Sanitary Facilities Location in Nigeria: Implications for population Health

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ABSTRACT
The study examined the location of sanitary facilities particularly, the septic tank and borehole water in a typical Nigerian urban center. Field measurements were utilized to generate location data on the distance between septic tank and borehole water on twenty-two sampled points across eleven residential zones in Eket LGA of AKS. Water samples from the boreholes were analysed for physico-chemical and bacteriological properties. The chi-square test of goodness of fit was applied on the location data to examine their level of conformity with WHO baseline data; while the regression analysis was conducted to examine the effect of location of septic tanks on the quality of the borehole water. Findings showed massive non-conformity with WHO standards for minimum allowable distance between septic tank and borehole water points. Though no significant relationship was found between septic tank location and the physico-chemical properties of borehole water, the study found significant effect of location on the bacteriological load of borehole water in the area, as it degrades the quality of borehole water and also threatens population health. Intensive awareness campaign against improper location of sanitary facilities (septic tanks) alongside strict enforcement of town planning laws could go a long way in mitigating the situation.
Keywords: Sanitary facilities: location; septic tank; borehole water; Nigeria; Population Health.
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1. INTRODUCTION

Improvement on access to safe water and sanitation facilities are among the core developmental issues facing the developing nations in the world today. The global mandate on water and sanitation are well articulated in the UN sustainable development goal (SDG) number six as a demonstration of global collaboration to address the problem of sanitation.

In Nigeria, whereas, access to water and sanitary facilities have significantly improved through the proliferation of borehole water and septic tanks construction (Abubakar, 2017), the issue of location of these facilities in terms of their conformity with laid down standards has been quite challenging. As quest for socio-economic opportunity drives population towards an already congested urban center, the Nigeria urban spaces have become blighted with wanton location of sanitary facilities within the neighborhoods (Abubakar, 2017).

In Nigeria urban centers, private boreholes are the main source of domestic and drinking water supply while the septic tanks serve as the major sewage disposal facility. As Ochuko and Thaddeus (2013) rightly noted, the underground septic tank system has been widely utilized in Nigeria living spaces to link old pit latrines and flush toilets as against an old practice of direct discharge of sewage into open drains and surface water courses. However, there is an ongoing debate on the suitability of on-site sanitary facilities such as the septic tank in a densely populated urban center (Kananga, 2003; Ladan, 2014 ;). The opponents of septic tank utilization as a sanitary facility argue that septic tank if poorly designed, ill-maintained and inappropriately located are likely to discharge pollutants into adjacent aquifer thereby threatening the quality and safety of groundwater consumption in those areas (Kawanga, 2003; WHO, 2006; Ochuko and Thaddeus, 2013; Victoria and Ismail, 2011).

A number of studies have attempted to link the depletion in groundwater quality to proximity to septic tank within residential neighborhoods. For instance, Igbinovia, Agwu and Atuanga (2016) concluded that poor management and location of septic tank were injurious to the environment as pathogenic bacteria isolate from septic tanks when released to the environment constitute potential source of epidemic and health concerns. Similarly, Oluwasola, Okunade and Adesina (2017) identified distance to septic tanks location as a significant factor in terms of bacterial pollution of well water in Ado Ekiti, Nigeria. In Lusaka, Zambia, Banda, Mbewe, Nzala and Halwindi (2014) thoroughly documented the level of violation of institutional provisions in the location of boreholes and septic tanks and the attendant repercussions. Though the study failed to establish a direct link between distance from borehole to septic tank and groundwater quality, it was significantly confirmed that alignment of boreholes with septic tank was a major source of groundwater contamination in the area. Elsewhere in Nigeria, findings have shown that improper location of sanitary facilities such as pit latrines, privies, cesspool water closet and septic tanks without compliance with standards can be hazardous to groundwater resource as well as compromise the quality of the urban Environment (Akoteyon, 2015; Odey, Zifi, lkhumhen, Kalakodo, Eniang and Giwa, 2016; Arwenyo, Wassawa, Nyeko and Kasozi, 2017).

The world health organization (2006) and the Nigeria Federal Ministry of Environment have stipulated 18 meters as the threshold limits within which the location of sanitary facilities relative to borehole points is permissible. However, the extent to which households and property developers comply with this regulation and the concomitant effect of non-compliance has always been an issue of research.

Eket LGA where the present study is based, is one of the fastest growing urban centers in AkwaIbom State, Nigeria. Eket LGA has a long history of oil and gas exploitation within the continental shelf of its coastal environment. With an extended shoreline/estuary that has attracted massive tourism, the town has been reckoned with rapid population growth (Etim 2016). The attendant challenge of a rapid urbanization in Eket town has been witnessed in the area of poor development control. The location of facilities especially the septic tank and borehole water points within the shrinking residential areas have been wanton and threaten both the aesthetic and health of the environment. There has been little empirical effort by previous researchers to examine the implications of the wanton location of sanitary facilities specifically the septic tank in this area. This paper seeks to contribute knowledge in this regard by assessing the status of compliance of septic tank location with the WHO standard and also relate findings with the quality of borehole water as well as its health implications. Inferences drawn from the observation would help accelerate effort towards improvement in water, sanitation and health standards not only in the study area, but in urban Nigeria in general.

2.MATERIAL AND METHOD

The study was designed as a cross-sectional research utilizing both observational and experimental approaches. A population of 116 septic tanks spread across 11 residential zones in the study area was listed. A sample of 22 septic tanks (2 from each zone) representing 18.9 percent of total number of septic tanks in the area was investigated in terms of their relative location to the nearest borehole water points.

A baseline measure of 18meters being the WHO allowable distance between borehole water points and a septic tank was used to assess the appropriateness of septic tanks distribution in the area after field measurements (using tape) of distance between each sample septic tank and the nearest borehole water point was taken. The affected boreholes were geo-referenced using the GPS and coded accordingly for clear identification. Water samples collected from the boreholes were analysed in the AkwaIbom State Ministry of Environment Laboratory Uyo, Nigeria using standard methods. The analysis was done to examine the level of pollution arising possibly from infiltration of pollutants from adjacent septic tank and the likely health implications of the phenomenon.

Specifically, the water samples were tested for bacteriological load such as total viable plate count, total coliform and faecal coliform bacteria. Physical properties such as electrical conductivity, PH, total dissolved solid (TDS) and temperature were analysed using potable meters. Chemical properties such as salinity, chloride, calcium, alkalinity and total hardness were determined using titrimetric method Sulphate, nitrate were determined using spectrophotometer, while magnesium were determined using an atomic absorption spectrophotometer.

The pearson correlation and the standard regression techniques were applied to examine the relationship between septic tanks location and the quality of adjacent borehole water while the chi-square test of goodness of fit was utilized to test for difference between the WHO baseline data and the observed distance between septic tank and borehole in the study area.

3.RESULTS

The results of the analysis alongside inferences drawn and relevant discussion are presented as follows:

3.1. Location of Septic Tank in the Study Area

The main thrust of this paper has been to examine the level of conformity to the WHO standards in the location of septic tank in relation to borehole water in the study area. The minimum allowable distance between the septic tank and borehole water according to WHO standard is 18 meters (WHO, 2016). This is to reduce the risk of the potential source of contamination from the septic tank. It is a known fact that septic waste water discharge to the sub surface soil infiltrate vertically through the unsaturated zone and into groundwater (lunge 2011) essentially therefore, the regulation on siting of septic tanks and borehole water is one institutionalized steps towards the preservation of groundwater quality. Data in Tables 1 and 2 shows the observable distance between septic tank locations and borehole water points in the study area as well as the descriptive statistic and chi-square result emanating from the data analyses.

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Table 1: Distance between septic tank and borehole water points in the study area(n=22)

CoordinaEasting	Northing	Sample Point Code	Observed Distance Between Septic Tank and Borehole Water (in meters)	Expected Distance between Septic and Borehole Water (WHO standard) in meters	Differer) (in met	Remarks
379412	519959	1	7	18	-11	Below WHO Expectation
379911	520013	2	11	18	-7	Below WHO Standard
379830	518114	3	19	18	+1	Above WHO expectation
379529	517932	4	10	18	-8	Below WHO expectation
378788	518640	5	13	18	-5	Below WHO expectation
378617	518550	6	11	18	-7	Below WHO expectation
378254	517953	7	8	18	-10	Below WHO expectation
378382	517264	8	20	18	+2	Above WHO expectation
378752	517059	9	8	18	-10	Below WHO expectation
381243	514745	10	15	18	-3	Below WHO expectation
381030	515046	11	12	18	-6	Below WHO expectation
379993	513747	12	21	18	+3	Above WHO expectation
383419	516967	13	20	18	+2	Above WHO expectation
383274	516850	14	18	18	0	No difference
383482	516368	15	21	18	+3	Above WHO expectation
383273	516533	16	17	18	-1	Below WHO expectation
382971	515267	17	20	18	+2	Above WHO expectation
384258	513528	18	19	18	+1	Above WHO expectation
386097	512584	19	10	18	-8	Below WHO expectation
386247	512325	20	12	18	-6	Below WHO expectation
383732	509583	21	23	18	+5	Above WHO expectation
384175	509692	22	16	18	-2	below WHO expectation

x_c =39.65;x_t=32.67; df =21; = 0.05
Source: Data Analysis by Authors

Table 2: Descriptive Statistics for Distance (in meter) between Septic Tank and Borehole Water in the Study Area

Variable	N	Minimum	Maximum	Mean	Std. Deviation
Distance	**22**	**7.00**	**23.00**	**15.04**	**4.99**
Valid N (list wise					

Source: Data Analysis by Authors

Table1 indicates that of the 22 sampled points in the study area, 14 representing 63.6 percent had their septic tank and borehole water located at distance less than 18 meters thereby violating the approved WHO and municipal requirement for the location of sanitary facilities. As data in table 2 indicate, the minimum observed distance between the septic tank and borehole water was 7 meters; while the maximum was 23 meters. However, the mean distance obtained (15.04 metres) reveal that majority of septic tanks in the study area are located in close proximity to Borehole water points. The Standard deviation of 4.99meters shows that distance between septic tank and borehole water points vary significantly from the mean distance of 15.04meters across different points to as low as 7 meters which is 8 meters less than the mean distance.

The chi-square analysis tested the goodness of fit between observed distance of septic tank to borehole water and the WHO expected values. At the 95% probability level (= **0.05**) and 21 degrees of freedom, it was observed that the calculated value of chi-square (**x_t = 36.67**) was by far greater than the table value of chi-square (**x^2**) implying a significant difference between the observed and expected distance. The rejection of the null hypothesis of "no significant difference between the observed and expected distance further affirm the status of non-conformity to locational standard by property owners in the study area.

1.2. Quality of Borehole Water in the Study Area

The results of physico-chemical analyses conducted on the water samples collected from the sampled borehole water in the study area are shown in Table 3. Specifically, Table 3 contains the descriptive statistics of physico-chemical properties of the water sample in relation to the WHO standards. Also, the microbial analysis indicating the general pollution status of each water sample is displayed in Table 4.

TABLE 3: Descriptive Statistics of Borehole Water Quality (Physiochemical Parameter)

Parameter	Min.	Max.	($\bar{x}$) Mean	Std. Dev.	WHO Standard
Colour	5.00	20.00	6.35	3.46	15.00
Temperature	26.10	27.80	26.79	0.44	27-28
Turbidity	0.24	0.93	0.47	0.18	5.00
Dissolved Oxygen (DO)	.50	1.80	1.48	0.25	6.00
PH	5.38	7.65	6.70	0.52	6.5-8.5
Electrical Conductivity (EC)	27.19	87.30	61.40	20.38	1000.00
Total dissolved solids (TDS)	14.15	49.20	31.68	10.45	500
Na^+	1.20	3.40	2.48	0.49	200
K	0.20	1.20	0.54	0.29	150
Chloride	7.40	8.93	8.14	0.42	250
NO_3^-	0.01	0.36	0.08	0.06	10
SO_4^-	0.30	2.30	1.76	0.41	1.5
Alkalinity	1.00	7.90	1.99	0.01	200
Total Hardness (TH)	15.68	39.60	25.04	6.21	100
Calcium	13.15	35.06	22.77	5.91	200
Magnesium	1.10	4.54	2.31	0.67	150

N/B: all units are in mg/$^{L-1}$ except for PH, Turbidity and Electrical Conductivity (u^{s}cm^{-1})

Source: Authors' Analyses

The result of physico-chemical properties of borehole water in the study area indicates a high variability in water colour; large homogeneity in temperature and a PH tilted towards acidity. Other parameters indicated that Turbidity ranged between 0.24 and 0.93 FTU, while the mean values for TDS, Alkalinity, $S0_4$, $N0_3$, Mg, Ca, and TH were 31.68mg/L^{-1}, 22.77mg/L^{-1}, and 25.0477mg/L^{-1}, respectively. Electrical conductivity ranged between 27.19 and 87.30 NScm^{1-}

TABLE 4: Microbial Load of Borehole Water in the Study Area

Coordinate Easting	Coordinate Northing	Sample code	Vol. Wat (100r	Total Viable plate count (cfu/100ml)	Total. Colform bacteria (cfu/100ml)	Faecal (E-coli) (cfu/100ml)	WHO standard (cfu/100ml)
379412	519959	WS_1	10(	2700	131	18	0
379911	520013	WS_2	10(	1800	122	9	0
379830	518114	WS_3	10(	70	18	7	0
379529	517932	WS_4	10(	2200	127	12	0
378788	518640	WS_5	10(	0	0	0	0
378617	518550	WS_6	10(	1900	12	1	0
378254	517953	WS_7	10(	2400	125	13	0
378382	517264	WS_8	10(	800	15	12	0
378752	517059	WS_9	10(	3100	129	14	0
381243	514745	WS_{10}	10(	0	0	0	0
381030	515046	WS_{11}	10(	2100	126	1	0
379993	513747	WS_{12}	10(	120	19	5	0
383419	516967	WS_{13}	10(	2000	110	8	0
383274	516850	WS_{14}	10(	100	157	9	0
383482	516368	WS_{15}	10(	1600	28	5	0
383273	516533	WS_{16}	10(	500	12	4	0
382971	515267	WS_{17}	10(	4300	183	27	0
384258	513528	WS_{18}	10(	20	11	5	0
386097	512584	WS_{19}	10(	800	16	7	0
386247	512325	WS_{20}	10(	0	0	0	0
383732	509583	WS_{21}	10(	900	198	32	0
384175	509692	WS_{22}	10(	0	0	0	0

N/B: cfu/ml = Colony forming unit per millimeter

Source: Authors' Analysis

The results of microbial analyses of borehole water in the study area indicate a high volume of bacteria content in the samples. Specific bacterial organisms observed in the borehole water were coliform count and E.coli. The total coliform bacteria range between 11.00 to 198 cfu/100ml, E.coli present in the water sample range between 1.00 and 32.00 cfu/100ml, while the total viable count range between 20.00 and 4300 cful100ml. Though there was a high

Variability in the amount of microbial load among the sample; results show that only 4 representing 18 percent of total sampled borehole water were found to be satisfactory, (having zero amount of microbial load) in line with WHO standards. More than 80 percent of samples were found to be unsatisfactory in terms of bacteriological quality of the water.

The high point of this study was to link the quality of sample borehole water in the study area to their relative location to septic tank. The next section of this paper addresses the above issue adequately.

3.3. Relationship between Location of Septic Tank and Quality of Borehole Water

Table 5 and 6 display the results of Correlation/Regression analyses conducted to examine the relationship between the location of septic tank and water quality parameters. The essence is to empirically ascertain the locational effects of septic tank on borehole water quality in the area.

TABLE 5: Relationship between Location of Septic Tank (Distance) and Physiochemical Parameter of Borehole Water.

Physiochemical Parameter	N	R	Sig.	Remark
Colour	22	0.0	0.56	NS
Temperature	22	0.17	0.33	NS
Turbidity	22	-0.03	0.87	NS
Dissolved Oxygen	22	0.19	0.26	NS
PH	22	0.05	0.76	NS
Electrical Conductivity	22	-0.15	0.39	NS
Total Dissolved Solid	22	-0.13	0.44	NS
Sodium	22	0.22	0.20	NS
Potassium	22	0.19	0.26	NS
Chloride	22	-0.17	0.30	NS
Nitrate	22	0.04	0.83	NS
Sulphate	22	-0.01	0.95	NS
Alkalinity	22	0.13	0.44	NS
Total Hardness	22	0.08	0.62	NS
Calcium	22	0.08	0.66	NS
Magnesium	22	0.15	0.38	NS

N/B: NS= not significantly related ()
Source: Authors' Analyses

Data in table 5 show clearly that relative location of septic tank to borehole water has no significant relationship with the physico-chemical properties of water in the study area. The correlation co-efficient obtained for each parameter were far below 0.50 with value higher than 0.05. However, the situation was different as data in table 6 indicate that the correlation co-efficient (r) for the three bacteriological variables were significantly related with septic tank location **().**

TABLE6:Relationship between Location of Septic Tank and Bacteriological Parameter of Borehole Water.

Parameter	Regression co-efficient	Correlation co-efficient (r)	r-square (r^2)	Sig
Total viable count	-94.23	-0.437	0.191	0.007*
Total Coliform	-4.44	-0.392	0.154	0.016*
Coliform Bacteria	-0.576	-0.372	0.138	0.023*

*

Correlation is significant at 0.05
Source: Authors' Analyses

Base on the above data, it is concluded that microbial count decreases with increasing distance of septic tank from the borehole water points. The significant relationship between septic location and microbial load in borehole water suggests that the regression co-efficient for the three indicators of microbial count can be used to predict and control the levels of borehole water contamination as a unit increase in distance (septic location) is likely to yield 4 units decrease in total viable plate count (B= -94.23;), 4 units in total coliform and a unit in faecal coliform. This prediction is further strengthened by the fact that distance (location of septic tank) accounted for over 19 percent of variation in total viable plate count, 15 percent in total coliform and 12 percent in faecal coliform.

4.DISCUSSION OF FINDINGS

The location of sanitary facilities, particularly the septic tank, (also called soakaway pit) and borehole water points are matters of municipal regulations. In Nigeria, such regulations are enacted in line with international standards such as the WHO Health Guidelines and enforced by The states Ministry of Environment/ City Planning Authorities. However, finding in this study indicates that these regulations only exist on paper as the authorities concerned and failed to enforce compliance. In the study area, as revealed in this study, more than 60 percent of septic tanks and borehole water points were located without recourse to the existing regulations. The chi-square test of 'goodness of fit' clearly showed significant deviation of actual location of these sanitary facilities from the expected standards. The indiscriminate siting of sanitary facilities in (septic tanks)

Urban residential areas as witnessed in the study area have weighty repercussions for the health of the population (WHO, 2006). This study has proven that proximity of septic

tank to borehole water could be hazardous to the quality of underground water and by extension the health of consumers of such water. Significant evidence abounds from the study linking the amount of microbial loads to relative location of septic tank in the area. The three bacteriological organisms- total coliform, faecal coliform and E-coli found in water samples drawn from these boreholes are the main contaminant of borehole water whose source are likely discharge from the soakaway pit. These findings are not in isolation, as previous studies by Bande, Mbewe, Nzala and Halunda (2014) affirmed that improper alignment of septic tank with borehole water were responsible for 33 percent of heavily contaminated groundwater reserve in parts of Lusaka, Zambia. However, other studies such as Victoria and Ismail (2011); Ochuko and Thaddeus, (2013) found direct association between proximity of septic tank and population of borehole water. Perhaps, explanation for this phenomenon can be obtained from Cornwall, Mullenga and Grana (2010) who posited that locating septic tank close to borehole water enhance the contact time between groundwater and predatory micro-organism that are present in the soils around soakways with resultant effect of contamination of ground water with bacteria that could be of human faecal origin.

In Nigeria, population health is being threatened by water borne diseases particularly typhoid fever and cholera in spite of effort at improving health standards. This is so because; majority of households consumes water from borehole sources without proper treatment and disinfection. Nigeria therefore, is siting on the edge of an impending water related epidemic except effort is made to check improper siting of sanitary facilities. In some parts of Nigeria according to Anaele (2014), pit latrines and open drainage facilities are also located indiscriminately close to domestic water sources. The amount of sampled borehole water proven to be unsatisfactory (over 80 percent) and unsafe for human consumption implies that for the study area alone, more than 60 percent of households are at risk of contracting water borne disease such as dysentery, cholera, typhoid and other diarrhoeal diseases.

5.CONCLUSION AND RECOMMENDATIONS

The improper location of sanitary facilities in Nigeria living spaces is by far one of the manifestations of weak regulatory framework evidenced in most developing countries. The declaration of a "state of Emergency" in the water and sanitation sector by national and international institutions is not enough to tackle the menace if such emergency intervention fails to sensitize and inform the people on the need to appropriately locate and manage sanitary facilities. Aside from the septic tank and borehole water, the location of sanitary facilities such as dump sites and waste receptacles need to be highly regulated by relevant authorities to guarantee the health of the population.

In line with the findings of this paper, the following measures are hereby set out as panacea to the menace of improper location of sanitary facilities in Nigeria urban space.

i. Stakeholders in the ministry of Environment, Land/Urban Planning must carry out rigorous sensitization and enlightenment campaigns on the health implications of improper sitting of sanitary facilities in residential areas.
ii. Regular monitoring by relevant agencies must be conducted to enforce compliance with location standard for sanitary facilities.
iii. The proliferation of boreholes in developing countries is largely due to failure OF municipal water supply systems. Municipal Authorities can discourage private boreholes by guaranteeing regular supply of municipal water.
iv. To curb impending epidemic arising out the consumption of contaminated borehole water, disinfectant and proper treatment of domestic water should be encouraged.

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