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Impact of Locating Boreholes Near Septic Tanks/ Pit Latrines on Drinking Water Quality in Uyo Metropolis, Akwa Ibom State

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ABSTRACT

Water is one of the most indispensible elements of life. One of the major uses of water by man is for drinking, hence drinking water quality has become a major concern in this regard because poor quality water can cause outbreak of major epidemics and death. In this study, impact of locating boreholes near septic tanks/ pit latrines on drinking water quality in Uyo metropolis, Akwa Ibom State was investigated. The water samples were collected from thirty (30) locations and categorized into: (i) water from boreholes near (W_{near}) and (ii) far from septic tanks/ pit latrines (W_{far}). Some physicochemical parameters analyzed were temperature, pH, electrical conductivity, turbidity, dissolved oxygen (DO), biochemical oxygen demand (BOD_5), salinity (i.e. sulphate, carbonate, nitrate, phosphate and chloride ions), total hardness (TH), total dissolved solids (TDS), total suspended solids (TSS) and total alkalinity. Pairwise comparison between quality of W_{near} and W_{far} revealed that only BOD_5, TH and TDS had significant mean difference (MD) at 5% level of probability while their comparison with World Health Organization permissible limit (P_{WHO}) showed higher significant MD. All the values of parameters were within P_{WHO}, except that of temperature and pH. Based on the results, the water chemistry is tolerable and may not cause any critical damage to the water distribution system as well as utility components. However, treatment is still suggested and boreholes should be drilled some reasonable distances far away from septic tanks/ pit latrine to guarantee safe drinking water.

KEYWORDS: *Boreholes, Septic Tanks/ Pit latrines, Drinking Water, Quality, Physicochemical parameters*

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INTRODUCTION

Water is one of most essential elements of life. It is required by human, animals and plants for various purposes. One of the major uses of water by humans is for drinking, in order to sustain life and other metabolic processes. In nature, water occurs naturally in gas, liquid and solid phases (GESAMP, 1988). It goes through ocean, atmosphere and land, and back to sea by a cycle known as hydrological cycle. It is important to note that groundwater is a part of hydrological cycle. Besides, contaminants in other parts of the cycle such as atmosphere, bodies of water or on land can eventually be transferred into groundwater supplies (GESAMP, 1988). Water can be a transmitting medium for variety of diseases causing organisms, some of which may be parasites (Salami *et al.,* 2001). Therefore, quality of drinking water has become a great concern. Furthermore, water pollution has contributed immensely to the outbreak of major epidemics and death (NEST, 1991). Boreholes/ groundwater pollution by anthropogenic sources has constituted a major threat to public health, and issues on water pollution should be given serious attention because the knowledge of sources, interactions and effects are essential in controlling the pollutants in an environmentally safe and economically acceptable manner (Cunningham and Sango, 1997). However, possible sources of water pollution could be from leachates, landfills, pit latrines, sewage disposal from septic tank, etc. Uyo Metropolis is characterized by the indiscriminate location of septic tanks/ pit latrines. These facilities are often built ignorantly close to portable water sources such as well, boreholes, etc. Recent cases of ill-health recorded could be traced to drinking polluted groundwater, especially those where boreholes are located few metres away from septic tanks/ pit latrines. Therefore, the main objective of this study was to examine the impact of locating boreholes near septic tanks/ pit latrines on drinking water quality in Uyo Metropolis. The specific objectives were to: (i) sample domestic structures in which boreholes were near, and far away from septic tanks/ pit latrines; (ii) determine water quality from both sources based on some physicochemical parameters; and (iii) carry out multiple pairwise comparisons of their mean values and World Health Organization permissible limits (P_{WHO}) of physicochemical parameters using Tukey's Honestly Significant Difference (HSD) Test. It is believed that this study would provide useful information on the status of water quality from sampled sources in Uyo Metropolis where appropriate government agencies could act on to remedy the present status.

THEORY

Sewage water from septic tanks/ pit latrine located near boreholes has the tendency to infiltrate or permeate into groundwater or aquifer formation. As a result, the quality of this water when examine may be questionable. However, the values of physicochemical parameters of water samples from boreholes near septic tanks/ pit latrines (W_{near}), far from septic tanks/ pit latrines (W_{far}) and a set standard (e.g. WHO permissible limits) can be compared paired-wisely using suitable statistical tool such as Tukey's HSD Test at 5% level of probability. Thus, if the calculated value of probability distribution (P_{cal}) $\leq$ table value of probability distribution (P_{Tab}), then null hypothesis (H_0) is rejected, which says that there is no statistical significant mean difference (MD) between the paired tests, else the alternative hypothesis (H_A) is accepted which holds that there is statistical significant mean difference (MD) between the paired tests (Stephen, 1998, SPSS, 2011).

METHOD

Study Area

Global Positioning System (GPS.12 x L) was used to establish spatial position and geographical co-ordinates of thirty (30) sampling points in Uyo Metropolis, Uyo, Akwa Ibom State as shown in Fig.1. The co-ordinates of twenty (20) locations of boreholes near septic tanks/ pit latrines (BHNS) were within the altitude of 52 – 84 m, 5.00341-5.00339 ^{0}N and 7.3543 – 7.56463^0 E while that of ten (10) locations of boreholes far from septic tanks/ pit latrines (BHFS) were between the altitude of 73 – 84 m, 5.00431 – 5.02532 ^{0} N and 7.51484 – 7.56382^0 E.

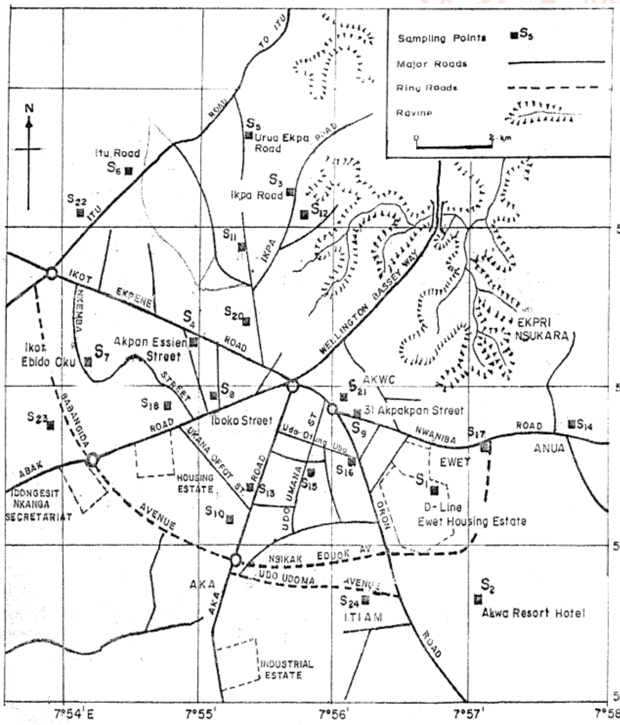

Figure 1: Map of Uyo Metropolis showing sampling points.
Source: GIS-University of Calabar (2010).

Data Collection

Data were first sourced through reconnaissance survey in order to identify the boreholes owned by private individuals and those drilled by Akwa Ibom Rural Water and Sanitation Agency (AKRUWATSAN) for public consumption, located near, and far away from septic tanks/pit latrines. Few of these facilities are shown in Fig. (2) to (5). However, distances of 20 BHNS ranged from 3.0 – 7.0 m while that of 10 BNFS ranged from 12.5 – 22.5 m.

Fig. 2: Borehole located 7 metres away from septic tank in Ikot Ebido by Winner' Chapel.

where B/H = borehole, GP tank = general purpose tank and S = septic tank/pit latrine.

Fig. 3: Borehole located 6 metres away from pit latrine along Urua Ekpa Road.

Fig. 4: Borehole located 4 metres away from septic tank around Akpakpan Street.

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

A. Procedure

Twenty and ten water samples were collected from boreholes near, and far away from septic tanks/pit latrines, respectively, stored in clean, sterilized and well-labelled one-litre bottles. These bottles were kept in a cooler and were later transferred to a refrigerator at 4^0 C prior to analysis to prevent further alteration. Some physicochemical parameters such as temperature, pH, electrical conductivity, turbidity, dissolved oxygen (DO), biochemical oxygen demand (BOD_5), salinity [e.g. sulphate (SO_4^{-2}), carbonate (CO_3^{-2}), nitrate (NO_3^-), phosphate (PO_4^{-3}) and chloride (Cl^-) ions], total hardness (TH), total dissolved solids (TDS), total suspended solids (TSS) and total alkalinity of water samples were analyzed in Quality Control Laboratory, AKWC, Uyo. The following methods/ equipment were used in analyzing the water samples from each location in replicates.

B. Determination of Temperature, pH and Electrical Conductivity

Sample temperature, pH and electrical conductivity were measured on-site using mobile thermometer, pH meter and electrical conductivity meter model 4460, respectively according to HACH (1997).

C. Determination of Turbidity

Sample turbidity was measured in the field. A Secchi disc was used by holding the rope attached to its central point on the side painted black and suspended into the water sample until it no longer appeared visible. This depth was determined by measuring the length of the rope (Akpan, 2010).

D. Determination of Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD_5)

Sample dissolved oxygen was found in-situ using potable dissolved oxygen meter model 5509, while BOD_5 was found as the difference between initial and final dissolved oxygen in the sample after incubation in the dark at 20 ^{0}C for 5 days (Wong *et al.,* 1996).

E. Determination of Sulphate (SO_4^{-2}) and Carbonate (CO_3^{-2}) Ions Concentrations

Sulphate ion concentration in the sample was determined by spectrophotometric method using $Ba(NO_3)_2$ as precipitant according to APHA (1998), while CO_3^{-2} concentration was found by spectrophotometric titration as described by Todd *et al*. (2009).

F. Determination of Nitrate (NO_3^-) and Phosphate (PO_4^{-3}) Ions Concentrations

The concentrations of NO_3^- and PO_4^{-3} in the water samples were found colorimetrically using spectrophotometric method described by APHA (1998).

G. Determination of Chloride (Cl^-) Ion Concentration

Chloride ion concentration in the sample was found by titration method using $AgNO_3$ solution and potassium chromate as indicator according to APHA (1998).

H. Determination of Total Hardness (TH)

Sample TH was determined by ethylenediamine tetra acetic acid (EDTA) complex metric titration technique using Erichrome black T indicator (Chapman and Kimstach, 1992).

I. Determination of Total Suspended Solids (TSS) and Total Dissolved Solids (TDS)

Sample TSS was found by filtration using a glass fibre, drying of residue at 105 ^{0}C, cooling in a desiccator and re-weighing of the glass fibre, while sample TDS was determined by weighing the deposit after evaporation of a known volume of sample filtrate (RCE, 2017).

J. Determination of Total Alkalinity

Sample total alkalinity was found by titration method using few drops of methyl orange and 0.1 M hydrochloric acid (HCl) as described by APHA (1998) and Aria (2002).

Statistical Analysis

The range, values of mean and standard deviation of the physicochemical 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 Tukey's HSD Test at 5% level of probability.

RESULTS AND DISCUSSION

The summary of values of some physicochemical parameters of water samples from boreholes near (W_{near}), and far from septic tanks /pit latrines (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 SOME PHYSICOCHEMICAL PARAMETERS OF WATER SAMPLES FROM BOREHOLES NEAR (W_{NEAR}) AND FAR FROM SEPTIC TANKS /PIT LATRINES (W_{FAR}), AND WHO PERMISSIBLE LIMITS (P_{WHO}) (WHO, 2008).

Parameters		(W_{near})				(W_{far})				WHO Limit
		Range	N	Mean	S.D.	Range	N	Mean	S.D.	
Temperature	(°C)	26.30 - 26.90	20	26.54	0.20	26.00 - 27.80	10	26.55	0.50	25
pH		5.40 - 6.20	20	5.67	0.21	5.40 - 5.80	10	5.58	0.13	6.5 - 8.5
Electrical Conductivity	(μscm^{-1})	16.90 - 34.80	20	25.29	5.67	18.00 - 28.90	10	21.38	3.81	1000
Turbidity (NTU)		0.43 - 0.80	20	0.60	0.10	0.58 - 0.66	10	0.61	0.02	5.0
Dissolved Oxygen, DO	(mg/l)	0.80 - 1.20	20	0.99	0.12	0.80 - 1.10	10	0.97	0.08	5.0
Biochemical Oxygen Demand,										
BOD_5	(mg/l)	0.40 - 0.80	20	0.55	0.10	0.30 - 0.51	10	0.39	0.08	1.0
Sulphate, SO_4^{-2}	(mg/l)	2.40 - 3.60	20	2.76	0.29	2.40 - 3.10	10	2.75	0.26	200
Carbonate, CO_3^{-2}	(mg/l)	0.80 - 1.00	20	1.00	0.05	1.00 - 1.00	10	1.00	0.00	500
Nitrate, NO_3^-	(mg/l)	0.10 - 0.16	20	0.12	0.02	0.10 - 0.15	10	0.12	0.02	10.0
Phosphate, PO_4^{-3}	(mg/l)	0.20 - 0.50	20	0.35	0.11	0.20 - 0.30	10	0.27	0.05	5.0
Chloride, Cl^-	(mg/l)	7.20 - 8.20	20	7.74	0.28	7.60- 8.10	10	7.83	0.16	250
Total Hardness, TH	(mg/l)	15.00 - 27.20	20	20.74	3.60	12.6 - 24.0	10	15.85	3.63	600
Total Dissolved Solids, TDS	(mg/l)	8.53 - 17.80	20	12.98	3.00	8.15 - 12.00	10	9.70	1.23	1000
Total Suspended Solids, TSS	(mg/l)	0.01 - 0.15	20	0.032	0.047	0.01 - 0.17	10	0.042	0.055	30
Total Alkalinity,	(mg/l)	1.20- 2.10	20	1.85	0.20	1.70 - 2.00	10	1.81	0.12	10.0

Source: Akpan (2010).

TABLE 2: SUMMARY OF MULTIPLE PAIRWISE COMPARISONS AMONG MEAN VALUES OF PHYSICOCHEMICAL PARAMETERS OF WATER QUALITY FROM BOREHOLES NEAR, AND FAR FROM SEPTIC TANKS /PIT LATRINES AND WHO PERMISSIBLE LIMIT.

Parameters	Pairs	MD	P_{cal}
Temperature (^{0} C)	P_{WHO}/W_{far}	-1.5500*	0.000
	P_{WHO}/W_{near}	-1.5350*	0.000
	W_{far}/W_{near}	0.0150	0.992
pH	P_{WHO}/W_{far}	1.9200*	0.000
	P_{WHO}/W_{near}	1.8350*	0.000
	W_{far}/W_{near}	-0.0850	0.774
Electrical Conductivity ($\mu s cm^{-1}$)	P_{WHO}/W_{far}	978.6200*	0.000
	P_{WHO}/W_{near}	974.7115*	0.000
	W_{far}/W_{near}	-3.9085	0.131
Turbidity (NTU)	P_{WHO}/W_{far}	4.3850*	0.000
	P_{WHO}/W_{near}	4.3960*	0.000
	W_{far}/W_{near}	0.0110	0.940
Dissolved Oxygen, DO (mg/l)	P_{WHO}/W_{far}	4.0250*	0.000
	P_{WHO}/W_{near}	4.0050*	0.000
	W_{far}/W_{near}	-0.0200	0.885
Biochemical Oxygen Demand, BOD_5 (mg/l)	P_{WHO}/W_{far}	0.6140*	0.000
	P_{WHO}/W_{near}	0.4515*	0.000
	W_{far}/W_{near}	-0.1625*	0.000
Sulphate, SO_4^{-2} (mg/l)	P_{WHO}/W_{far}	197.2550*	0.000
	P_{WHO}/W_{near}	197.2440*	0.000
	W_{far}/W_{near}	-0.0110	0.994
Carbonate, CO_3^{-2} (mg/l)	P_{WHO}/W_{far}	499.0000*	0.000
	P_{WHO}/W_{near}	499.0050*	0.000
	W_{far}/W_{near}	0.0050	0.948
Nitrate, NO_3^- (mg/l)	P_{WHO}/W_{far}	9.8790*	0.000
	P_{WHO}/W_{near}	9.8790*	0.000
	W_{far}/W_{near}	0.0000	1.000
Phosphate, PO_4^{-3} (mg/l)	P_{WHO}/W_{far}	4.7300*	0.000
	P_{WHO}/W_{near}	4.6550*	0.000
	W_{far}/W_{near}	-0.0750	0.129
Chloride, Cl^- (mg/l)	P_{WHO}/W_{far}	242.1700*	0.000
	P_{WHO}/W_{near}	242.2650*	0.000
	W_{far}/W_{near}	0.0950	0.576
Total Hardness, TH (mg/l)	P_{WHO}/W_{far}	584.1500*	0.000
	P_{WHO}/W_{near}	579.2610*	0.000
	W_{far}/W_{near}	-4.8890*	0.004
Total Dissolved Solids, TDS (mg/l)	P_{WHO}/W_{far}	990.3000*	0.000
	P_{WHO}/W_{near}	987.0175*	0.000
	W_{far}/W_{near}	-3.2825*	0.006
Total Suspended Solids, TSS (mg/l)	P_{WHO}/W_{far}	29.9580*	0.000
	P_{WHO}/W_{near}	29.9680*	0.000
	W_{far}/W_{near}	0.0100	0.858
Total Alkalinity, (mg/l)	P_{WHO}/W_{far}	53.1900*	0.000
	P_{WHO}/W_{near}	53.1550*	0.000
	W_{far}/W_{near}	-0.0350	1.000

NB: MD= mean difference; MD values with asterisk are significant at P = 0.05, P_{cal}= calculated value of probability distribution.

From Tables 1 and 2, the temperature of W_{far} ranged from 26.00 – 27.80 ^{0}C with a mean value of 26.55 ^{0}C, while that of W_{near} was within the same range, and with mean value of 26.54 ^{0}C. Their mean values were not statistical different from each other. These values were a bit above WHO permissible limit (P_{WHO}) (25.00 ^{0}C) with significant mean difference (MD) at 5% level of probability. The observed values may not significantly stimulate the growth of micro-organisms, odour and colour. The pH of W_{near} and W_{far} ranged from 5.40 – 6.20 and 5.40 — 5.80 with mean values of 5.67 and 5.58, respectively. Statistically, there was no significant MD. The observed values were a bit above P_{WHO} (6.50 – 8.50). pH is simply the measure of hydrogen ion concentration in a sample. The measured values from both sources indicate that the samples were less acidic, and somewhat close to P_{WHO}. The values of electrical conductivity (EC) of W_{near} and W_{far} were within 16.90 – 34.80 $\mu s cm^{-1}$ and 18.00 – 28.90 $\mu s cm^{-1}$ with mean values of 25.29 and 21.38 $\mu s cm^{-1}$, respectively. Statistically, both water sources had the same values of EC which were within P_{WHO} (1000 $\mu s cm^{-1}$). This implies that the water sample must have contained very little amount of dissolved salts and inorganic materials such as alkalis, sulphates, etc., which may aid laxative effect in human. The sample turbidity of W_{near} and W_{far} ranged from 0.43 - 0.80 NTU and 5.80 – 0.66 NTU with mean values of 0.60 and 0.61 NTU, respectively. Both mean values were statistically the same and were within P_{WHO} (5 NTU). The measured values are an indication of certain level of cloudiness of the water sample caused by the present of some particulates invisible to the naked eyes. The observed values imply that water samples would aid in water disinfection and possible reduction of chances of bacteriological growth (UW Extension, 2009; NIS, 2015).

Besides, the values of DO of W_{near} and W_{far} were within the same range (0.8 – 1.2 mg/l) with mean values of 0.99 and 0.97 mg/l, respectively. The mean values were statistically the same and within P_{WHO} (5 mg/l). This means that the samples had very little amount of DO. The values BOD_5 of W_{near} and W_{far} ranged from 0.40 - 0.80 mg/l and 0.30 – 0.51 mg/l with mean values of 0.55 and 0.39 mg/l, respectively. Though their mean values were statistically different, they were still within P_{WHO} (1.00 mg/l). The BOD_5 value of W_{near} indicates that the water sample must have required more amount of DO, as compared to W_{far}, needed by aerobic micro-organisms to breakdown organic matter in the water (NIS, 2015; Orua *et al.,* 2019).

In addition, the sample SO_4^{-2} concentrations of W_{near} and W_{far} were within the same range (2.40 – 3.60 mg/l), with mean values of 2.76 and 2.75 mg/l, respectively. Both mean values were statistically the same and were within P_{WHO} (200 mg/l). The observed values are an indication of impossibility of having gastrointestinal effect in human. The sample CO_3^{-2} concentrations of W_{near} and W_{far} were within the same range (0.80 – 1.00 mg/l). Their mean values (1.00 mg/l) were statistically the same and were within P_{WHO} (500 mg/l). The values of NO_3^{-} concentrations of W_{near} and W_{far} were within the same range (0.10 – 0.16 mg/l) and with the same mean value of 0.12 mg/l which was within P_{WHO} (10.0 mg/l). The measured value is an indication of impossibility of such water to cause methemoglobinemia in infants. However, the values of PO_4^{-3} concentration of W_{near} and W_{far} ranged from 0.20 - 0.50 mg/l and 0.20 – 0.30 mg/l with mean values of 0.35 and 0.27 mg/l, respectively. Both mean values were not statistically different and were within P_{WHO} (5.0 mg/l) .The range of Cl^{-} concentrations from W_{near} and W_{far} were found to be 7.2 – 8.2 mg/l while their mean values were 7.74 and 7.38 mg/l, respectively. Their mean values were not statistically different and were within P_{WHO} of 250 mg/l. The recorded values from both sources reveal very minute quantity of dissolved salt (UW Extension, 2009; NIS, 2015).

Furthermore, the range of samples TH of 15.0 – 27.2 mg/l and 12.6 – 24.0 mg/l; and their mean values of 20.74 and 15.85 mg/l were found for W_{near} and W_{far}, respectively. Even though their mean values were statistically different, they were within P_{WHO} (600 mg/l). The measured values are an indication of the presence of very little amount of magnesium and calcium ions in the water samples (very soft water) to ensure mineral balance. Hence, the probability of causing cardiovascular disease would be slim; the water samples would prevent excess soap wastage during laundry, and cum formation in boiling vessels. The range of samples TDS of 8.53 – 17.80 mg/l and 8.15 – 12.0 mg/l; and mean values of 12.98 mg/l and 9.70 mg/l were recorded for W_{near} and W_{far}, respectively. Their mean values were statistically different but were still within P_{WHO} (1000 mg/l). The observed values imply the presence of very minute dissolved quantity of inorganic and organic substances. The concentrations of TSS in the samples ranged from 0.01 – 0.15 mg/l and 0.01 – 0.17 mg/l while their mean values of 0.032 mg/l and 0.042 mg/l were recorded for W_{near} and W_{far}, respectively. Their mean values were not statistically different and were within P_{WHO} (30 mg/l). The measured values indicate the presence of very little amount of particles in the sample that did not go through the filter caused by turbidity. The concentration of total alkalinity in both samples was within the same range (1.20 – 2.10 mg/l). Mean values of 1.85 and 1.81 mg/l were found for W_{near} and W_{far}, respectively. They were not statistically different and were within P_{WHO} (10 mg/l) (UW Extension, 2009; NIS, 2015).

Generally, pairwise comparison of physicochemical parameters between W_{near} and W_{far} revealed that only BOD_5, TH and TDS had significant MD at 5% level of probability while their comparison with P_{WHO} showed higher significant MD. Only the values of temperature and pH were a little above P_{WHO}. Besides, the observed values of temperature, pH, turbidity, salinity (e.g. SO_4^{-2}, CO_3^{-2}, PO_4^{-3} and Cl^{-}), TDS, TSS and total alkalinity of water samples would not permit formation of deposits in water distribution pipelines, scales on boiling/cooking vessels, corrosion of metallic pipes, objectionable characteristic taste and frequent replacement of filters. It was, therefore, deduced that the water samples from both sources must have been given a certain level of treatment but not holistic. Hence, it was found that the water chemistry is tolerable and safe based on the physicochemical parameters analysis.

PRACTICAL IMPLICATIONS

Based on the results, the water chemistry is tolerable and may not encourage formation of deposits in water distribution pipelines, scales on boiling/cooking vessels, corrosion of metallic pipes, objectionable characteristic taste and frequent replacement of filters. The amounts of BOD_5, TH and TDS in W_{near} inform holistic water treatment to be carried out. Hence, borehole should be located at least 12.5 m away from septic tanks/ pit latrine.

CONCLUSION

In summary, it was found that all the values of parameters were within P_{WHO}, except that of temperature and pH. Based on the results, the water chemistry is tolerable and may not cause any critical damage to the water distribution system as well as utility components. However, treatment is still suggested. Besides, boreholes should be drilled some reasonable distances away from septic tanks/ pit latrine to guarantee safe drinking water. Lastly, careful survey should be made around the vicinity to avoid proximity to other adjacent facilities from neighboring structures.

REFERENCES

[1] S. A. Akpan, "Water quality status of boreholes located near pit latrine/septic tanks in Uyo Metropolis, Akwa Ibom State." Unpublished MSc Thesis, Department of Geography and Regional planning, University of Calabar, Calabar, Nigeria, 113p, 2010.

[2] GIS-University of Calabar, "Geographical Information System Unit," University of Calabar, Calabar, Cross River State, 2010.

[3] APHA, "Standard Methods for the Examination of Water and Wastewater", 19th Ed. American Public Health Association (APHA), 1998.

[4] S. Aria, "Global view on functional foods: Asian perspectives." Nrit J. Nutr. 88:139-143, 2002.

[5] Cunningham, W.P. and Saigo B.W. "Environmental Science. A Global Perspective" (4th Edition), M. Graw Hill, Boston, 1997.

[6] D. Chapman, and V. Kimstach, "The Selection of Water Quality Variables. In Deborah C. (Ed.), Water Quality Assessments: A Guide to Use of Biota, Sediments and Water in Environmental Monitoring." Chapman and Hall, London, 1992.

[7] GESAMP (Group of Experts on Scientific Aspects of Marine Pollution). "Report of the Eighteenth Session, Paris." GESAMP Reports and Studies 33, United Nations Educational Scientific and Cultural Organization, Paris, 1988.

[8] HACH. "Water Analysis Handbook," 3rd Edn., HACH Company, Loveland, Colorado, USA, 1997.

[9] NEST (Nigeria Environmental Study Action Team), "Nigeria's Threatened Environment: A National Profile," NEST, Ibadan, 1991.

[10] O. O. Orua, U. E. Assian, & D. U. Innocent, "Investigation into the effect of brewery effluent discharged on soil and selected leafy vegetables: Champion Brewery as case study," Proceedings of International Conference on Research and Innovations in Engineering, University of Uyo, Uyo, 2 (1): 248 – 254, 2019.

[11] NIS (Nigerian Industrial Standard), "Nigerian Standard for Drinking Water Quality, Standards Organization of Nigeria Handbook: 1-28, 2015.

[12] RCE (Read Civil Engineering), "Determination of solids in water-total solids, fixed and suspended solids, 2017. Available online at https://readcivil.com/determination-solids-ee-lab

[13] T. Salami, C. Iroegbu and J. N. Egila, "Impact of refuse dump sites on groundwater quality in Jos, Bukum and environs, Nigeria," Global Journal of Pure and Applied Sciences, 7(3): 437-441, 2001.

[14] SPSS "Statistical Package for Social Scientists," User's Guide Version 20.0 for Windows. SPSS Inc., Illinois, Chicago, 170p, 2011.

[15] L. J. Stephens, "Schaum's Outline of Theory & Problems of Beginning Statistics," McGraw- Hill Companies, New York, 380p, 1998.

[16] R. M. Todd, W. J. Hann and S. J. Kenneth, "Determination of carbonate ion concentration and inner sphere carbonate ion pairs in seawater by ultraviolet spectrophotometric titration," Marine Chemistry, 115 (3–4): 145-154, 2009.

[17] UW Extension, "Interpreting drinking water quality results," Center for Watershed Science and Education,: 1- 6, 2009. Available Online at www.uwsp.edu/cnr/watersheds.

[18] WHO (World Health Organization),"Guidelines for Drinking Water Quality" (3rd edition), Vol. 1, WHO, Geneva, 515p, 2008.

[19] J. W. Wong, G. X. Li, and M. H. Wong, "The growth of Brassica chinensis in heavy metal contaminated sludge compost from Hong Kong," Bio-resources Technology, 58: 209-313, 1996.