

DOMESTIC WASTEWATER PROBLEMS AND STRATEGIES FOR ITS MANAGEMENT IN ILORIN, NIGERIA

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***Abstract:** This paper examined the problems of domestic wastewater management in tropical city of Nigeria. Specifically, the study examined the sources from where domestic wastewater is being generated, it investigated the methods of wastewater management practices, assess the effects of some socio-economic characteristics of household heads on wastewater management and propose strategies for wastewater management in the study Area. The research used systematic unaligned random sampling to select 118 houses and their household heads for investigation using both direct observation and the use of questionnaire. The results of the study indicates nine main sources of wastewater generation. It shows that wastewater management practice in the city is very poor, most especially in the traditional area where direct observation revealed unhealthy and unsightly street, highly polluted soil and noxious odors. The result further shows that family size, level of education and income of household heads affects wastewater management practices in the city. Strategies for domestic wastewater management were subsequently suggested.*

***Keywords:** Wastewater; Domestic; Household; Management; Environment*

INTRODUCTION

The increasing population in most cities in developing countries brought about by rapid population growth and rural-urban migration is increasing domestic water usage and consequently, resulting in significant increase in volume of waste water being generated.

Wastewater comprises of all used water in homes and industries including storm water and runoffs from lands. According to Corcoran, et al (2010), wastewater can be defined as a combination of one or more of the following:

- i. domestic effluent consisting of blackwater (excreta, urine and fecal sludge) and grey water (kitchen and bathing waste water);
- ii. water from commercial establishments and institutions, including hospitals;
- iii. industrial effluents, storm water and other urban-runoff; and
- iv. agricultural, horticultural and aquaculture effluent, either dissolved or as suspended matter.

The above definition thus depict wastewater as encompassing domestic, commercial, industrial agricultural and storm water runoff as can be seen on Figure 1 where commercial, industrial and agricultural wastewater has been grouped as industrial.

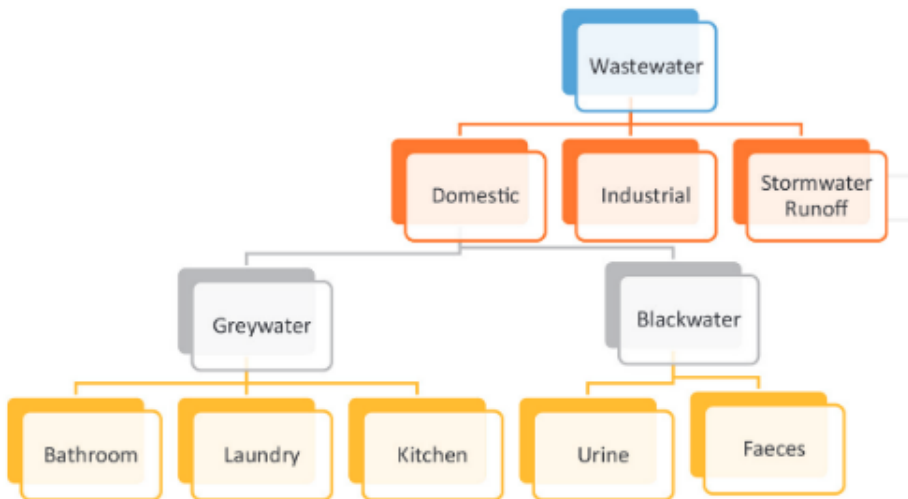


Fig. 1: Types of Wastewater

Problem induced by poor wastewater management in most cities in developing countries is being compounded by poor sewage system. According to Oladoja (2017) the relatively low gross national product of most of developing countries had made investment in social infrastructure to wane. This situation thus makes the wastewater being generated in these countries to be discharged directly into the environment without any treatment. Edokpayi, et al (2017) observed that, most cities in developing countries generate an average of between 30 and 70 million m³ wastewater per person per year. According to the report, much of this wastewater and its effluents are often discharge into surface water sources owing to lack of or improper wastewater treatment facilities.

Domestic wastewater which is the focus of this particular research is a by-product of utilized potable water. Domestic wastewater consist of blackwater (excreta, urine and faecal sludge and grey water, kitchen and bathing waste water). The mix and composition of domestic wastewater is a function of the water supply and sanitation facilities available, water use practices and social norms (UN Water, 2014). According to Laugesen et al (2010), almost half of the world's population have no means of disposing sanitary wastewater from toilets, and even greater number lack adequate means of disposing wastewater from kitchen and baths. The production of domestic wastewater especially in developing countries is being exacerbated by urbanization and rapid population growth which represent the two factors of increased domestic water demand. These two factors result in corresponding increase in volume of wastewater generated from toilet usage, dish washing, laundry and other income generating activities.

Untreated wastewater can spread disease and contaminate drinking water source. According to Macros (2007), wastewater contains 99.7 percent water with the remaining 0.03 percent made up of dissolved and suspended matter containing many microorganisms such as viruses, bacteria, Fungai and parasitic organisms which may be harmful to humans, animals and environment. Edokpayi, et al., (2015) and Toze (1997) observed that health risk from wastewater usually comes from microbial pathogens, nutrient loads, heavy metals and some organic chemicals.

Amongst the diseases that can be contacted when exposed to wastewater or its product include gastroenteritis, giardiasis and cryptosporidiosis, viral infections and infections of the skin or eyes. Foul odours can also be generated by wastewater; though this may not be a direct health concern. The danger inherent in access to unsafe water, particularly in developing countries are many. Infact; the World Bank as far back as over two decades ago reports thus:

“microbial diseases-costing billions dollars in lost lives and unhealthy workers are endemic in the poorest parts of most cities of the developing world; where water source are contaminated and sanitation facilities are minimal or non-existent; where, rats, flies and mosquitoes abounds, typhoid, dysentery and encephalitis are among the scourges of the poor” (World Bank Report, 1998).

Unfortunately, the above-described situation still persists in most parts of developing countries. In Ilorin, the study area, domestic wastewater in most houses is subjected to either direct disposal to water bodies or land. It

is only in few houses that autonomous sanitation systems such as septic tank and traditional latrines are used in managing wastewater. In some cases, the traditional systems used in managing wastewater also generate effluents rich in fecal coliform. Urban safety in most parts of the city is constantly threatened by stagnant sewage on floor in open spaces, on the street and in drains. Where wastewater sewage remain stagnant, especially in places where the ground water table is high, there is a high risk of ground water contamination through infiltration and percolation processes.

Proper wastewater treatment and disposal is as important for protecting community health as drinking water treatment and garbage collection. The release of wastewater which comprises of several macro organisms, heavy metals, nutrients and radio molecules has led to the increase in freshwater pollution and depletion of clean water resources. According to Edokpayi et al (2017) the major sources of freshwater pollution are raw and partially treated waste water.

Wastewater needs to be adequately treated prior to its disposal or reuse in order to protect receiving water bodies from contamination. The fact that improper management of wastewater is increasingly causing irreversible damage to the ecosystem calls for an investigation on domestic wastewater management problems in the study area. Specifically, the study seeks to examine the sources from where domestic wastewater is being generated, investigate the methods and practices of wastewater management and practices, assess the effects of socio-economic characteristics of household heads on waste water management and propose wastewater management strategies for the study area.

THE STUDT AREA

Ilorin, the capital city of Kwara State, Nigeria is the study area in this investigation (Fig. 1). The city lies at the intercept of latitude $8^{\circ}30'$ North and longitude $4^{\circ}35'$ East. The city is characterized by humid tropical climate with distinct wet and dry seasons (Geography Dept., 1981). Wet season in Ilorin begins towards the end of March when Tropical Maritime Airmass is prevalent and ends in October, often abruptly. Dry season in the city begins with the onset of Tropical Continental Airmass which is prevalent between the months of November and February. The mean annual rainfall for the town is 1200 mm (Olaniran, 2002). Rainfall concentration is usually between the months of May and September, exhibiting double maxima pattern with peak periods in the months of June and September and a period of dry spell in August.

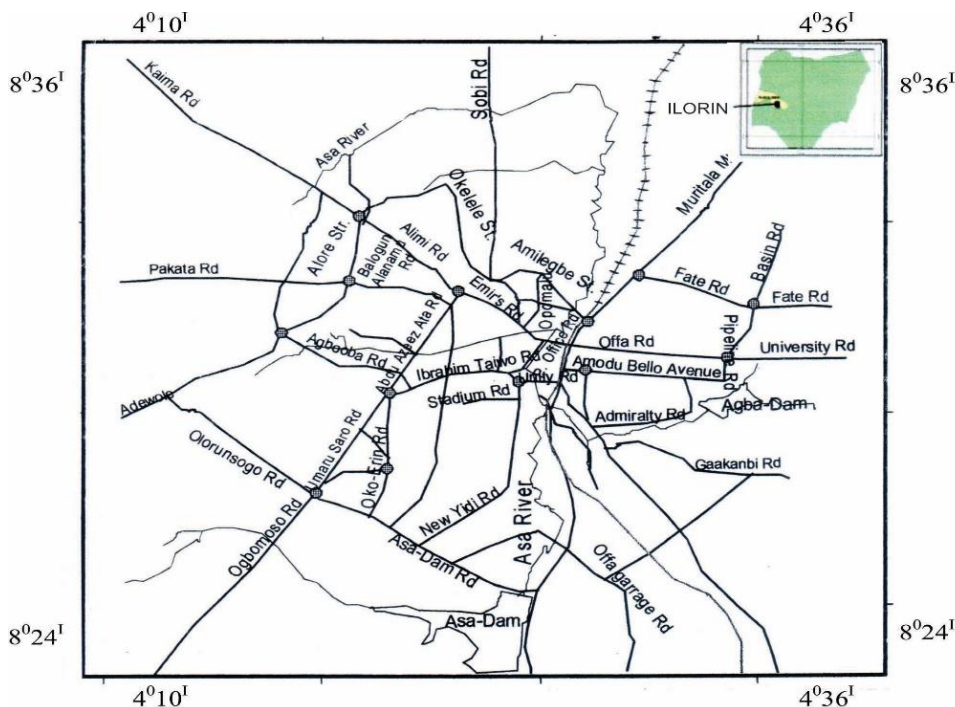


Fig. 2: Street Map of Ilorin, the Study Area with Nigeria as Inset

The soil type in Ilorin has both Sandy and Clayey deposits lying on each other. Urbanization is fast replacing the natural surfaces in the town with artificial surfaces with consequent effects on runoff generation. The four major residential structures of a Nigerian city as identified by Sada (1977) can clearly be recognized in the city. These are Government Reserved Area (GRA), Traditional Area (TA), Modern Private Layout (MPL) and Urban Fringes (UF). These four divisions which coincides with the socio-economic strata in the city aided in sampling process in this study.

METHOD OF STUDY

The sampling technique adopted in this research is the systematic unaligned sampling as explained by Harvey (1974). This sampling method involves the gridding of the study area into a total of fifty two (52) 2km square grids which altogether cover almost 83%t of the entire study area.

A total of ten (10) 2km square grids were finally chosen systematically as sampling units for acquiring data used in the study; this was however

based on ratio analysis as the four residential structures are not of the same size (Table 1). The number of households investigated in each of the ten (10) 2 km square grids ranged between five and thirteen. In all, 118 houses and their household heads were investigated using both field observation and use of questionnaire. While the field observation involves the inspection of living environment and monitoring of wastewater management practices, the questionnaire was used in soliciting information on socio-economic characteristics of household heads such as level of education, income and family size. Other information sourced through the questionnaire include sources of domestic wastewater production, and domestic wastewater management practices.

Table 1: Number of Questionnaire Administered in each Residential Structure

Residential Structure	Area Occupied (Km ²)	Total No of 2 km Square Grids	No of 2 km Square Grids Investigated	No of Household Administered with Questionnaire
Government Reserved Area	12	4	1	5
Traditional Area	28	6	2	37
Modern Presidential Layout	78	18	5	52
Urban Fringes	32	8	2	24
Total	150	36	10	118

Source: Author’s Fieldwork (2020)

RESULTS AND DISCUSSIONS

Wastewater Production in the Study Area

Wastewater is generated mainly from nine different sources in the study area, these sources are cooking, bathing, laundry, dishwashing, car/motorcycle washing, religious activity of ablution, clearing of domestic animals, flower wetting and from economic activities such as pepper grinding, saloon work (washing and setting of hair) and food vending. While wastewater is being generated from all the aforementioned sources with the exception of flower wetting in Traditional Area of the city, wastewater production from cleaning of domestic animals and from economic activities were not reported in GRA. All the nine sources of

wastewater production can however be identified in both Modern Residential Layout and Urban Fringes of the town.

Although this particular study did not investigate the amount of wastewater being generated from different sources, earlier result obtained by Oyegun (1985) on the use and waste of water in the same city which indicates social-stratification in the use and waste of water did not deviate much from observations made in this study. While residents in Traditional Area use a cup of water to rinse their mouth in the morning after “chewing stick”, residents in GRA use liters of water to carry out the same task as those people usually keep tap running continuously while brushing. In the same vain, while an adult in Traditional Area uses a 20 litres bucket to bath, an adult in GRA will use more than 50 litres of water to bath with a shower; this according to Oyegun (1985), is because, once the shower is opened at the beginning of a bath, it is left opened till the end; sometimes fully opened.

Methods of Wastewater Management

There is no single wastewater treatment facility in the study area. Domestic wastewater being generated in city are mostly discharged into individual facility (usually septic tanks) in GRA and in few houses in Modern Residential Layout. Wastewater in most houses in Modern Residential Layout and in Urban Fringes are usually discharged into undersized open drains that are designed for storm water conveyance. Such drains where available are also clogged in many places (Fig. 3).



The reason for lack of wastewater treatment facility in the study area may not be unconnected with the fact that wastewater management is capital intensive. Wastewater management cost according to UNEP/GPA (2000) tends to be two or three times more expensive than the costs of abstracting, treating and distributing tap water.

In Tradition Area of the city, living environment is highly deteriorated by wastewater. Out of the thirty seven houses investigated in this study, only four have septic tank, this is because the four houses use modern toilet. Seventeen (17) houses in the area use improved latrines (defecation pit covered with concrete slab). Because the area is unplanned, there are no drainages. Out of the four (4) houses with septic system in the area, it is only in three (3) that domestic wastewater is being partially managed through septic tank. Wastewater in the fourth house is not being directed into septic tank; it is being discharged directly into the open space. In response to the reason why wastewater from the building is not being discharged into the septic tank; the household head express his worry that the septic tank might get filled up quickly because of the number of people (14) living in the building.

The above reported observations thus shows that domestic wastewater management in Traditional Area of the city is very poor. Only 8.1% of respondents in the area are managing their wastewater while the remaining 91.9% do not. Much of the wastewater being generated here are disposed-of directly on the street. In some houses, wastewater is discharged right in the courtyard while others discharge it in front of their houses. These actions thus makes the soil in the area to be polluted, the streets to be unsightly (Fig. 3) and the environment to be filled with foul odours. Disposing wastewater in this manner can make groundwater to be contaminated, especially in places with high water table.

Complacency about wastewater management can be dangerous. UN Environment (2015) estimates that, worldwide, 80 % of infectious diseases may be water related. The report further revealed that diarrheal disease traced to contaminated water kill approximately two million children and cause about 900 million episodes of illness each year.

Effect of Socio-Economic Characteristics of Household Head on Wastewater

Behaviour of man has greatly been influenced by his social and economic environment since time immemorial. While family size and educational level of household heads were used in studying the effects of socio characteristics on wastewater management practices income of

household heads was used in evaluating the influence of economic condition on wastewater management practices in the study area. Table 2 shows the result of household family size.



Fig. 4: Domestic Wastewater Disposal Problems in the Study Area
Source: Author's Fieldwork, (2020)

Table 2: Household Family Size in the Study Area

Household Family Size	GRA		Traditional Area		Modern Private Layout		Urban Fringes		Total	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%
4 and Below	2	40	2	2.7	14	26.9	9	37.5	27	22.9
5-7	3	60	18	46.7	34	65.4	12	50.0	67	56.8
8-10	-	-	12	33.4	3	5.3	2	8.3	17	14.4
Above 10	-	-	5	15.5	1	1.9	1	4.2	07	5.9

Household family size in the study area is smallest in GRA where 40 % of respondents have family size that is not more than 4 persons. No household in this housing structure is having up to 8 persons. Household family size is largest in the Traditional Area of the city where 47.9 percent of respondents have more than 8 persons in their households. However, more than 77% of households in the study area have more than 5 persons. The larger the household size, the greater the need for wastewater management; this is because volume of household waste generation has been shown to exhibit positive correlation with family size (Suthar, 2014; Tramg et al 2016; Ogwueleka, 2013). Household size, no doubt has a direct relationship with volume of wastewater that is generated. Households with small population in this study were observed to have modern toilets with septic tanks. The septic tanks are use in managing the wastewater being generated. Households with large population however do not have modern toilets; such households make use of latrine which do not require the construction of septic tank.

In response to a question directed to heads of households on the reason why they are not using modern toilet, all the household heads complained of irregular water supply which is required for cleanliness of the toilets. Some household heads however indicates that, even with regular supply of water, they will still prefer to use latrines instead of modern toilet that requires the construction of septic tanks; according to them, septic tank will quickly be filled up because of the large population in their houses.

The fact that more than 65% household heads in this study are not educated beyond secondary level (Table 3) further compounds the problem of wastewater management in the study area.

In the traditional area of the city, only 18.6% household heads possess tertiary education as compared with 100% in GRA. In Modern Private Layout and Urban Fringes the percentages of household heads with tertiary education are 36.6 and 29.2% respectively. The fact that all the houses investigated in this study in GRA have flushing toilet that are used in managing wastewater demonstrates the importance of education in

wastewater management in the study area. The Higher the level of education of household head, the more the adoption of healthier practices for wastewater management in the study area. Formal education according to Adzawla, et al (2019) is expected to improve people’s understanding of the need to keep a healthy and hygienic environment. It is one of the most effective tool to shape the world and solve its problems. When man is better informed, he pay more attention to what may cause health problems for his family. Troschinetz and Mihelcic (2008) has earlier observed that education, such as the extent of knowledge about waste management systems, is one of the major factors that influence sustainable waste management in developing countries.

Table 3: Educational Level of Household Heads

Household Size	GRA		Traditional Area		Modern Private Layout		Urban Fringes		Total	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%
No Formal Education	-	-	21	56.8	3	5.8	7	29.2	31	26.3
Primary	-	-	5	13.5	8	15.4	3	12.5	16	13.6
Secondary	-	-	4	10.5	22	42.3	7	29.2	33	28.0
NCE/Diploma	-	-	4	10.5	3	5.8	4	16.7	11	9.3
Degree	4	80	2	5.4	14	26.9	3	12.5	23	19.5
Postgraduate	1	20	1	2.7	2	3.9	-	-	4	3.4

Income, which represents household per capital expenditure is a measure of household welfare. Less than 15% of household heads in this study earn more than ₦100,000 (\$213) per month (Table 4).

Table 4: Income of Household Heads in the Study Area

Household Size	GRA		Traditional Area		Modern Private Layout		Urban Fringes		Total	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Less than 30,000	-	-	31	83.8	4	7.7	7	29.2	42	35.6
31,000 to 50,000	-	-	2	0.1	12	23.1	10	41.7	24	20.3
51,000 – 100,000	-	-	3	8.1	28	53.9	5	20.8	36	30.5
101,000 – 200,000	-	-	1	0.03	9	17.3	2	8.3	12	10.2
Above 200,000	5	100	-	-	4	7.7	-	-	5	4.3

The bad income situation in the study area is even worse in the Traditional Area of the city where 83.8% of household heads earn less than ₦30,000 (\$64) per month. This is in sharp contrast with what is obtainable

in GRA where all the household heads investigated in this study earn more than ₦200,000 per annum.

Wastewater management requires money. Undertaking the cheapest management practice of 10 meters drainage construction, just to lead wastewater away from building will require money to buy 8 bags of cement (₦3,800 x 8 = ₦30,400), 120 blocks (₦250 x 120 = ₦30,000), and a tipper load each of gravel (₦24,000) and sharp sand (₦14,000). This gives a total of ₦98,400 not counting the cost of labour. Carrying out this task will require more than half of the annual salary of most household heads in the traditional area of the city. The low income level of household heads may thus account for the reason why wastewater management practice seems not to be a major concern, most especially to residents in the Traditional Area of the city.

Strategies for Domestic Wastewater Management in the Study Area

Wastewater management refers to the ways by which wastewater is handled to protect the environment and ensure public health, alongside economic, social and political soundness. The main objective of wastewater management is to recycle wastewater for reuse, thereby preserving the scarce water resources.

In ancient time, there was no specific management method for wastewater. Wastewater during this period was always channeled from building into waterways through micro channels and canals. Such wastewater usually ended up in rivers, streams, lakes, and oceans which were used by man (Tarr, et al 1986). This natural treatment process based on dilution was adequate then, presumably due to smaller population, low population density as well as low human activities which resulted in lower pollution load as compared to the present situation.

However, the increase in population coupled with industrial growth has led to high generation of wastewater polluted with several microorganisms, heavy metals, nutrients, radionuclides, pharmaceutical and other contaminant whose disposal are causing irreversible damage to receiving surface water body. Wastewater management can and have proven to be a reliable and veritable tool for achieving sustainable development, by serving as a means of pollution prevention, source of alternative water for non-potable uses and disease prevention (Iheukwumere, et al 2018).

Wastewater management method can broadly be categorized into two; these are the centralized and decentralized management systems. The centralized method which is also called off-site management method collects wastewater from many wastewater producers (households, commercial areas, industrial plants and institutions) and transport it to

centralized wastewater treatment plant in an off-site location outside the settlement and dispose/reuse the treated wastewater, usually in faraway place from the point of origin. Examples for centralized wastewater management system include activated sludge, trickling filter, oxidation pond integrated biological chemical system, rotary biological contactors etc. The decentralized method is referred to as on-site management. Wastewater being managed through this method is collected, treated and disposed/reuse at or near the point of generation. The decentralized method was the first to be developed before the invention of the centralized management method towards the end of the nineteenth century.

In order to safeguard the health of residents of the study area and to ensure environmental sustainability, it is necessary to suggest an appropriate wastewater management method for adoption. Any method being suggested should however meet two main qualities of affordability and appropriateness. Affordability is related to the cost of the project and appropriateness, which can be linked to complexity of construction, operation, maintenance and requirement of high and reliable water consumption.

This research is suggesting the adoption of decentralized method of wastewater management in the study area. This method of wastewater management has the advantage of combining many practical options and represent a vast choice in wastewater management technologies (Umuhoza, et al., 2010). Decentralized wastewater management method according to Burian, et al (2000) and Crites and Tchobanoglous (1998) currently serve 25% of US population and approximately 37% of new development. Bakir, (2000) observed that decentralized management method can be applied on different scales such as individual households, clusters of homes, a neighbourhood, public facilities, commercial area, industrial parks and small portion of large community.

Although the centralized wastewater management system remained the preferred urban wastewater management method in most European countries as well as other industrial nations (Burian et al 2000; Wilderer and Schreff,2000; UNEP/GPA, 2000 Marriott, 1996), its requirement of high skilled labour, large amount of capital and steady socio-economic conditions will definitely make its adoption difficult in the study area. This observation is in agreement with Oladoja (2017) finding which indicates that, the high cost and stringent requirements for the construction and operation of the centralized wastewater management method will make the technique less attractive in under resourced regions of the world. Jackson (1996) also observed that, the centralized system may be less suitable for areas with unreliable water supply system like the study area.

There are different techniques of on-site (decentralized) wastewater management; such can either be basic or more advanced. It is however the basic techniques that are being suggested in this write up. Among such basic techniques include the use of cesspools pit latrines, gravity percolation and septic tanks. All these according to UNEP/GPA, (2000) are relatively low-tech and low-cost technologies which allow construction and operation by local community and they can reduce public health problem related to wastewater.

A cesspool is an underground chamber constructed for storing wastewater without treatment on mind. Such can be constructed using a variety of different materials including concrete, plastic and fiber glass. Cesspool however need to be regularly emptied, a characteristic which makes it expensive and thus unfit for adoption in the study area.

A pit latrine is a dry technology. It collects excreta and wastewater in a pit dug in the ground beneath the toilet structure. During storage in the pit, decomposition of organic substances takes place under anaerobic conditions. Seepage of wastewater into the surrounding soil takes place through the sides and bottom of the pit, further decomposing organic matter by soil bacterial and reducing BOD levels. Pit latrines however pose problems when groundwater is shallow. It also generate odour and attract insects. When pit latrine is filled with sludge, it also need to be emptied. These shortcomings thus prevents its recommendation for usage in the study area.

Gravity percolation of wastewater through a reactive material is another decentralized technique that can be used in wastewater management. Wastewater in this technique is transisted through a percolator which can be slag and ground stones, soil materials such as sands and organic materials like bamboo and straw (Bishop and Kinner, 1986; Pell et al 1984; Kirchhof, 1988; Lowengart et al 1993). The movement of the wastewater through the percolator purifies it by physicochemical and biological processes. This technique which uses simple technology has been found to be highly effective, economical and reliable and can thus be recommended for usage in the study area.

Septic tank is waste management facility which perform function of treatment of sewage before it is finally discharged through soak-away. In septic system, wastewater flows from the household sewage lines into an underground septic tank from where the following process takes place:

- i. The waste components separate, with the heavier solids (sludge) settling to the bottom and the grease and fatty solids (scum) floating to the top.

- ii. Bacteria partially decompose and liquefy the solids.
- iii. Baffles in the tank provides maximum retention time of solids to prevent inlet and outlet plugging, and to prevent rapid flow of wastewater through the tank
- iv. The liquid portion (effluent) flows through an outlet on the septic tank to the soil absorption field.
- v. The absorption field is usually series of parallel trenches, each containing a distribution pipe or tile line embedded in drain field,
- vi. The effluent drains out through holes in the pipe or seams between file sections, then through the drain field and into the soil
- vii. The soil filters remaining minute solids, some dissolved solids, and pathogens (disease-producing micro-organisms). Water and dissolved substances slowly percolate outward into the soil and down toward ground water or restrictive layers. A portion of the water evaporates into the air, and plant growing over the drain field lines utilize some of the water.

A septic tank may have a lagoon instead of a soil absorption field. When properly constructed and maintained, a septic system can provide a few years of safe, reliable and cost effective service (Etnier et al., 2000). Its usage in the study area for domestic wastewater management is thus being strongly recommended in this study.

CONCLUSION

Problem of domestic wastewater management is fast becoming a serious issue, especially in urban settlements in developing countries. As number of people within a given settlement increase due to rural-urban migration and rapid population growth, volume of water demand increases. The increase in water demand consequently increase the volume of wastewater being generated. Domestic wastewater is a product of utilized potable water while environmental conditions arising from poor wastewater water management pose significant threats to human healthy well-being and economic activity. The damage done by wastewater to ecosystem and biodiversity is also dire. Effort to secure access to safe drinking water and basic sanitation have been partly hindered in different parts of the world by problem of wastewater management. The problems induced by poor wastewater management can best be addressed through integrated programme.

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