

6. Sanitation and urban wastewater management

This chapter discusses key sanitation and wastewater management issues in Ghana and their relevance to urban agriculture. It reviews common wastewater concepts and describes the domestic wastewater disposal and treatment facilities in Ghana's main urban centers and how they are managed. The chapter is based on local literature, interviews with relevant stakeholders and observations made by visiting the urban centers.

6.1 Review on wastewater concepts

6.1.1 Wastewater types and terminologies

Due to limited industrial development, *domestic* effluent and urban run-off contribute the bulk of wastewater generated in Ghana. Domestic wastewater usually contains *greywater (sullage)*, which is wastewater from washrooms, laundries, kitchens etc. and can also contain *blackwater*, which is generated in toilets. Blackwater might contain besides urine and faeces/excreta (together sometimes called nightsoil) also some flush water. The mixture is termed as *sewage* if it ends up in a sewerage system or *septage* if it ends up in a septic tank.

Figure 6.1 shows a schematic diagram that summarizes the different types of wastewater.

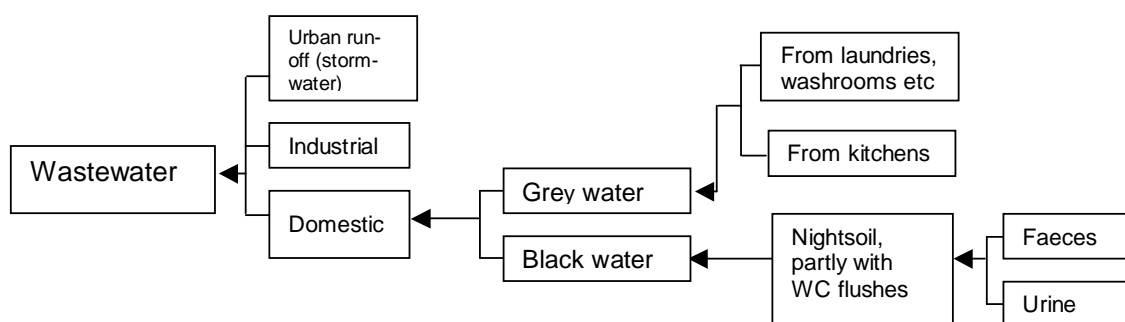


Figure 6.1: Typical types and terminologies used for wastewater in Ghana

Faecal sludge refers to all sludge collected and transported from on-site sanitation systems by vacuum trucks for disposal or treatment (Strauss *et al.* 1997) and differs slightly from conventional wastewater as its quality is subject to high variations due to storage duration, temperature, technology and performance of septic tanks etc. Table 6.1 shows the wide differences in the characteristics of faecal sludge and wastewater. The figures combine results of studies in Accra/Ghana, Manila/Philippines and Bangkok/Thailand. Box 6.1 explains some of the indicators used in this book.

Box 6.1: Key indicators of water quality

- **Electrical Conductivity (EC)** indicates the salt content
- **Total Dissolved Solids (TDS)** comprise inorganic salts and small amounts of organic matter dissolved in water
- **Suspended solids (SS)** comprises solid particles suspended (but not dissolved) in water
- **Dissolved Oxygen (DO)** indicates the amount of oxygen in water
- **Biochemical oxygen demand (BOD)** indicates the amount of oxygen required by aerobic microorganisms to decompose the organic matter in a sample of water in a defined time period
- **Chemical oxygen demand (COD)** indicates the oxygen equivalent of the organic matter content of a sample that is susceptible to oxidation by a strong chemical oxidant
- **Total coliforms (TC)** is encompassing faecal coliforms as well as common soil microorganisms, and is a broad indicator of possible water contamination
- **Faecal coliforms (FC)** is an indicator of water contamination with faecal matter. The common lead indicator is the bacteria *Escherichia coli* or *E. coli*.
- **Helminth** analysis looks for worm eggs in the water
- **NH₄-N** and **NO₃-N** show dissolved nitrogen (Ammonium and Nitrate, respectively)
- **Total Kjeldhal Nitrogen** is a measurement of organically-bound ammonia nitrogen
- **Total-P** reflects the amount of all forms of phosphorous in a sample

Table 6.1: Characteristics of faecal sludges and sewage from tropical countries

	Faecal sludge		Sewage
	High strength	Low strength	
Source	Public toilet or bucket latrine sludge	Septage	Tropical countries
Characterization	Highly concentrated, mostly fresh; stored for days or weeks only	Low concentration: usually stored for several years; more stabilized	
Chemical oxygen demand (COD) (mg/l)	20,000 – 50,000	<15,000	500 – 2,500
COD/BOD*	5:1 -10:1	5:1 -10:1	2:1
NH ₄ -N (mg/l)	2,000 – 5,000	<1,000	30 – 70
Total solids (%)	≥ 3.5	< 3	< 1
Suspended solids (mg/l)	≥ 30,000	≈ 7,000	200 – 700
Helminth eggs (no/ l)	20,000 – 60,000	≈ 4,000	300 – 2,000

Source: Strauss *et al.* (1997) and Mara (1978).

6.1.2 Disposal and treatment methods

Wastewater disposal taking place at the point of waste production like within individual houses without transportation is termed as *on-site disposal* while in *off-site disposal*, there is a transportation element. On-site methods include dry methods (pit latrines, composting toilets), water saving methods (pour-flush latrine and aqua privy with soakage pits and methods with high water rise (flush toilet with septic tanks and soakage pit, which are not emptied). Off-site methods are bucket latrines, pour-flush toilets with vault and tanker removal and the conventional sewerage system. Conventional sewerage systems can be combined sewers (where wastewater is carried with storm water) or separated sewers.

Wastewater treatment can also be done on-site or off-site. An example of on-site treatment is with septic tanks. There are three broad levels of treatment: primary treatment where gross particles and objects, sand, grit, suspended solids are removed. Secondary treatment is the removal of organic matter and tertiary treatment is when nitrogen compounds and phosphorus compounds and pathogenic microorganisms are removed. The treatment can be done mechanically like in trickling filters, activated sludge methods or non-mechanically like in anaerobic treatment, stabilization ponds etc. The major treatment methods found in Ghana are highlighted as follows.

Stabilization ponds: this is a low-technology treatment process; basically a shallow body of wastewater contained in an earthen basin (lagoon). It usually has 4 or 5 ponds of different depths with different biological activities taking place in each, hence their names (anaerobic, facultative and maturation ponds). The first pond, anaerobic pond, is mainly a pre treatment step acting as settling tanks with anaerobic degradation of organic matter, like faeces. In the facultative ponds¹, organic matter is further broken down to carbon dioxide, nitrogen and phosphorous by using oxygen produced by algae in the pond. Maturation ponds are aerobic systems used as post treatment to facultative ponds, to further reduce organic matter and pathogenic microorganisms before disposal into natural water bodies. Such ponds are in Asafo (Kumasi) and Tema Community Three, as well as in Legon staff village, Achimota AMA and Teshie Nungua AMA.

¹ Most plants in Ghana have two facultative ponds.

Trickling filter: it is made up of a round tank filled with a carrier material (volcanic rock, gravel or synthetic material). Wastewater is supplied from above and trickles through the carrier material covered with a biofilm, with living bacterial matter responsible for degradation of organic matter. The effluent of a trickling filter contains sludge washed from the carrier material and is removed by means of a secondary filter. This method is widely used in Accra, like at Burma Camp, the Nsawam Prison and in Kumasi at the University of Science and Technology (Akuffo, 1998).

Activated sludge: it is based on the principle that intense wastewater aeration forms flocs of bacteria (activated sludge), which are capable of thorough degradation of organic matter and could easily be separated by sedimentation. A part of the activated sludge is recycled to maintain the concentration of active bacteria in the tank. The system consists of an aeration tank with mechanical mixers and the system exists in various forms i.e. conventional installation, oxidation ditches, carrousel process and processes aimed at biological nitrogen and phosphorous removal. Most larger hotels in Accra like La Palm, Labadi and Golden Tulip or the 37 Military Hospital use this method.

6.2 Domestic wastewater disposal and treatment in Ghana

Urban wastewater management is based on domestic or municipal wastewater. Most industrial activities in Ghana are evident in urban centers along the coastline like Tema, Accra and Takoradi and they dispose off their wastewater directly to the ocean. According to the Global Water Supply and Sanitation Assessment 2000 Report, 63% of Ghanaian population has improved sanitation facilities with countries like Niger and Benin having less than 25%. While most countries in the West African sub-region show a very high disparity in the provision of sanitation services between rural and urban areas like in Senegal (94% urban, 48% rural), Benin (46% urban, 6% rural), Ghana seems to have a good balance (62% urban, 64% rural). However, an inter-regional analysis for Africa shows that West Africa has a very bad sanitation coverage (48%), Central Africa has the worst (29%) while North Africa has the best (74%) followed by South Africa (63%) and East Africa (62%) (WHO/UNICEF, 2000).

6.2.1 Disposal facilities

The population and housing census carried out in Ghana in 2000 analyzed waste disposal facilities in three categories; the kind of toilet facilities being used, means of solid waste

disposal and means of liquid waste disposal (Ghana Statistical Service, 2002). Figure 6.2 shows the kinds of toilet facilities² that the population used.

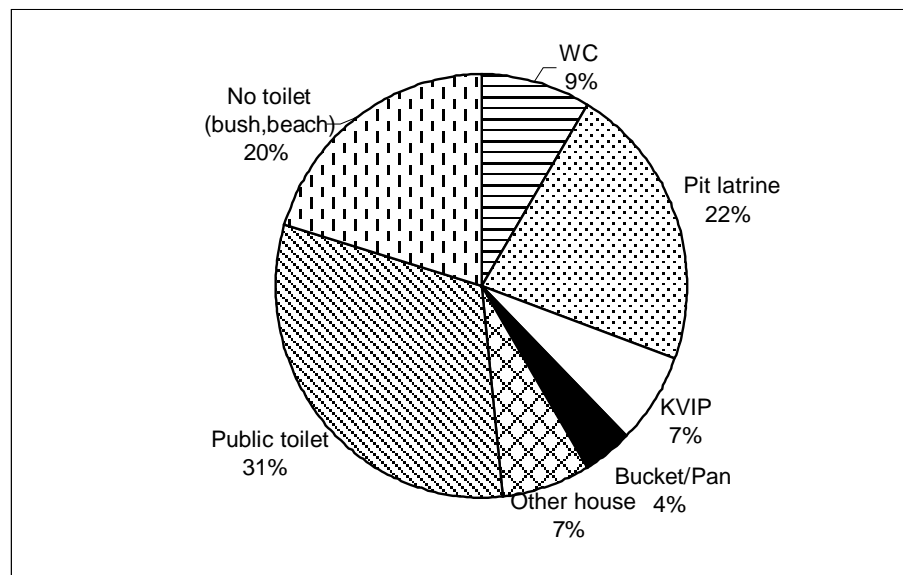


Figure 6.2: Kinds of toilet facilities used (Data from Ghana Statistical Service, 2002).

Pit latrine is more prevalent in rural areas and the wastewater is unavailable for use. Water closet (WC) and Kumasi Ventilated Improved Pit latrines (KVIP) are not common in households in most regions, possibly because of the cost of construction and the need for piped water in using the WC. Many households countrywide however use public toilets reflecting the absence of toilet facilities in many dwelling places. Quite striking though is that more than 20% of the households in Ghana have no toilet facilities, with the percentage increasing to about 70 for the three northern regions.

On liquid waste disposal³, about 38% of Ghana's population throw it on the streets or outside, 21% directly throw it in the gutters, 35% in the compound and 1% in other places. Only 5% of the population dispose their liquid waste through sewerage networks connected to treatment plants as shown in Figure 6.3. All officially recorded sewerage systems were in urban areas, mainly Tema, Accra and Kumasi. A smaller study carried out in Accra estimated that about 12% of the population throws it on the streets or outside, 53% directly into gutters, 20% in the compound.

² Toilet facilities here mainly carried blackwater.

³ Liquid waste here mainly refers to greywater.

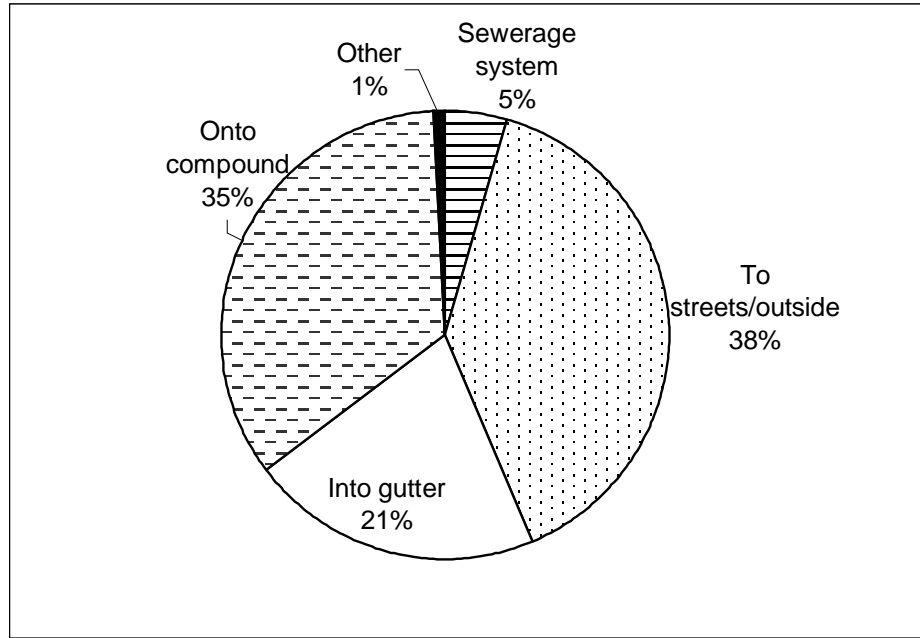


Figure 6.3: Means of liquid waste disposal (Data from Ghana Statistical Service, 2002).

6.2.2 Treatment facilities

Industrial wastewater treatment in Ghana is minimal. Some industries and abattoirs carry out some primary treatment. Most of the treatment facilities in Ghana are for treating faecal sludge and sewage. Sewage treatment systems receive wastes from the sewerage system while faecal sludge treatment plants are fed by trucks carrying waste from septic tanks, public toilets etc. Following a monitoring survey by Ghana's Environmental Protection Agency (EPA) on the number, status, treatment methods and distribution of both faecal sludge and sewage treatment plants in Ghana (EPA, 2001), a follow up survey was carried out by this study to crosscheck some of the information obtained. Figures 6.4 and 6.5 summarize the information of both sources:

More than half of all treatment plants in Ghana are in the Greater Accra region, mainly in the capital city of Accra and port city of Tema. Two regions (Brong Ahafo and Upper West) have no treatment plants at all. The stabilization pond method is the most extensively used with almost all faecal sludge and large-capacity sewage treatment plants using the method. Most trickling filters and activated sludge plants recorded have a low capacity and belong to private enterprises like larger hotels. Less than a quarter of the treatment plants are operational (Figure 6.5).

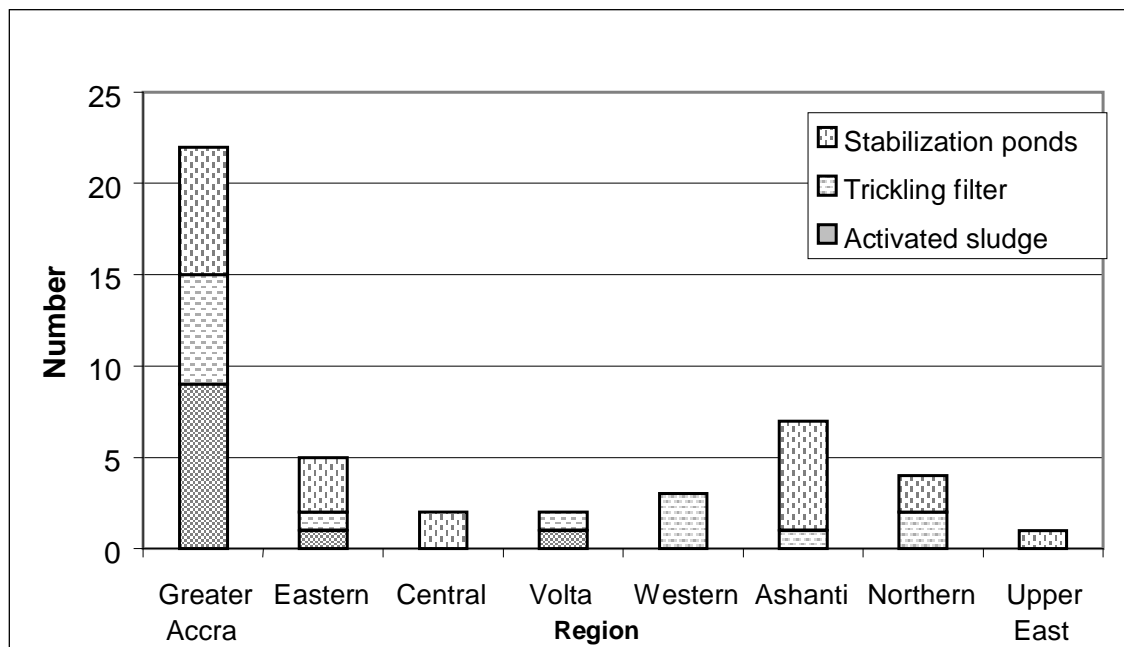


Figure 6.4: Regional distribution and design of wastewater treatment systems in Ghana

No precise figure can be given on the percentage that meets the EPA effluent guidelines and the capacity of these, but indications show that hardly any of the plants is meeting them (Akuffo, 1998).

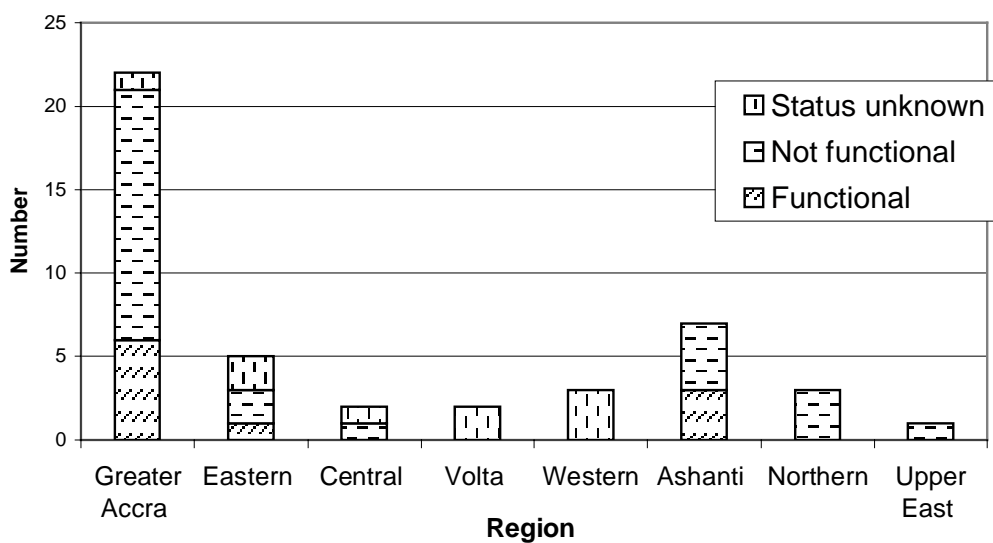


Figure 6.5: Status of wastewater treatment plants in Ghana (2001)

6.3 Kumasi as a case study

6.3.1 Background information

Kumasi, the capital of the Ashanti region is the second largest city in Ghana. It has a population of about one million people with an annual growth rate of 5.9% (Ghana Statistical Service, 2002). The city covers an area of 22,300 ha but only 5,575 ha are developed. Four main streams (Daban, Sisa, Wiwi and Subin) flow through Kumasi city, with the Subin originating from and cutting through the city center. The streams join downstream the Oda River. Quite characteristic of the drainage system in Kumasi is a concrete drain that was superimposed on the Subin River to avert flooding in the city. This has now turned into a 'solid and liquid waste highway' due to the dumping of all sorts of wastes in the drain.

6.3.2 Volumes and sources of wastewater

Domestic wastewater: Most residents of Kumasi (about 38 %) use public toilets. There are about 400 public toilet facilities in Kumasi, equipped with either facilities to flush and a holding tank or KVIP latrines with 2 pits per latrine (used alternatively) or one pit per latrine. The use of double pit latrine has not proved successful. As the pits were filling up faster than expected; the sludge retention time in the unused pit was too short to allow sludge stabilization. About 120,000 people use bucket (pan) latrines. However, it is being phased out because of its unhygienic nature. Another 26 % of the population use household water closet (WC) linked to septic tanks and seepage pits. Septic tanks perform well in areas where there is sufficient space for a drain field but most of the existing septic tanks overflow to surface drains due to undersized or non-existent drain fields. Only 8 % of the population are connected to a sewerage system while the rest of the population have no toilet facilities at all (See Figure 6.6).

Industrial wastewater: Kumasi being an inland city is not highly industrialized. Thus industrial wastewater is not significant in quantitative terms. The principal generators of industrial wastewater in Kumasi are the two breweries, a soft drink bottling plant and an Abattoir. Together, they generate about 1,000 m³ of effluent daily, all of which end up in the city's drains without treatment. Light industrial activities in the so called "Suame Magazine" suburb and sawdust from the sawmills also generate significant amounts of waste oil and leachate respectively which add to environmental pollution (Simon et al., 2001).

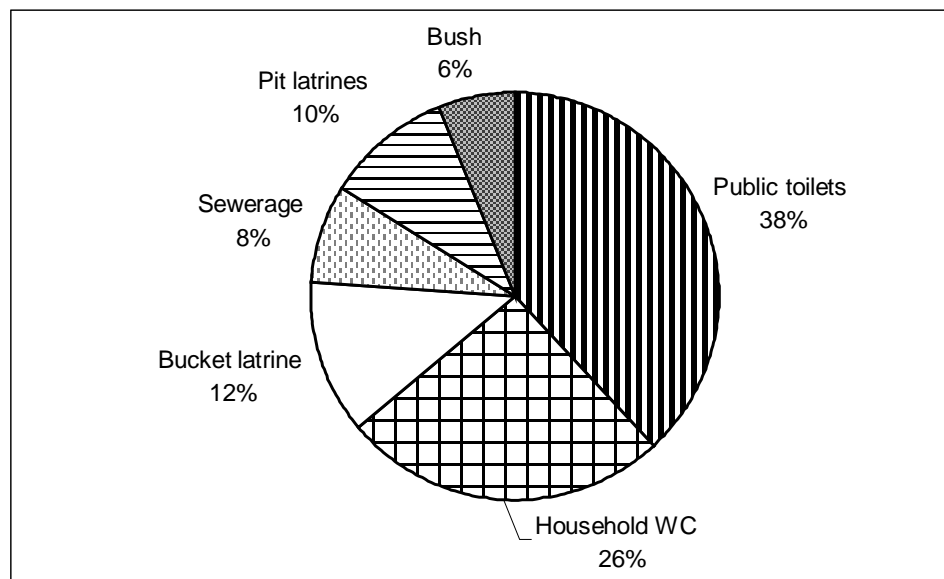


Figure 6.6: Means of domestic wastewater in Kumasi

6.3.3 Disposal and treatment of domestic wastewater

Sewage treatment plants: Five separate small-scale sewerage systems currently exist in Kumasi. There are two conventional systems at a local university (KNUST) and one connecting the Komfo Anokye Teaching Hospital (KATH), City Hotel and the central parts of the 4BN Army barracks. There are two satellite systems at Ahinsan and Chirapatre suburbs and one simplified sewerage system at Asafo suburb. However, both of the conventional systems are not in operation.

The KNUST plant was designed as a trickling filter system and had an inflow of about 390 m³/day but has been under rehabilitation [and out of order] for more than 10 years now and raw sewage from KNUST is discharged to a ‘wetland’ linked to River Wiwi, where urban farmers practice vegetable farming. Greywater mainly from students’ hostels and staff quarters (250 m³/day) runs in open gutters to nearby streams (Wiwi and Sisa).

Asafo’s simplified sewerage network was built in 1994 in a high population density suburb of Asafo. The plant has 4 stabilization ponds and can serve up to 20,000 people but only 60% of the people are connected (1.2% of the Kumasi population). The ones not connected say that they cannot afford the connection fee. It is usually in good working condition. Its effluent (Table 6.2) is discharged into a nearby stream-turned-wastewater drain called the Subin drain.

Table 6.2: Effluent quality of Asafo sewage treatment plant

-----Effluent quality -----							
pH	EC ($\mu\text{S/cm}$)	NH ₄ -N (mg/l)	NO ₃ -N (mg/l)	DO (mg/l)	SS (mg/l)	TC x 10 ⁶ (MPN/100ml)	FC x 10 ⁴ MPN/100ml
7.5	722	50.13	16.0	8.47	0.33	4.15	9.15

Source: Keraita et al. (2002a)

The two satellite plants are at two low-cost housing estates of Chirapatre and Ahinsan. They were built in the late 1970s. They were equipped with a sewer network and communal septic tank systems for black water. Chirapatre had six communal septic tanks for a population of 1800 inhabitants and Ahinsan five for about 1500 inhabitants. Sewer lines were blocked and septic tanks were in a bad state of maintenance. Both schemes have been replaced with two sewerage networks with waste stabilization pond treatment methods. *Greywater* (effluent from bathrooms and kitchens) is discharged into the drainage system.

Faecal sludge treatment plants: until a few years ago, there has not been any proper treatment plant for faecal sludge in Kumasi. A temporary treatment facility with design capacity 144 m³/day was built south of Kaase in 1999 (Leitzinger and Adwedaa, 1999). It was soon overloaded with up to 500 m³/day (Table 6.3) and faecal sludge flowed into the Sisa River (see Figure 7.1) without any treatment. However, having no alternative, the Kaase plant was used until 2003, when another 200 m³/day capacity plant started being used at Buobai. The use of the Buobai plant was stopped due to conflicts with the community. Since March 2004, the local authority is operating a second faecal sludge treatment plant at Dompooase with a design capacity of 300 m³/day of faecal sludge and 300 m³/day of leachate from the nearby landfill. The actual inflow of sludge is about 240 m³/day of the 500 m³ collected per day by on-site systems.

Table 6.3: Quality of wastewater at Kaase Faecal sludge treatment plant

	EC ($\mu\text{S/cm}$)	BOD (mg/l)	COD (mg/l)	NH ₄ -N (mg/l)	NO ₃ -N (mg/l)	Total P (mg/l)	Helminths (No/l)
Influent	37,300	14,090	43,543	1,948	59	319	787,837
Effluent	23,000	3,250	5,807	1,653	104	399	7,388

Source: Leitzinger and Adwedaa (1999).

6.3.4 Institutional aspects of wastewater management in Kumasi

The Kumasi Metropolitan Assembly (KMA) is responsible for wastewater management in the city. Currently, it engages more in the promotion and establishment of active involvement of communities and the private sector in more direct services like collection and haulage of faecal sludge, operation and maintenance of the facilities (public toilets, sewerage systems, treatment systems), collection of user charges etc. KMA has a sanitation strategic plan for Kumasi with recommendations for each type of housing area in the city based on the characteristics of these areas as well as the preference of the user, and willingness and ability to pay. The plan recommends the use of simplified sewerage in high population density areas, latrines in the medium-density areas and WCs and septic tanks in the low-density areas. The construction of new treatment plants and public sanitation facilities in markets, schools and light industrial areas was encouraged, while existing public bucket latrines were phased out.

The KMA has by laws addressing environmental sanitation (KMA, 2000). Liquid waste collection and treatment by service providers is governed by regulations. KMA and the Environmental Protection Agency (EPA) are the two bodies responsible for certifying any treatment plant that is constructed in Kumasi. They also address city drainage and pollution control. With increasing water pollution in Kumasi, many people attribute it to the failure of KMA to collect, treat and dispose of wastewater efficiently. EPA, the government body with the corresponding monitoring and prosecution mandate has limited resources, hence lacking the basis for any legal suit. In addition, government institutions like hospitals, learning institutions etc also contribute to water pollution, making the prosecution of individuals or private establishments a farce.

6.4 Situation in Accra and Tamale

In Accra-Tema, there are about 22 sewerage systems and sewage treatment plants serving institutions and hotels, but – as mentioned above – only a few are operating and maintained in accordance with designers' intentions (Akuffo, 1998; EPA, 2001). These plants serve in total about 5-7% of Accra's population (Figure 6.7). The largest plant, which started operations in 2000, works with an upflow anaerobic sludge blanket (UASB). The plant can handle about 16,000 m³/day but receives less than 5000 m³/day due to the small size of the sewerage. After a one-year test run the plant was handed over to the Municipality and broke partially down in 2003/4. The sewage was consequently directed into the ocean.

Faecal sludge treatment plants in Accra are no better. The main plants at Achimota with dumping rate of about 250 m³/day; Korle Gonno (50 m³/day) and Teshie-Nungua (80 m³/day) are badly maintained or out of order. Untreated faecal sludge ends up being disposed of in nearby streams (Achimota, Teshie) or in the seashore, as is the case at Korle Gonno, also called “Lavender Hill”. Currently, more than half of Accra’s collected faecal sludge is dumped into the ocean.

Like in Kumasi, greywater is mostly transferred through storm water gutter into drains and streams. Accra’s major wetland, the Korle Lagoon, receives ‘fresh’ water through the Odaw stream, which is the main urban storm water drain with a catchment area covering more than 60% of the city. Due to Accra’s limited sanitation infrastructure, the Odaw and the lagoon receive a vast amount of wastewater as well as solid waste (Biney, 1998; Boadi and Kuitunen, 2002).

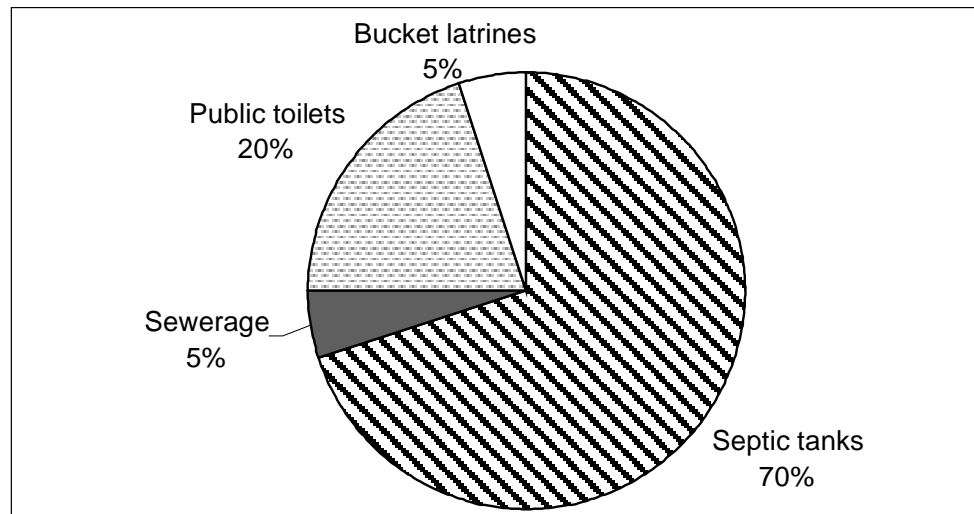


Figure 6.7: Means of nightsoil collection in Accra

In Tamale, there is no conventional public sewerage system. The two private treatment plants that were in existence (Kamina barracks and Tamale hospital at Kokuo) are not functional. From a survey conducted in 100 households in Tamale (Asare, 2002), 37% had individual household toilet facilities (in which 15% were using WCs, 6% KVIPs and 16% bucket latrines). Fifty one percent (51%) were using public toilets while the rest (12%) had none (see Figure 6.8).

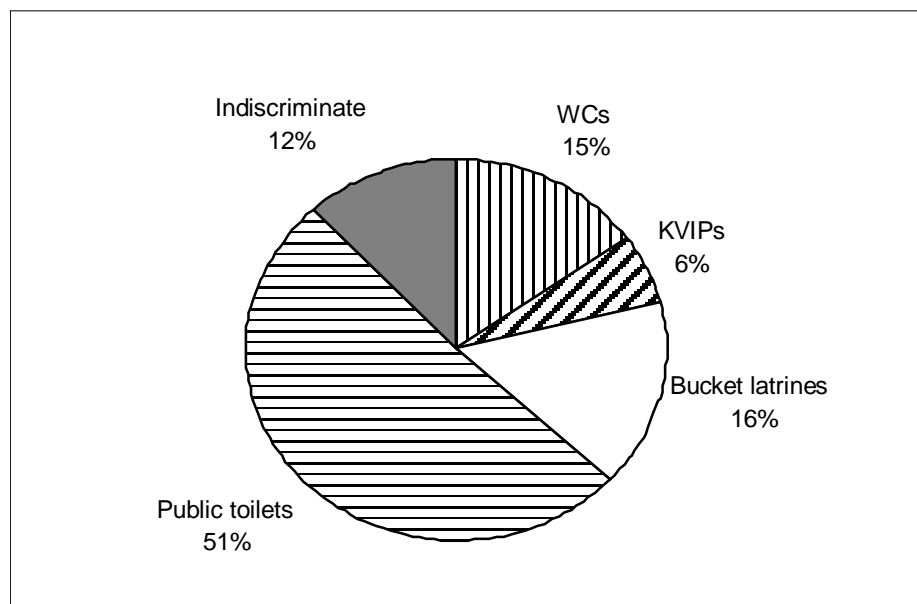


Figure 6.8: Means of nightsoil collection in Tamale

The records of the Municipal Sanitation Unit (MSU) in Tamale show that average volume of faecal sludge generated annually is 30,600 m³. About 83% of this is collected by the MSU and disposed of on wetlands and on farms in more than ten informal locations in and around the city. Though the MSU has no official reports on farm delivery of this waste, the suction truck drivers reported that during the dry season, farmers do request for faecal sludge to be discharged on their lands (see Chapter 8). Individual households, particularly those who use bucket latrine, dispose of the remaining 17%. A first sanitary landfill has recently been developed which should absorb besides solid waste also faecal sludge.

6.5 Applicability of conventional wastewater treatment systems

Efficient wastewater treatment and controlled use as evident in most high and middle income countries like Israel, Tunisia, Jordan etc have proved worthwhile in reducing the health and environmental risks associated with wastewater irrigation. However, in Ghana, as in most low-income countries, especially in sub-Saharan Africa, there is virtually no sanitation infrastructure. For efficient collection and treatment of wastewater, much investment is needed, which is not available. The little funds available in these countries are used for more prioritised sectors like provision of food, water supply, medical care and education.

Gijzen (2001) estimated the period of time needed to meet the European Union's (EU) effluent standards by a number of low and middle income countries, assuming that 1.5% of the GNP could be invested in sewers and treatment facilities (Table 6.4). The table shows that this time frame exceeds by far the economic lifetime of the treatment plant (20 – 30 years) and in many cases even that of sewers (50-60 years). For the implementation of conventional wastewater collection and treatment in developing countries to reach EU standards is therefore unrealistic.

Table 6.4: Estimated period of time needed to meet EU effluent standards at an investment level of 1.5%

Country	Population (Million)	GNP/capita (US \$/capita)	Cost to meet EU standards (US \$ / capita)	Time needed at 1.5% GNP per year (Years)
Bulgaria	8.5	2210	3755	113
Egypt	60	1030	4000	259
India	935	335	3750	746
Kenya	29.2	290	4500	1034
Mexico	92.1	2705	3750	92
Poland	38.3	1700	1230	48
Romania	23.2	1640	1422	58

Source: Gijzen (2001).

Other than cost implications, laying sewerage systems, especially in densely populated areas seems economically unjustified. For example in Accra, the UASB treatment plant built near the Korle lagoon cannot operate to its full capacity. This is because the area is densely populated such that making sewer connections would mean rebuilding whole suburbs, which has not only economic but also social consequences.

6.6 Conclusions and Recommendations

Urban wastewater management in Ghana is the responsibility of local municipal authorities and is mainly concerned with domestic wastewater, as there are only few industrial activities and these are often along the coastline. The use of public toilets, latrines and open defecation are the forms of sanitation available in most Ghanaian cities with very limited sewerage

networks (<5%). Statistics show that 63% of Ghanaians have access to improved sanitation facilities, but the distribution is poor with more than 70% of the population in the northern part of Ghana having no access to sanitation facilities. Wastewater treatment has an equally low coverage. Of the 42 plants in Ghana, more than half are in Accra and most of them, especially the public ones with larger capacity, are not or only partially functional.

There is more to be done to reduce wastewater production, improve sanitation infrastructure and enhance appropriate disposal strategies. The applicability of conventional sanitation and waste collection treatment and disposal systems is questioned as the financial and institutional resources and efficiency required alone for their maintenance are beyond the means of most municipalities. The World Bank currently supports solid waste management and its privatization in many West African countries. It is highly recommended that similar efforts be extended to the wastewater challenge. Town and city planning should develop corresponding realistic – decentralized - scenarios in close collaboration with the private sector and the research community to address for example the challenges of nonpoint source pollution. Special emphasis for immediate action should be given to those currently developing suburbs at the fringes of Accra and Kumasi where there are still opportunities to lay the ground for future sanitation infrastructure, which opportunities have been missed too often in the past.