direct use of peelings

as animal feed especially banana peelings should also be encouraged.

*Sullage/storm water drains:* Lining of drains should be encouraged. Dumping of garbage in all drains should be prohibited and the culprits penalized. Natural wetlands currently receiving these wastewaters should be gazetted and encroachment restricted. Low cost decentralized wastewater treatment systems such as waste stabilization ponds and constructed wetlands would require large land areas. However, alternatives such as anaerobic treatment of these wastes should be considered.

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