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EFFECT OF BOREHOLES CLOSENESS TO SEPTIC TANKS / PIT LATRINES ON DRINKING WATER QUALITY (MICROBIOLOGICAL LOADS) IN UYO METROPOLIS, AKWA IBOM STATE

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Abstract: Poor water quality due to faecal contamination with potential pathogenic microorganisms is life threatening. In this study, the effect of boreholes closeness to septic tanks / pit latrines on drinking water quality in Uyo metropolis, Uyo was investigated. The water samples were collected from thirty different locations and grouped into: (i) water from boreholes close to septic tanks/ pit latrines ($\mathbf{W_{close}}$) and (ii) water from boreholes far away from septic tanks/ pit latrines ($\mathbf{W_{far}}$). Some microbiological parameters analyzed were total coliform (TC), Escherichia coli (E. coli) and Heterotrophic bacteria (HB) using standard method. Pairwise comparison among quality parameters of $\mathbf{W_{close}}$ and $\mathbf{W_{far}}$, and World Health Organization permissible limit ($\mathbf{W_{Lim}}$) and $\mathbf{W_{close}}$ revealed significant mean differences (MD) while $\mathbf{W_{far}}$ and $\mathbf{W_{Lim}}$ did not show any statistical significant MD at 5% level of probability. The ANOVA result showed that the mean value of the combined parameters in $\mathbf{W_{close}}$ was significantly higher than of $\mathbf{W_{far}}$. Based on the results, the presence of intolerable amount of TC, E. coli and HB is an indication of faecal contamination and probably due to inadequate water treatment which may likely pose public health threat. Hence, it is suggested that boreholes should be drilled at a reasonable distance away from septic tanks/ pit latrines, and that proper routine treatment should be adopted to ensure safe drinking water to the populace.

Keywords: Boreholes, Septic tanks/ pit latrines, Drinking water, Quality, Microbiological loads

INTRODUCTION

The quality of drinking water has been of great importance because it determines the welfare of humans. Poor water quality due to faecal contamination with potential pathogenic microorganisms represents an obvious health risk (Cunningham and Saigo, 1997). Occasional epidemics of bacterial and viral diseases are carried in drinking water (Meybeck and Helmer, 1992). Borehole water can be a transmitting medium for variety of disease causing organisms. A major outbreak of cholera and water borne toxic chemicals is now posing the greatest threat to the safety of water supplies in industrialized nations and this is particularly true of groundwater. In view of this, the World Health Organization has spelt out permissible limits of water quality parameters for various applications (WHO, 2008). However, Uyo Metropolis is characterized by indiscriminate siting of pit latrines and septic tanks. Pit latrines and septic tanks are often located quite close to potable water sources such as shallow boreholes and hand dug wells. This practice is bound to affect the quality of potable water. According to Etang (2000), the people of Uyo mostly depend on water from boreholes for drinking, general household and domestic sanitation. Drilling of boreholes / wells has been a thing for almost every compound. The migration of underground contaminants is dependent on the permeability and porosity of the subsurface rocks strata, which control the capillary and hydraulic system of the soil (Pettijohn, 1965). Increase in population and socio–economic activities in Uyo has led to increase in pollution stress on the groundwater and it can be inferred that borehole water quality in the vicinity of public supply sources are threatened by waste dumps. Domestic waste causes water pollution when mineral and organic substances such as refuse, faeces, urine and decomposed organic matters are channeled into water bodies (Salami et al., 2001). However, recent study by Akpan et al. (2020), on impact of locating boreholes near septic tanks/ pit latrines on drinking water quality in Uyo Metropolis based on physicochemical parameters revealed that all parameters were within World Health Organization permissible limit except temperature and pH. Consequently, water treatment was still suggested. So, there was need to also examine the quality of these water samples based on the microbiological parameters (total coliform [TC], Escherichia coli [E. coli] and Heterotrophic bacteria [HB]) to ascertain its status. Therefore, the main objective of this research was to examine the effect of boreholes closeness to septic tanks/ pit latrines on drinking water quality (microbiological loads) in Uyo Metropolis. The specific objectives were to: (i) sample domestic structures where boreholes were close to, and far away from septic tanks / pit latrines; (ii) determine water quality from both sources based on some microbiological parameters; (iii) carry out multiple pairwise comparisons of their mean

values with World Health Organization permissible limits (W_{Lim}) using Ordinary Least Significant Difference (LSD) Test and (iv) determine the influence of borehole proximity to septic tanks / pit latrines on combined microbiological parameter using Analysis of Variance (ANOVA). The study would create awareness on the status of water quality from sampled sources in Uyo Metropolis and sensitize the populace on the danger of rampant and indiscriminate drilling of boreholes for drinking water. However, the theory behind this study is based on the fact that the infiltration or permeation of sewage disposal from septic tanks/ pit latrines into nearby groundwater, aquifer formation or boreholes may be possible. Consequently, the quality of this water when subjected to analysis may be objectionable.

MATERIALS AND METHODS

— Study Area

Global Positioning System was used to generate the position and geographical co–ordinates of thirty (30) sampling points in Uyo Metropolis, Uyo, Akwa Ibom State as shown in Figure 1. The co–ordinates of ten (10) locations of boreholes far from septic tanks / pit latrines (BFS) were between the altitude of 73 – 84 m, 5.00431 – 5.02532 0 N and 7.51484 – 7.563820 E while that of twenty (20) locations of boreholes close to septic tanks/ pit latrines (BCS) were within the altitude of 52 – 84 m, 5.00341– 5.00339 0N and 7.3543 – 7.564630 E.

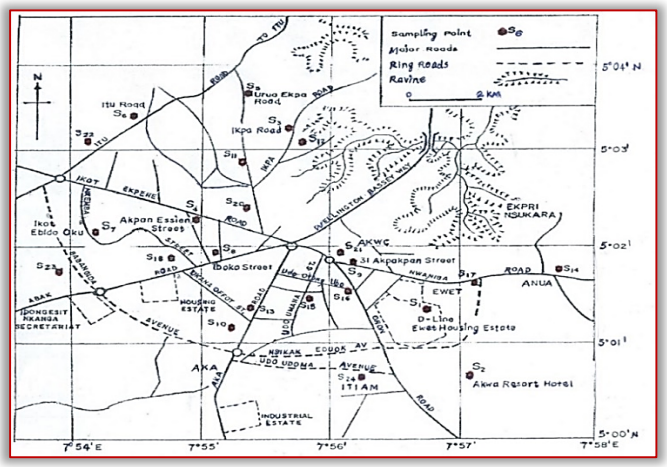

Figure 1: Map of Uyo Metropolis showing sampling points.
Source: GIS–University of Calabar (2010).

— Data Collection

Data were initially collected through reconnaissance survey from boreholes owned by private individuals and those dug by Akwa Ibom Rural Water and Sanitation Agency (AKRUWATSAN) for public use, boreholes located close to, and far away from septic tanks/pit latrines. Some of these facilities are presented in Figure 2 to 5. Meanwhile, distances of 10 BFS ranged from 12.5 – 22.5 m while that of 20 BCS ranged from 3.0 – 7.0 m, where B/H = borehole, GP tank = general purpose tank and S = septic tank/pit latrine.

Figure 2: Borehole located 4.2 metres away from septic tank at a premises located along Akpan Essien Street

Figure 3: Borehole located 4 metres away from septic tank with GP tank on top along Ikpa Road

Figure 4: Borehole located 4 metres away from septic tank along Akpakpan Street

Figure 5: Akwa Ibom Water Corporation (AKWC) reservoir tank and pipe borne water treatment facility about 18 metres away from septic tank

≡ Procedure

Ten (10) and twenty (20) water samples were obtained from BCS and BFS, respectively. They were stored in clean, sterilized and well–labelled one–litre containers. These containers were kept in a cooler and later transferred to a refrigerator at 4 °C prior to analysis to prevent further reaction. Microbiological parameters of water samples were analyzed in Quality Control Laboratory, AKWC, Uyo.

≡ Determination of Microbiological Parameters

Media preparation and culturing were used to determine the microbiological content (total coliform [TC] Escherichia coli [E. coli] and Heterotrophic bacteria [HB]) of borehole water samples from different locations in order to ascertain the presence of TC and E. coli per 100 ml of the sample. Nutrient agar and sodium lauryl sulphate broth were commercially formulated and prepared according to the manufacturer's specification. The major techniques employed were pour plate technique and membrane filtration technique with varying incubation temperatures of 37 °C and 44 ± 0.5°C and incubation periods of 24 hours and 29 hours as required. Other laboratory analyses were carried out for nutrients based on standard methods. These include: argentometric method (titration) analysis for chloride, cadmium reduction method (reduction column) for nitrate, ascorbic acid method for phosphate and turbidimetric method for sulphate (Rodier, 1975). The experiment was conducted in duplicates.

≡ Statistical Analysis

The range, values of mean and standard deviation of the microbiological parameters of water samples from both sources were calculated using Statistical Package for Social Scientists Version 20.0 (SPSS). Multiple pairwise comparisons of their mean values as well as WHO permissible limits (WHO, 2008) were carried out using Ordinary Least Significant Difference (LSD) Test, and ANOVA used to determine the influence of borehole proximity of septic tanks / pit latrines at 5% level of probability (Stephen, 1998; SPSS, 2011).

RESULTS AND DISCUSSION

The summary of values of some microbiological parameters of water samples from boreholes close to ($\mathbf{W_{close}}$), and far from septic tanks / pit latrines ($\mathbf{W_{far}}$) and WHO permissible limit (WHO, 2008) is presented in Table 1, while that of multiple pairwise comparisons of their mean values is shown in Table 2.

Table 1: Summary of values of microbiological parameters of water samples from boreholes close to ($\mathbf{W_{close}}$) and far away from septic tanks /pit latrines ($\mathbf{W_{far}}$), and WHO permissible limits ($\mathbf{W_{lim}}$) (WHO, 2008)

BHP		Microbiological Parameters		
		Total coliform (per 100 ml)	E. coli (per 100 ml)	H.B (per 100 ml)
$\mathbf{W_{close}}$	Range	30 – 80	11 – 73	72 – 124
	N	20.00	20.00	20.00
	Mean	51.45	40.30	94.05
	S.D.	14.90	20.30	15.50
$\mathbf{W_{far}}$	Range	0 – 7	0 – 5	0 – 14
	N	10.00	10.00	10.00
	Mean	2.60	1.30	4.80
	S.D.	2.40	1.80	4.70
$\mathbf{W_{LIM}}$		0.0	0.0	–

Note: BHP = boreholes proximity, N = number of observations and italicized values are standard deviations.

Table 2: Summary of multiple pairwise comparisons among mean values of microbiological parameters of water quality from boreholes close to and far away from septic tanks /pit latrines and who permissible limit

Parameters	Pairs	MD	$\mathbf{P_{cal}}$
Total coliform (T.C) (per 100 ml)	$\mathbf{W_{Lim}/W_{far}}$	−2.600	0.784
	$\mathbf{W_{Lim}/W_{close}}$	−51.45*	0.000
	$\mathbf{W_{far}/W_{close}}$	−48.85*	0.000
Escherichia coli (E.coli) (per 100 ml)	$\mathbf{W_{Lim}/W_{far}}$	1.300	0.920
	$\mathbf{W_{Lim}/W_{close}}$	40.30*	0.003
	$\mathbf{W_{far}/W_{close}}$	39.00*	0.000
Heterotrophic bacteria (HB) (per 100 ml)	$\mathbf{W_{Lim}/W_{far}}$	–	–
	$\mathbf{W_{Lim}/W_{close}}$	–	–
	$\mathbf{W_{far}/W_{near}}$	−89.25*	0.000

NB: MD = mean difference; MD values with asterisk (*) are significant at $\mathbf{P_{cal}} < 0.05$

From Tables 1 and 2, the concentration of TC in $\mathbf{W_{close}}$ ranged from 30–80 counts per 100 ml with a mean value of 51.45 counts per 100 ml, while that of $\mathbf{W_{far}}$ was within 0–7 counts per 100 ml, and with mean value of 2.6 counts per 100 ml. Their mean values were statistical different from each other. Pairwise comparison between the amount of TC in $\mathbf{W_{close}}$ and WHO permissible limit ($\mathbf{W_{Lim}}$) also revealed significant mean difference (MD) at 5% level of probability while that of $\mathbf{W_{Lim}}$ and $\mathbf{W_{far}}$ did not have any statistical significant MD. This might have been attributed to the fact that greater number of water samples from 10 locations recorded TC within 0 to 4 counts per 100 ml. The amount of E. coli in $\mathbf{W_{close}}$ and $\mathbf{W_{far}}$ ranged from 11–73 counts per 100 ml and 0– 5 counts per 100 ml ; with mean values of 40.3 and 1.3 counts per 100 ml, respectively. Statistically, there were significant mean differences. Comparison between the concentration of E. coli in $\mathbf{W_{close}}$an $\mathbf{W_{Lim}}$ (0 count per 100 ml) recorded significant MD while that of $\mathbf{W_{Lim}}$ and $\mathbf{W_{far}}$ did not show any statistical significant MD. This might be as a result of 7 out of 10 locations recorded between 0–1 count per 100 ml of E. coli. The amount of HB in $\mathbf{W_{close}}$ and $\mathbf{W_{far}}$ were within 72–24 counts per 100 ml and 0–14 counts per 100 ml ; with mean values of 94.05 and 4.8 counts per 100 ml, respectively. On comparison between content of HB in $\mathbf{W_{close}}$ and $\mathbf{W_{far}}$, there was statistical significant MD. This implies that both water sources varied in HB content. However, as at the time of this report, there was no information on the $\mathbf{W_{Lim}}$ which could have been used in comparison. Besides, HB was observed to record the highest content in both water sources. Meanwhile, Heterotrophic bacteria majorly help in breaking down organic matters or recycling of minerals in aquatic ecosystem.

Generally, the observed values of microbiological parameters in $\mathbf{W_{close}}$and $\mathbf{W_{far}}$ are not tolerable and are an indication of faecal contamination and probably due to inadequate water treatment which may likely result in gastrointestinal illness, urinary tract infections, bacteraemia, meningitis, diarrhea, acute renal failure and haemolytic anaemia (UW Extension, 2009; NIS, 2015;

CENGAGE, 2020). Meanwhile, the summary of ANOVA result of the effect of boreholes closeness on drinking water quality based on combined microbiological parameters is shown in Table 3 while a bar chart showing the mean concentration of combined microbiological parameters of W_{close} and W_{far} is presented in Figure 6.

Table 3: Summary of ANOVA result of the effect of boreholes closeness on drinking water quality based on combined microbiological parameters

Source Variance	SS	df	MS	R^2	F	P_{cal}
BHP	23720.82	1	23720.82	0.834	140.52*	0.000
Error	4726.65	28	168.81			
Total	28447.47	29				

NB: F–values = variance ratio; F– value with asterisk (*) is significant at P_{cal} (calculated value of probability distribution) < 0.05.

From Table 3, since $P_{cal} <$ 0.05, then F–value was significant coupled with high coefficient of determination (R^2) of 0.834, which implies that W_{close} had significant different concentrations of combined microbiological parameters from that of W_{far}.

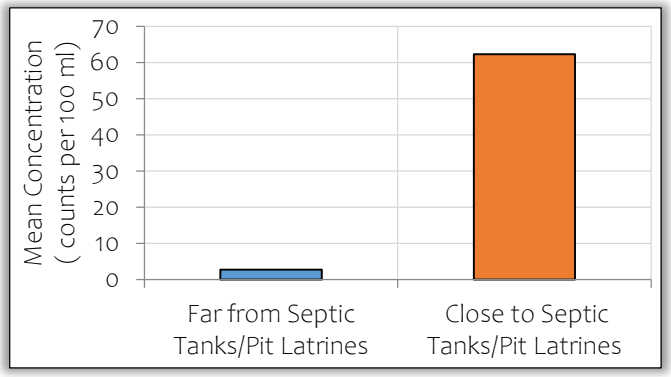

Figure 6: Bar chart showing the mean concentration of combined microbiological parameters of water quality from boreholes close to and far from septic tanks/pit latrines

From Figure 6, the mean concentration of combined microbiological parameters of W_{close} and W_{far} were 62.35 and 2.7 counts per 100 ml, respectively. The mean concentration of these parameters in W_{close} was higher than that of W_{far} by 95.7%. Hence, water from boreholes close to septic tanks/pit latrines is bacteriological unsafe for drinking.

CONCLUSIONS

In summary, the coliform groups of bacteria were virtually found in all W_{close}, but were greatly reduced in W_{far}. Some samples of W_{far} did not record any trace of coliform groups of bacteria. However, the concentrations of microbiological parameters in W_{close}were all above W_{Lim} for drinking water. The ANOVA result showed that the mean value of the combined microbiological parameters in W_{close} was significantly higher than of W_{far}. Based on the results of water quality analysis (microbiological load), the presence of traces of TC, E. coli and HB is an indication of faecal contamination and probably due to inadequate water treatment which may likely pose public health challenge. Hence, it is recommended that boreholes should be drilled at some rational distance far away from septic tanks/ pit latrines with adequate routine treatment to ensure bacteriological safe drinking water.

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