Assessment of on-site wastewater treatment in Urban Coastal Area of Lagos Island, Lagos State, Nigeria

G. A. Sodamade*, E. O Longe and R. M. Balogun-Adeleye

Department of Civil and Environmental Engineering, University of Lagos, Nigeria
*Corresponding author email: gsodamade@unilag.edu.ng

Abstract

On-site wastewater management is a system being used to manage most of the domestic wastewater in all sectors of a nation's economy where central wastewater treatment is not available. It is assumed that this system proffers treatment solution to the domestic wastewater in the households that do not have the central wastewater treatment plant. Hence, there is need to assess the On-site Wastewater Treatment (OSWT) in urban coastal areas of Lagos Island, Lagos State, in order to know the quality of the effluents being discharged into porous media with high water table. The following parameters, Acidity or alkalinity (pH), Temperature, Dissolved Oxygen (DO), Total Suspended Solid (TSS), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Nitrogen (TN), Ammonium Nitrogen (NH_4-N), Nitrate-Nitrogen (NO_3N), Ammonia Nitrogen (NH_3-N),Phosphate (PO_4-P) and Total Coliforms, were tested for. Results revealed that the average values recorded for TSS, BOD, COD, TN, NH_4-N, NO_3-N and PO_4-P are 68.85, 142, 345.9, 56.6, 49.21, 0.19, 14.14 mg/L respectively, while the Total Coliform has 2.13E+08 col/100 mL. The values recorded for BOD, COD and Total Coliform are above the recommended values allowed by World Health Organisation (WHO) for the effluent discharge into the environment, this will be a threat to groundwater in the area.

Keywords: coastal area, on-site wastewater treatment, septic tank, wastewater

1.0 INTRODUCTION

The problem of poor sanitation in the urban cities in most developing countries is due to inadequate access to potable water supply, lack of safe drinking water, high cost of living, poor housing system and high rate of migration from rural to urban cities in Nigeria (Longe *et al*., 2009). Globally, 2.1 billion people lack access to adequate water supply with Africa having the lowest total water supply coverage in the world (WHO/UNICEF, 2017). The uncontrolled population growth in urban areas has made planning and expansion of water and sewage systems very difficult and expensive by any tier of government (Sodamade *et al*., 2014). Statistics reported by WHO/UNICEF (2017) shows that 2.3 billion of the world population does not have basic sanitation services. In developing countries, 644 million urban residents have no access to sanitation, especially the low-income urban dwellers. In addition, most migrants to the city are low income earners, who find it difficult to pay for good accommodation, hence dwell in slums with inadequate sanitary facilities (Looker, 1998). Approximately two-thirds of the population in the developing world have no hygienic means of disposing excreta and even greater number lack adequate means of disposing wastewater (Rose, 1999). WHO/UNICEF, (2017) also reported that lack of access to safe drinking water and poor sanitation are linked to transmission of diseases such as dysentery, hepatitis A and typhoid. Statistics have shown that every year, 361,000 children under five years die due to diarrhoea (WHO/UNICEF, 2017). This is connected to lack of provision of safe water and sanitation facilities in homes, healthcare and schools.

In Sub-Saharan Africa, most sanitary facilities consist of on-site individual wastewater treatment systems such as latrines and septic tanks which usually have high quantity of excreta (faecal sludge) to manage (Mbeguere *et al*., 2010). In most main cities, where wastewater is not collected by individual systems, it is discharged untreated onto the street or into the public storm water drains,

with subsequent contamination of water bodies and health risks (Hounkpe *et al*., 2014). The most common household wastewater treatment in Nigeria consists of the use of Pit Latrine; VIP Latrine or Pour-flush latrine using septic tank/soak- away system. All these systems have proved to be in-efficient as many researchers have found out that the leakages from these systems percolate and pollute the groundwater (Sodamade *et al*., 2014; Hounkpe, *et al*., 2014; Vaidya and Raut, 2015).Untreated domestic wastewater contains pathogens, organics and nutrients, while wastewater from industrial and other establishments, apart from the organic load, may also contain a variety of hazardous substances, including heavy metals. Untreated wastewater contaminates the environment, causing widespread disease and damage to ecosystems (WHO/UN-Habitat, 2018).
Most countries do not have monitoring systems in place to assess performance of on-site wastewater treatment systems and ensure treatment plants are sufficiently managed and maintained to deliver effluent suitable for safe disposal (WHO/UN-Habitat, 2018). Hence, the aim of this study is to assess the effectiveness of the on-site wastewater treatment system in the treatment of household wastewater in some selected urban coastal areas of Lagos State. This includes household identification and characterization; physico-chemical and biological assessment of the septic tank effluents from the selected households.

2.0 MATERIALS AND METHOD

The study was carried out in urban coastal area of Lagos Island in Lagos state. Although there are many urban coastal areas in Lagos State, such as Victoria Island, Lagos Island, Apapa, Lekki Peninsula and Ikoyi, the pre-survey done in these areas revealed that most of the households were not ready to give access to carry out assessment of their on-site wastewater treatment system, as a result, Lagos Island was chosen due to co-operation of some of the dwellers and accessibility to their homes. Questionnaires were administered to obtain relevant information regarding dwelling occupancy, number of people per household, social economic status and sizes of septic tank. Detailed information on the nature of wastewater management systems, type and the state of their septic tanks were also obtained.

Of the 150 questionnaires that were distributed, only 73 of the households cooperated with the field workers by filling the questionnaires and returned them.

Twenty of the 73 households surveyed have their septic tank filled and supernatant water flowing out which made sampling of the effluent water from these septic tanks possible. The effluents from the septic tank were collected and analysed for their physico – chemical properties. The parameters considered for the analysis were Total Suspended Solid (TSS), Biochemical Oxygen Demand (BOD), Ammonium Nitrogen (NH_4-N), Nitrate-Nitrogen (NO_3N), Ammonia Nitrogen (NH_3-N), Phosphate (PO_4-P) and Total coliform using standard analytical method (APHA, 2005). The sampling was carried out for 10 weeks in all the households and samples were carefully collected and taken to laboratory for analysis.

3.0 RESULTS AND DISCUSSION

The results revealed that 90% of the households surveyed have septic tank facilities while the remaining 10% do not have the facility in their households as shown on Table 1. The study of the area revealed that the households without on-site wastewater treatment system discharge their

wastewater directly into water bodies. Some defecate openly and some make use of the traditional '*Po*' system (bucket latrine) in Lagos Island.

In the urban coastal communities of Lagos Island, only 66 (90%) of the households has access to sanitation facilities. This is higher than 49.0% recorded in the rural coastal communities of Lagos by Longe *et al.* (2009) and the rural communities of Amuwo Odofin and Ojo Local Government areas where there is an inadequate presence of sanitation facilities (Longe and Yaya, 2015). This may not be unconnected to the level of education and civilization of the people living in urban centre and scarcity of land. Of the 66 households that have access to sanitation facilities (septic tank), 30% of the households have their OSWT filled.

Table 1: Status of households' wastewater treatment in the studied area

S/N	No of Households	Type of OSWT	Status
1	38	Septic	Functioning
2	20	Septic	Filled
3	8	Septic	Collapsed
4	7	None	None

The survey revealed that 58% of the existing septic tanks were functioning, 30% were full to constructed capacity and needed to be evacuated while 12% have collapsed. The effluent from the collapsed septic tank constitute nuisance to the environment in form of foul odour with rodents and flies being common indicators in the area. The assessment of the collapsed septic tanks showed that the material used were mostly hollow blocks that were neither reinforced nor filled with concrete. Due to the hydrostatic force and aggressive nature of the salty water environment, the material deteriorated over time and eventually collapsed.

Table 2 shows the average number of people living in a household and the sizes of the households' septic tank. Household sizes ranged from eight persons to a maximum of 34 persons. The survey revealed that 80% of the household owners also utilized part of the building for commercial activities thereby serving as a means of maximizing economic gains. This indirectly led to unavailability of adequate space for the location of septic tank. The septic tank size of the households varied without any basis as shown on Table 2. Site assessment showed there was no rule guiding the sizing of septic tank construction. Individual house owners constructed their septic tank to accommodate the available space in their respective buildings. Nnajia and Agunwamba (2012), reported that in Nigeria, septic tanks are rarely designed, rather, most house owners resort to arbitrary sizing in the construction of their septic tank. From Table 2, the area of the septic tanks of the households surveyed range from 3.24 m^2 to 7.44 m^2 with an average of 5.089 m^2. It was revealed that the number of people per square meter of the septic tank ranges from 2 to 6 with an average of 4 person per square meter.

In most of the surveyed households, there was lack of soak-away pits due to high water table, thus, the supernatant water from the septic tanks was discharged directly into surrounding. This may eventually lead to groundwater contamination.

3.1 Physico-Chemical and Microbial Characteristics of Septic Tank Effluent (STE)

The average results of the septic tank effluent's properties for 10 weeks are shown in Table 3. The descriptive statistics for STE at the site are summarized and presented in Table 4.

Table 2: Households population and septic tank size

S/N	Household population	Septic tank size (m)	Septic Tank Area (m^2)	No. of People per square meter of septic tank
1	20	2.9 x 1.9	5.51	3.63
2	16	3.0 x 2.4	7.2	2.22
3	24	3.1 x 2.1	6.51	3.7
4	12	1.8 x 1.8	3.24	3.75
5	17	2.7 x 1.9	5.13	3.13
6	18	3.0 x 2.4	7.2	2.5
7	16	2.7 x 1.5	4.05	3.95
8	20	1.2 x 4.0	4.8	4.2
9	21	3.2 x 1.3	4.16	5.05
10	8	2.7 x 1.8	4.86	1.65
11	32	3.2 x 1.8	5.76	5.6
12	26	2.7 x1.6	4.32	6.02
13	28	3.1 x 1.8	5.58	5.09
14	23	2.6 x 1.7	4.42	5.2
15	19	2.4 x 1.5	3.6	5.3
16	29	3.0 x 2.0	6	4.83
17	34	3.1 x 2.4	7.44	4.6
18	18	3.0 x 1.4	4.2	4.3
19	17	2.8 x 1.5	4.2	4.05
20	18	3.0 x 1.2	3.6	5
		Average	5	4.2
		Maximum	7	6
		Minimum	3	1.65
		Standard Deviation	1.27	1.16

Generally, the BOD_5 concentration from the septic tanks surveyed ranged from 78 to 215 mg/L with an average of 142±34.9 mg/L. The maximum BOD_5 value of 215 mg/L was obtained in household No.9 that had 21 residents. Although the population of this household was not the highest among those surveyed, it was observed that the household depend majorly on water vendors which led to economical use of water in toilet; and consequently, high BOD_5 from the septic tank effluents. The economical usage of water in toilet for this household resulted in low dilution which eventually led to high organic load.

The least BOD_5 value was obtained in household No. 8 which had 8 residents. Site investigation revealed that the household had modernized toilet facilities with adequate water supply system. Increased water usage in this household was also responsible for dilution and low organic strength

of the wastewater. The adequate sizing of septic tank (2.7 m x 1.8 m) in this household also led to high anaerobic digestion and low BOD_5 value.

Other possible reasons for differences in wastewater strength may be socioeconomic or lifestyle of the household members. Increase in wastewater strengths in recent years have been associated with increased use of low flow plumbing fixtures, use of antibiotics, cumulative effect of increased use of antibacterial products and household cleaners (Scott *et al.*, 2004).

The average BOD_5 value was remarkably close to those reported by Otis *et al*. (1974) and Oregon DEQ (1982), was found within the US EPA (1980) typical range. The values of BOD_5 recorded are higher than the recommended value of 30 mg/l or standard to be discharged into a water body (FEPA, 1991).

Table 3: Average value of properties of the effluents from the households

	BOD	COD	TSS	TN	NH_4-N	NO_3-N	PO_4	Total Coliforms col./100mL
1	154	354.2	79	63.0	54.81	0.21	15.8	2.1E+08
2	149	387.4	80	48.0	41.76	0.15	11.3	1.9E+08
3	198	495.0	68	72.0	62.64	0.18	13.5	2.8E+08
4	149	312.9	56	35.0	30.45	0.22	16.5	2.1E+08
5	120	312.0	24	61.0	53.07	0.16	12.0	2.0E+08
6	106	243.8	51	57.0	49.59	0.11	8.3	2.1E+08
7	144	345.6	59	59.0	51.33	0.17	12.8	2.8E+08
8	176	440.0	78	61.0	53.07	0.30	22.5	2.2E+08
9	215	494.5	68	36.0	31.32	0.16	12.0	2.1E+08
10	78	218.4	32	49.0	42.63	0.09	6.8	1.6E+07
11	180	414.0	47	68.0	59.16	0.14	10.5	1.9E+08
12	135	310.5	76	48.6	42.28	0.21	15.8	2.4E+08
13	124	359.6	83	73.0	63.51	0.23	17.3	2.8E+08
14	131	320.9	78	54.0	46.98	0.20	15.0	2.2E+08
15	154	354.2	63	50.4	43.85	0.23	17.3	1.9E+08
16	178	462.8	88	67.8	58.99	0.14	10.5	2.1E+08
17	123	282.9	92	78.5	68.30	0.18	13.5	2.8E+08
18	98	284.2	120	53.0	46.11	0.25	18.8	2.2E+08
19	124	285.2	76	49.0	42.63	0.15	11.3	2.1E+08
20	104	239.2	59	48.0	41.76	0.29	21.8	1.9E+08

All parameters are in mg/L except where stated

Table 4: Summary of the Physico-Chemical and Biological Parameters of the STE

	BOD_5	COD	TSS	TN	NH_4-N	NO_3-N	PO_4-P	Total Coliforms col./100mL
Average	142	345.9	68.85	56.6	49.21	0.19	14.14	2.13E+08
Maximum	215	495	120	78.5	68.3	0.30	22.5	2.80E+08
Minimum	78	218.4	24	35	30.5	0.09	6.8	1.60E+07
Std. Dev	34.9	81.8	21.5	11.7	10.2	0.06	4.1	5.62E+07

All parameters are in mg/L except where stated

TSS concentration from the septic tank effluent ranged from 24 to 120 mg/L with an average of 68.85mg/L. The maximum TSS value 120 mg/L was recorded in household 18 while the minimum value of 24 mg/L was recorded in household 5. This showed that the effluent from household 18 contained more of suspended solid compared with household 5 with less suspended solid.

Total suspended solids (TSS) consist primarily of organic particles with a specific gravity near or below unity, they are not easily removed by sedimentation but by filtration. According to Siegrist (1987) normal residential septic tank effluent typically contains 80 mg/L TSS, a substantial portion of which are slowly biodegradable or inert. It was reported by Siegrist (1987), that half of the TSS in the domestic septic tank effluent comprised of slowly biodegradable or inert material. Average TSS values obtained falls within the range reported by Crites and Tchobanoglous (1998), and EPA (2002); but lower than the reported values obtained by Assayed *et al.* (2010) for Abu Farth Village in Jordan. Ammonium nitrogen concentration from the septic tank effluent ranged from 30.5 to 68.3 mg/L with an average of 49.21 ± 10.2 mg/L. The maximum Ammonium nitrogen value 68.3 mg/L was recorded in household 17 while the minimum value of 30.5 mg/L was recorded in household 4. This value falls within the range of 30 to 50 mg/L that is expected from the septic tank effluent as reported by Regent of the University of Minnesota (2010) and USEPA (1980; 2002).

NO_3-N concentration from the septic tank effluent ranged from 0.09 and 0.3 mg/L with an average of 0.19 ± 0.06 mg/L. The maximum NO_3-N value 0.3 mg/L was recorded in household 8 while the minimum value of 0.09 mg/L was recorded in household 10. This value was lower than what was reported by Assayed *et al.* (2010). The low NO_3-N concentration was as a result of denitrification of the organic nitrate in the septic tank to NH_4-N due to anoxic condition of the septic tank. The anaerobic microbes decomposed much of the suspended organic material and utilized some of the nutrients such as nitrogen (IDEM, 2008).

The concentration of total nitrogen, which is a combination of nitrate, nitrite and ammonium range from 35 to 78.5 mg/L with an average value of 56.6 ±11.7 mg/L. The maximum total nitrogen value 78.5 mg/L was recorded in household 17 while the minimum value of 35 mg/L was recorded in household 4.The values obtained were in line with the report of IDEM (2008) and most of this nitrogen is in the form of ammonium nitrogen 75 to 85% and organic nitrogen 15 to 25%.

PO_4-P concentration from the septic tank effluent ranged from 6.8 and 22.5 mg/L with an average of 14.14 ± 4.1 mg/L. The maximum PO_4-P value 22.5 mg/L was recorded in household 8 while the

minimum value of 6.8 mg/L was recorded in household 10. High PO_4-P values are associated with use of detergent for domestic activities.

Total Coliform count from the septic tank effluent ranged from 1.6E+7 and 2.8E+8 cfu/100 ml with an average value of 2.13E+8 ± 5.62E+7 cfu/100 ml. This value is within the range reported by (Regent of the University of Minnesota, 2010). Households 3, 7, 13 and 17 recorded the highest values of total coliform of 2.8 E+08 cfu/100 ml in their respective septic tank effluents. The minimum value of 1.6E+07 cfu/100 ml was recorded in household 10 which incidentally had the least number of inhabitants. The pathogen concentration of the septic tank effluent of household 9 was high with a value of 2.1E+08 cfu/100 mL. This household also had the highest BOD_5, an indication that the household generates more biodegradable organic matter.

The result showed that septic tank systems only serve as a pre-treatment option with biodegradation and sedimentation for wastewater containing organic and inorganic matters; and pathogens. The inability of the septic system to effectively remove the organic and inorganic matters and pathogens from the domestic wastewater result in poor quality effluents. This can lead to the emergence of health-related issues if the effluents get in contact with the environment. The contamination of ground and surface water resources become a significant health matter if such waters are used for drinking and contact recreation. Discomfort produced by malodorous effluent treatment systems may be significant.

4.0 CONCLUSION

The concentration of the physico-chemical especially the BOD_5 and the PO_4; and microbial parameters of the septic tanks' effluent from the urban coastal areas of Lagos Island are more than the recommended values by WHO. This will lead to pollution of the receiving water body or pollution of the underground water source. Therefore, there is need to harness further treatment method(s) that can complement the existing wastewater treatment system towards safeguarding the groundwater resource from contamination in high water table areas of Lagos Island. Routine performance monitoring of on-site wastewater treatment systems needs to be implemented as this will guide in choosing the most appropriate type of wastewater treatment system (WHO/UN-Habitat, 2018).

REFERENCES

APHA (2005). Standard Methods for Examination of Water and Wastewater. American Public Health Association, 800 I Street, NW. Washington, DC. 20001-37110.

Assayed,A. K., Dalahmeh, S. S. and Suleiman, W. T. (2010). On-site greywater treatment using septic tank followed by intermittent sand filter – A case study of Abu Al Farth village in Jordan, *International Journal of Chemical and Environmental Engineering*, 1(1), 67-71.

Crites, R. W. and Tchobanoglous, G. (1998). Small and Decentralized Wastewater Management Systems. McGraw - Hill Series in Water Resources and Environmental Engineering. Publisher: McGraw - Hill College, Blacklick, Ohio.

EPA. (2002). On-site wastewater treatment manual. http://www.epa.gov/nrmrl/pubs/625r00008/htm/625R00008.htm).

FEPA, (1991). Guidelines and Standard for Environmental Pollution Control in Nigeria, pp.238.

Hounkpe, S.P., Adjovi, E.C., Crapper, M. and Awuah, E. (2014). Wastewater Management in Third World Cities: Case Study of Cotonou, Benin. *Journal of Environmental Protection*, **5**, 387-399

India Department of Environmental Management (2008). Nitrates, Groundwater and On-site sewage systems in Indiana. A report to the Legislature, Indiana State Department of Health. 30pp.

Longe, E. O., Kehinde, M. O., Sodamade, G. A. and Omotoso, O. B. (2009). Appraisal of sanitation facilities in selected rural coastal communities of Lagos State. *Journal of Engineering Research,* **14**(1), 58-68.

Longe, E. O and Yaya, F. M. (2015). Assessment of water and sanitation service levels in 20 rural communities of Amuwo Odofin and Ojo Local Government Areas of Lagos State, Nigeria. *American Journal of Environmental Engineering and Science,* **2**(6), 53-61.

Looker, N. (1998). *Municipal Wastewater Management in Latin America and the Caribbean*, R.J. Burnside International Limited, Published for Roundtable on Municipal Water for the Canadian Environment Industry Association, 1998.

Mbeguere, M., Gning, J. B. and Kone, D. (2010). Socio-economic profile and profitability of faecal sludge emptying companies. *Resources Conservation and Recycling,* **54**(12), 1288-1295.

Nnajia, C. C. and Agunwamba, J. C. (2012). A rational approach to septic tank design. *Nigerian Journal of Technology*, **31**(1), 68-78.

Otis, R. J., Boyle, W. C. and Sauer, D. K. (1974). The performance of household wastewater treatment units under field conditions. *Proceedings of the National Home Sewage Disposal Symposium*. American Society of Agricultural Engineers, St. Joseph, Ml, 191-201.

Oregon Department of Environmental Quality (DEQ), (1982). Final Report – Oregon On-Site Experimental Systems Program. Final Report, US EPA Water Pollution Control Research Demonstration and Development Grant No. S806349Regent of the University of Minnesota: 2010

Rose, G. D. (1999). Community-Based Technologies for Domestic Wastewater Treatment and Reuse: Options for Urban Agriculture. N. C. Division of Pollution Prevention and Environmental Assistance, CFP Report Series: Report 27, 1999.

Scott, C. A., Faruqui, N. I. and Raschid-Sally, I. (2004). Wastewater Use in Irrigated Agriculture Management Challenges in Developing Countries. In Scott C. A. *et al.* (Eds) *Wastewater Use in Irrigated Agriculture: Confronting the Livelihood and Environmental Realities.* Pp 2-3, Oxfordshire, UK: IDRC and CABI

Siegrist, R.L. (1987). Hydraulic loading rates for soil absorption systems based on wastewater quality. On-Site Wastewater Treatment: *Proceedings of the Fifth National Symposium on Individual and Small Community Sewage Systems*. American Society of Agricultural Engineers (ASAE), St. Joseph MI. p 232-241.

Sodamade, G., Longe, E., and Sangodoyin, A. (2014). Depth and performance evaluation of a laboratory scale sand filtration for wastewater treatment. *Turkish Journal of Engineering and Environmental Science,* **38**(2), 209-216

U.S. Environmental Protection Agency (EPA), (1980). Design Manual – On-site Wastewater Treatment and Disposal Systems. Office of Water Program Operations, Office of Research and Development - Municipal Environmental Research Laboratory. Doc. # EPA 625/1-80-012.

U.S. Environmental Protection Agency (USEPA), (2002). On-site *wastewater treatment systems manual*, Chaps. 1 and 4, U.S. EPA, Office of Water, Office of Research and Development, Washington, D.C., 6–34. U.S.

Vaidya, S. D. and Raut, V. R. (2015). Alternative On-Site Systems for Domestic Wastewater Treatment and Disposal: A Review. *International Journal of Engineering Research & Technology*, **4**(7), 1234-1237

World Health Organisation (WHO) and United Nations Children's Fund (UNICEF) (2017). Progress on Drinking Water, Sanitation and Hygiene: 2017 Update and SDG Baselines. Accessed August 27, 2019 @ https://www.unicef.org/publications/index_96611.html

World Health Organisation (WHO) and UN-Habitat (2018). Progress on safe treatment and use of wastewater: piloting the monitoring methodology and initial findings for SDG indicator 6.3.1. Accessed August 15, 2019 @ https://apps.who.int/iris/bitstream/handle/10665/275967/9789241514897-eng.pdf?ua=1