Analysis of Physiochemical Parameters of Borehole and Dug Well in Ubon Akwa Community, Obot Akara Local Government Area, Akwa Ibom State, Nigeria

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ABSTRACT

The borehole and dug well in Ubon Akwa Community, Obot Akara Local Government Area was assessed. Six (6) borehole (BH) and one dug well (DW) samples were sampled from the three (3) villages (Ikot Obong, Ikot Akpan Enuek, and Nto Ikpang) that make up Ubon Akwa Community. Standard analytical procedures were employed in analyzing the physiochemical, Heavy metals and the bacteriological composition of the water samples. The results of the analysis were compared with the Nigerian Standard for Drinking Water Standards (NSDWQ). While some of the investigated physiochemical parameters were either below or within the permissible limits as prescribed by NSDWQ, some of the parameters had values above the acceptable limits set by the regulatory body. NO_3^- (52.96 ± 5.2) mgL^{-1} was slightly higher than the NSDWQ acceptable limit of 50mgL^{-1} . BOD_5 (5.5 ± 0.9) mgL^{-1} also showed concentration above the limit 5.0mgL^{-1} set by NSDWQ. The Fecal Coliform recorded a higher colony forming units (84 CFU/100ml) against the recommended NSDWQ limit of 10 CFU/100ml. The heavy metals were within the permissible limits. Higher concentrations of BOD_5, NO_3^- and Fecal Coliform Bacteria suggest organic matter contamination and feces which could either be from humans and or warm blooded animals. These water sources should be treated before use. A common practice in the community is the use of pit toilet. Therefore, awareness campaigns should be carried out to sensitize people of the community the negative impact of sitting a borehole close to a pit toilet or septic tanks.

INTRODUCTION

Background

Water plays a vital role in bodily intake of essential elements by man (Ann, 2004). Boreholes are drilled wells that tap into underground aquifers to access groundwater, while dug wells are manually excavated structures that reach the water table. Both types of wells provide access to groundwater, which can vary in quality depending on geological, environmental, and anthropogenic factors. The contaminants which include heavy metals, bacteria, virus, Nitrate, etc are found in supplied water as a result of improper disposal of waste from humans, livestock, industrial discharges and improper treatment of water before supply (Sarabjeet and Luke, 2003). Contaminants such as microbes can cause waterborne diseases such as Cholera, Typhoid and Giardiasis. (Ashbolt, 2004). The physiochemical characteristics of water from these sources can impact its suitability for drinking, irrigation, industrial use, and other purposes. Water as an essential compound in which life existence depends on is obtained primary from sources like surface water, rain water, rain water and ground water. (Abdullahi et al. 2020; Ighalo and Adeniyi, 2020). Access to safe and reliable water sources is fundamental to human health and sustainable development. In many regions, particularly in Ubon Akwa Community, boreholes and dug wells play a crucial role in providing communities with access to groundwater resources with limited information on these water qualities. When this water is needed for domestic use, it should be at a high level of purity. Generally, it is expected that ground water should be less contaminated but on the contrary, it's hydrogen bonds and polarity (large permanent dipole moment) makes it able to suspend, absorb or adsorb impurities (Ajala et al. 2020). Thus water from these natural sources could get contaminated

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from anthropogenic sources emanating from its surrounding. The quality of these water sources is a paramount concern, as it directly impacts the well-being of the population relying on them. Understanding the factors that contribute to the quality of boreholes and dug wells is essential for ensuring the long-term sustainability of water supply systems.

Numerous studies have highlighted the importance of clean water in preventing waterborne diseases and promoting community health (Smith et al., 2018; WHO, 2020). However, challenges such as contamination, inadequate maintenance, and structural issues can compromise the quality as well as the functionality of boreholes and dug wells (Foster and MacDonald, 2014). Therefore, a periodic comprehensive assessment is necessary to identify and address these challenges effectively. The people in the study area depend largely on borehole and the dug well water for drinking and other domestic use. The presence of water or lack of it determines what becomes of the nature of the natural environment in which life and economic activities depend on. (Usoro et al., 2021). This research has been designed to analyze the level of contamination in these water samples and create awareness for the people in the study area on the health implication of drinking from these contaminated water sources. It is also intended to recommend water treatment procedures as well as factors to be considered when sitting a borehole.

MATERIALS AND METHOD

Study Area

The study area is Ubon Akwa Community in Obot Akara Local Government Area. This community is located in Latitude 5^0 11 ' 13.0"N and longitude 7^0 33' 40.3" E. It is divided into three (3) villages namely: Ikot Obong Village, Nto Ikpang Village and Ikot Akpab Enuek Village. The major occupation of Ubon Akwa people are petty trading and subsistence farming. For spread of sampling points, two (2) boreholes each were randomly picked in each of the villages in addition to the dug well situated at the boundary between Ikot Obong village and Nto Ikpang village. The dug well has been in existence for over 100 years and has been a major source of water used by the people of Ubon Akwa community even before the emergence of boreholes.

Sample Collection and Preparation

Three replicate samples were obtained from each of the 6 boreholes using containers that were pre-cleaned with acetone, rinsed with distilled water and kept in a dust free enclosure ASTM (2016). The samples were collected in duplicates at each borehole. Sample for Biochemical oxygen Demand (BOD) and Dissolved Oxygen (DO) were stored in amber bottles. Before collection of sample, the borehole was allowed to flow for 10minutes before collecting for Physiochemical parameters. For heavy metal analysis, 1ml of 2M Nitric acid was added to the samples at point of collection. For Dissolved oxygen (DO), Biochemical Oxygen demand (BOD_5), the month of the water tap was pre-heated with hot flame in order to eliminate any bacteria that must have been present in the mouth of the tap. After this, the water was allowed to flow for 5minutes before taking the samples. The collected samples were labeled properly, stored in an iced insulated container and transported to the laboratory for analysis.

Table 1: Sampling Locations (Village and Compound) Within Ubon Akwa Community and Their Codes.

SERIAL NO	VILLAGE	COMPOUND	SAMPLE CODE
1	IKOT OBONG	MR. S. U. UDOKA'S COMPOUND	BH_A
2	IKOT OBONG	ELDER. E. IKPAI'S COMPOUND	BH_B
3	IKOT AKPAN ENUEK	MR. A. ESSIENS'S COMPOUND	BH_C
4	IKOT AKPAN ENUEK	MR. ALPHONSUS'S COMPOUND	BH_D
5	NTO IKPANG	MR. ETOKAKPAN'S COMPOUND	BH_E
6	NTO IKPANG	MR. OKONNAH'S COMPOUND	BH_F
7	IKOT OBONG/NTO IKPANG	IKOT OBONG/NTO IKPANG	DW

BH = BOREHOLE

DW = DUG WELL

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METHOD OF ANALYSIS

Physical parameters such as pH, Temperature, Turbidity, Electrical conductivity, and Dissolved Oxygen were measured in-situ. Mercury in glass thermometer was employed in measuring the Temperature of the samples. pH was measured using a digital P^H meter (HACH SESSION$^+$), HACH 20100N digital turbidity meter was used to measure the turbidity while Electrical conductivity was measured with ORION 3 STRAR Conductivity meter. Dissolved Oxygen and Biochemical Oxygen Demand were measured using a digital DO meter ( ). Hardness was determined by complexometric titrimetric method using EDTA, Chloride was done using titrimetric method (Mohr's titration). Fecal Coliform count, Nitrate and Heavy metal determination were carried out using standard procedures according to APHA, (2005), and ASTM, 2016.

Statistical Analysis

Descriptive statistical analysis was applied on the parameters of the water samples (BH and DW) to see the Range, Minimum value, Maximum values, Mean and Standard Deviation of the various parameters assessed in the water samples. Pearson Correlation coefficient was performed on the parameters using SPSS IBM version 25. The various concentrations of the parameters were also presented on Histogram.

RESULTS AND DISCUSSION

Table 2 shows the results of the physiochemical properties of the boreholes and dug well in Ubon Akwa Community. Table 3 and 4 presents the descriptive statistics and the Pearson Correlation matrix of these samples from the study area respectively. The correlation matrix reveals the strength of correlation among the investigated parameters. The Temperature in the entire sample was between 26.5^{0}C in DW to 29.3^{0}C in BH_C with a range of 2.80. These values were between the allowable limits of NSDWQ. The pH was lowest in DW with a value of 5.89 and highest in BH_C with a value of 7.90 with the average value of 7.03 which were similar to mean pH values of 7.03 ± 0.23 (ground water) obtained in study of the determination of physicochemical parameters and some heavy metals levels of surface and ground water of Ibiaku Osuk Community, Akwa Ibom State by Nde, (2021).

The range in Electrical conductivity was seen as 2.01 and, all the measured values fell within the permissible limits as set by NSDWQ. Electrical conductivity had a range of 17.91 with a minimum value of 0.39 µS/cm and a maximum value of 18.3 µS/cm in BH_B and DW respectively. Turbidity results for all the water borehole samples were between 0.53mg/L in BH_B to 0.91mg/L in BH_E and these values were all within the acceptable limit set by NSDWQ while the dug well recorded the highest turbidity (5.95 FTU) which is higher than the allowable limit (5.00 FTU) set by NSDWQ. Dissolved Oxygen was lower in the borehole samples than the dug well. The lowest DO was seen in BH_E (0.29mg/L) and the highest DO was seen in DW as 2.30mg/L. The dug well is open to trap oxygen from the atmosphere which explains the higher DO seen in the dug well. All the water samples had values for BOD_5 above the permissible limit set by NSDWQ except BH_D and BH_F which gave 4.55mg/L and 4.71mg/L respectively. This indicated the presence of microbial activities and organic pollutants which if predicted to result principally from proximity to pit latrines. This is so because survey results reveal that 97% of the people in the study area uses pit latrines and are sited closer than the 15m distance as prescribed by World Health Organization (WHO, 2007). Similar trend was reported in Uyo metropolis by Umana, (2022) signifying a high load of organisms and impurities in the water. Total Hardness for all the water samples were within the acceptable limit of 150mg/L set by NSDWQ. The range from all the samples was 26.04mg/L with minimum and maximum values of 19.33mg/L and 45.33mg/L in BH_A and DW respectively. The samples were all soft water according to World Health Organization classification (WHO, 2004). Chloride concentrations in all the water samples had a range of 20.29mg/L and had a minimum concentration of 15.21mg/L in BH_F while the highest level was seen as 35.50mg/L in DW. Chloride levels were generally below the allowable limit of NSDWQ. Concentrations of Nitrate were higher than the allowable limit of 50mg/L except BH_D AND BH_F which had 47.93mg/L and 49.75mg/L respectively. Values for TSS and TDS were within the permissible limits set by NSDWQ as 10mg/L and 500mg/L respectively. The range for TSS in all the samples was 3.39mg/L while TDS had a range of 27.02mg/L. Minimum and Maximum values for TDS were 20.73mg/L and 47.75mg/L respectively while 0.51mg/L and 3.90mg/L were

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minimum and maximum values recorded for TSS in the water samples. Heavy Metal concentrations were all within the NSDWQ permissible limits except Iron (Fe) in BH_A with a value of 0.32mg/L which was higher than the allowable limit of 0.30mg/L. Meanwhile, Cadmium (Cd) concentrations were below detectable limits in BH_D and DW. Results for Fecal Coliform Bacteria revealed colonies higher than the NSDWQ limit of 10CFU/100ml. The range was 37.00CFU/100ml while the minimum and maximum values were 66.00CFU/100ml in BH_D and 103.00CFU/100ml in DW. These higher values indicate bacteria contamination from excreta of humans and warm blooded animals possibly penetrating into the sub-surface and thereby contaminating the water sources and would cause water-borne diseases such as dysentery, diarrhea, and cholera. This trend (high Coliform count) was also reported in Eket Local Government by Eno et al., (2019).

Table 2: Physiochemical Parameters of Borehole and Dug Well in Ubon Akwa Community.

PARAMETER	BH_A	BH_B	BH_C	BH_D	BH_E	BH_F	DW	NSDWQ
TEMP (^oC)	29.1	28.9	29.3	28.7	28.7	27.9	26.5	AMBIENT
pH	7.05	7.15	7.90	6.90	7.35	6.97	5.89	6.5-8.5
EC (µs/cm)	0.50	0.39	0.51	0.70	0.61	0.55	18.3	1000
TURBIDITY (FTU)	0.77	0.53	0.63	0.77	0.91	0.57	5.95	5
DO (mg/L)	0.36	0.33	0.39	0.30	0.29	0.37	2.30	5
BOD_5 (mg/L)	6.10	6.01	5.01	4.55	5.07	4.71	7.10	1-5
TH (mg/L)	19.33	21.15	19.99	22.15	20.30	19.95	45.37	150
Cl^- (mg/L)	21.21	16.77	21.15	17.25	17.00	15.21	35.50	250
NITRATE (mg/L)	55.25	53.10	50.05	47.93	51.10	49.75	63.55	50
TDS (mg/L)	23.71	25.55	27.00	21.99	25.91	20.73	47.75	500
TSS (mg/L)	0.73	1.01	0.55	0.53	0.60	0.51	3.90	10
Cd (mg/L)	0.001	0.001	0.001	BDL	0.003	0.001	BDL	0.003
Fe (mg/L)	0.32	0.15	0.10	0.25	0.09	0.05	0.16	0.300
Pb (mg/L)	0.002	0.003	0.001	0.001	BDL	0.005	0.001	0.010
F.COLIFORM (CFU/100ml)	99	90	79	66	85	70	103	10.00

Values are Mean values of three (3) replicate samples.

Table 3: Descriptive Statistics of Boreholes and Dug Well in Ubon Akwa Community Containing Six (6) Boreholes and One (1) Dug Well.

	N	Range	Minimum	Maximum	Mean	Std. Deviation
TEMP	7	2.80	26.50	29.30	28.4429	.96412
pH	7	2.01	5.89	7.90	7.0300	.60473
EC	7	17.91	.39	18.30	3.0800	6.71208
TURBIDITY	7	5.42	.53	5.95	1.4471	1.98996
DO	7	2.01	.29	2.30	.6200	.74171
BOD_5	7	2.55	4.55	7.10	5.5071	.92478
T.HARDNESS	7	26.04	19.33	45.37	23.8914	9.49404
CL^-	7	20.29	15.21	35.50	20.5843	6.95924
NITRATE	7	15.62	47.93	63.55	52.9614	5.24316
TDS	7	27.02	20.73	47.75	27.5200	9.19418
TSS	7	3.39	.51	3.90	1.1186	1.23882
Cd	7	.00	.00	.00	.0010	.00100
Fe	7	.27	.05	.32	.1600	.09522
Pb	7	.01	.00	.01	.0019	.00168
FC	7	37.00	66.00	103.00	84.5714	13.93864

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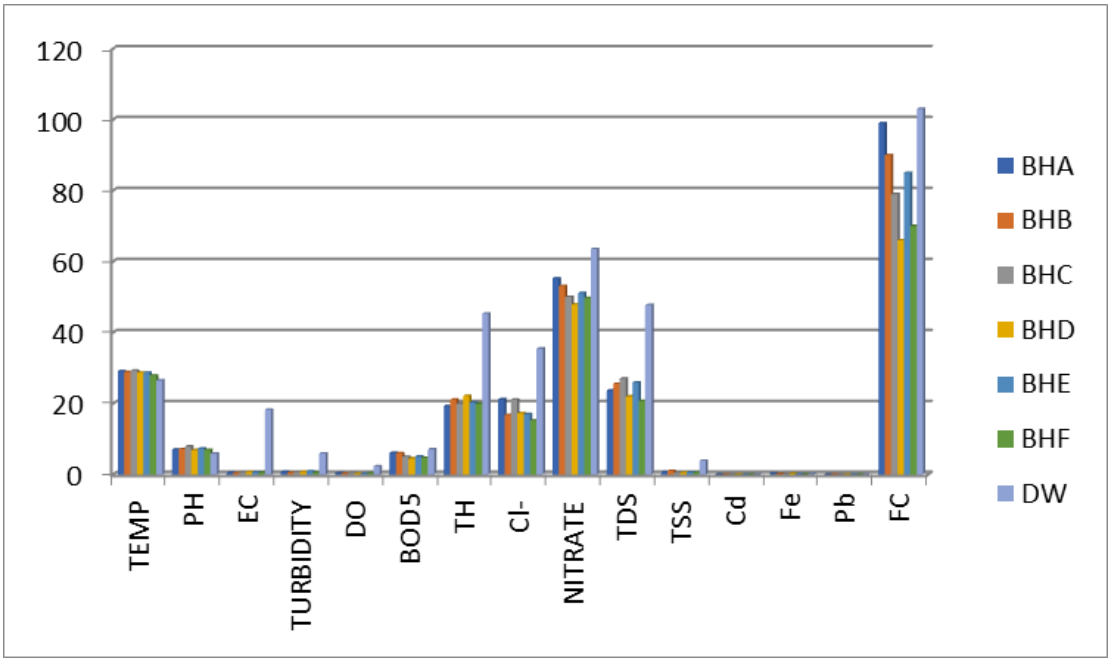
Table 4: Pearson Correlation Matrix

	TEMP	pH	EC	Turbidity	DO	BOD_5	TH	Chloride	Nitrate	TDS	TSS	Cd	Fe	Pb	FC
Temp	1														
pH	0.889	1													
EC	-0.8904	-0.8331	1												
Turbidity	-0.8817	-0.8308	0.9983	1											
DO	-0.8847	-0.8191	0.9983	0.9946	1										
BOD_5	-0.5285	-0.6389	0.7522	0.7515	0.763	1									
TH	-0.8879	-0.8451	0.9957	0.9929	0.991	0.73298	1								
Chloride	-0.7126	-0.687	0.9441	0.9468	0.9514	0.80209	0.92627	1							
Nitrate	-0.7098	-0.7512	0.8859	0.8882	0.8936	0.96001	0.86106	0.9039	1						
TDS	-0.7766	-0.6959	0.9687	0.9699	0.9694	0.79666	0.96165	0.9567	0.8967	1					
TSS	-0.8583	-0.8319	0.9884	0.9845	0.9881	0.82971	0.98647	0.9362	0.9259	0.9728	1				
Cd	0.3803	0.5264	-0.441	-0.4104	-0.4539	-0.2721	-0.4746	-0.449	-0.295	-0.325	-0.43	1			
Fe	0.207	-0.2249	0.0014	0.0202	-0.0073	0.28731	0.01109	0.1626	0.1904	-0.038	0.03	-0.4026	1		
Pb	-0.0884	-0.0493	-0.231	-0.274	-0.2024	-0.124	-0.2427	-0.356	-0.1597	-0.36	-0.2	-0.1989	-0.2402	1	
FC	-0.3147	-0.4249	0.5754	0.5883	0.5862	0.93884	0.53768	0.6851	0.877	0.6646	0.65	0.012	0.3127	-0.238	1

Fig 1: Histogram Presentation of the Borehole and Dug Well Parameters



CONCLUSION

Acceptable limits for physical, chemical and microbiological parameters of a water sample has to be met for water to be described as portable and thus safe for drinking and other domestic use. These limits are set by regulatory bodies such as World Health Organization (WHO), Nigeria Standard for Drinking Water Quality (NSDWQ) etc. Results from the analysis of Boreholes and dug well in Ubon Akwa community, Obot Akara Local Government Area reveals that the water are contaminated with organic matter and feces which could either come from humans and or warm blooded animals as this is evident in higher levels of Biological Oxygen Demand (BOD_5), Nitrate (NO_3^-) and Fecal Coliform counts recorded. Other physiochemical parameters analyzed were either below or within the permissible limits set by Nigeria Standard for Drinking Water Quality (NSDWQ) except Turbidity in the Dug well which is 5.95 FTU and this value is higher than the permissible limit of 5 FTU thus, making the Dug well Turbid. The borehole water and Dug well should be treated before use. People of the community should be sensitized on the negative impact of sitting pit toilets close to boreholes rather; they should ensure that pit toilets are sited 15m away from the borehole. Lastly, since

water quality is dynamic as it can change as a result of human and anthropogenic activities, frequent monitoring is recommended to routinely assess the portability of these water sources.

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