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Assessment of Water Quality from Bore Holes in Ikot Akpaden and Some Surrounding Villages of Mkpat Enin Local Government Area of Akwa Ibom State, Nigeria

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Abstract:
The physico-chemical and bacteriological analysis of borehole water in Ikot Akpaden and the surrounding villages in Mkpat Enin Local Government area of Nigeria designated as S_1,S_2,S_3,S_4,S_5 and S_6 have been carried out using standard analytical techniques. The physico-chemical results show that the secondary water quality parameters such as pH, EC, TDS, Turb., Alka., CaH., MgH., TH., DO., Cl^-., NO_3^-, NO_2^-, SO_4^{2-}, F^-, Fe were either within or below the permissible range recommended by NSDWQ, USPH and WHO.The Statiscal analysis shows a high positive correlation between EC and TDS ; TH and MgH; SO_4^{2-} and CaH ; evidently, their distribution were significantly correlated, r >0.5. High negative correlation coefficient were seen between F^- and Alka; NO_2^- and pH . Coefficient of Variation has also been calculated for the various parameters. However, the results of bacteriological analysis indicated that the water samples were E.coli contaminated in sites S_4 and S_5, while all the samples were T.c contaminated.
Keywords: Borehole water; Physico-Chemical, Bacteriological , Analysis , Statistical.

1. Introduction

Groundwater is one of the major sources of drinking water all over the world, though mostly originates from rain or snowmelt infiltrates through soils into subsurface aquifers, and is apparently purer than surface water because of the natural purification process which it undergoes while percolating through piles of soils ,Aturamu (2012). Groundwater is a vital component of the global water cycle and the environment Adebo and Adetoyinbo(2009) and is also widely used as a source, for drinking water supply and irrigation in food production Zekstar and Everett(2004). Underground water may be subjected to pollution and may not be as safe as is generally assumed Odeyemi *et al.,* (2011). The main ionic components are Chloride, Nitrate, Sulphates, Potassium, Sodium and Calcium.

The shortage of safe and available drinking water is therefore becoming a major challenge in many parts of the world especially developing countries. The issue of portable water is very important. Over a large part of the world, humans have inadequate access to portable water and use sources contaminated with disease vectors, pathogens or unacceptable levels of toxins or suspended solids. In many developing countries, availability of water has become critical and urgent problem and it is a matter of great concern to families and communities depending on non-public water supply system ,Okonko *et al.,* (2008).

The kind of impurity to be expected in a water supply depends whether or not the water has been for long in the ground in contact with soluble minerals, whether or not it has been exposed on surface to organic pollution. Water in its natural state may not be pure because it is a universal solvent with the ability to dissolve numerous chemicals and to carry a lot of impurities that may predominantly come from man's socio-economic and technological activities that may be injurious, pathogenic or toxic with deleterious health consequence to humans if tolerable limits are exceeded.

Nigeria, Africa's most populated country, with about 150million people has limited water supply not only in the arid to semi arid north, but also in the southern region along the Atlantic Ocean. The standard of water in Nigeria should be in line with the Nigerian Standard for Drinking Water Quality (NSDWQ) and World Health Organisation (WHO) among others.

Ikot Akpaden and the surrounding villages in Mkpat Enin Local Government Area of Nigeria, are rural areas that have witnessed increased human population due to the establishment of the Akwa Ibom State University. As a result, the needs for additional sources of potable water have necessitated the sinking of boreholes by Landlords.

This paper is the result of the physico-chemical and bacteriological investigation of borehole waters from selected sources in this area in other to ascertain whether these sources of water supply meet the national and or international standard for potable water.

2. Material and Methods

2.1. Study Area

Figure 1, shows the map of the study area which is located between latitude $4^0$35'0" and $4^0$4'0"North of the equator and between longitude $7^0$45'0" and $7^0$50" east of Greenwich Meridian

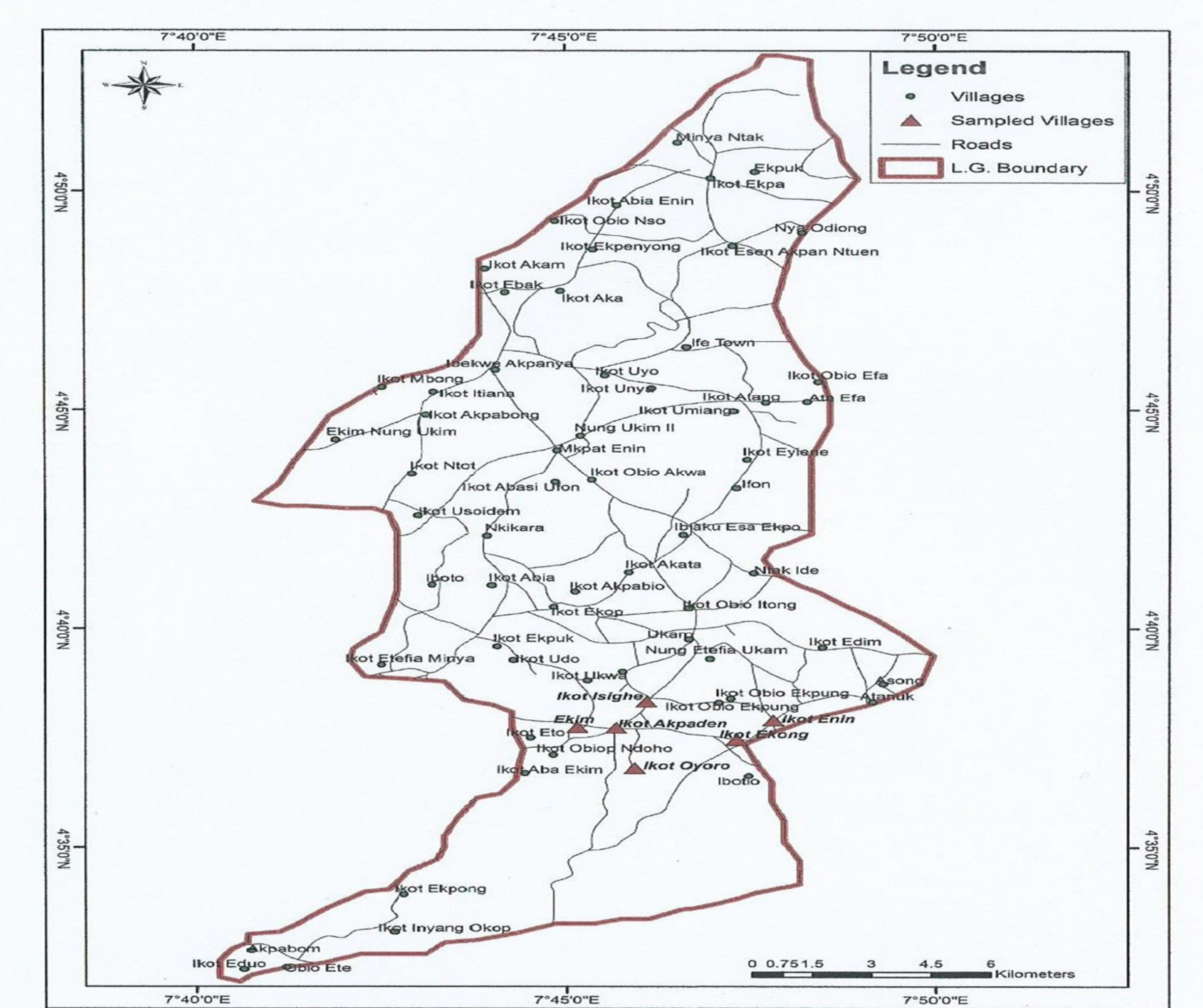

Fig. 1: Mkpa Enin L.G.A. showing Sampled Villages

The area is predominantly agricultural and residential.

2.2. Sampling and Method of Analysis

A total of two samples of water per borehole from selected villages around Akwa Ibom State University in Mkpat Enin L.G.A : (a) Ikot Akpaden(S_1), (b)Ekim(S_2), (c) Ikot Oyoro(S_3), (d) Ikot Ekong(S_4) , (e) Ikot Enin(S_5) and (f) Ikot Isighe(S_6) were collected and analysed. Prior to the collection of water samples, the nozzle of the taps were flamed and sterilized by cleaning with cotton wool soaked in a methylated spirit to avoid contamination. The tap was allowed to run for 5-10 minutes to bring forth the underground water and not the one in the distributing pipeline. The new 500mL (polyethylene) bottles, were carefully closed to avoid contamination from fingers. Samples were transported to the laboratory in an ice-packed container and preserved in a refrigerator for physico-chemical and bacteriological analysis. Samples for bacteriological analysis were analyzed within 24 hours.

A detailed field sampling exercise was carried out, while laboratory analyses of the water samples were carried out at Akwa Ibom Water Company Limited Quality Control Unit. pH was determined using pH meter with the model HACH SENSION 3, the meter was warmed for about 15-20 minutes. Turbidity (Turb.) was determined using turbid meter with the model 2100P TURBIDIMETER. Dissolve oxygen (DO) was determined using dissolve oxygen meter with the model JYD-IA. Electrical Conductivity (EC), Total dissolve Solid (TDS**)** was determined using Conductivity meter with the model HACH SENSION 5. Nitrates (NO_3^-), Nitrite (NO_2^-), Sulphate (SO_4^{2-}), Chloride(Cl^-) Fluoride (F^-), and Iron (Fe) were determined colorimetrically using portable data logging spectrophotometer which measures light intensity of each element with the model DR 2010 HACH SENSONS. Total alkalinity, Total hardness,(TH) Calcium hardness, (CaH) were determined titrimetrically, while the Magnesium Hardness (MgH) was obtained from the difference between Total Hardness and Calcium hardness.

For microbial determination, Nutrient Agar (NA), Eosin Methylene Blue (EMB), and Mac Conkey (MC) media's method were used.

In the statistical analysis, the Mean, Standard Deviation(SD), Standard Error (SE), and Coefficient of Variation (CV) were calculated using Minitab 16 while the Correlation Coefficient were obtained using IBM SPSS Statistics 19. The result of the various parameters have been compared with the recommended guidelines of (WHO 1984, 2004, 2009,2011) ; (NSDWQ, 2007) and United States Public Health Standard (USPH)

3. Results and Discussion

Table 1 shows the result of the physico-chemical analysis of the water samples. pH value of drinking water is an important index of acidity and alkalinity. It is also considered as an important ecological factor that provides an important piece of information in many types of geological equilibriums or solubility calculations (Shyamah, R et al,2008). A pH value greater than 8.5 indicates the presence of significant amount of sodium bicarbonate in water. The result shows that the pH is in the range of 6.4 – 6.6 which is well within the WHO, NSDWQ and USPA recommended values.

Electrical Conductivity (EC) is a direct function of its total dissolved salts , Hanlal, C. C. et al (2004) and a measure of the capacity of water to conduct electric current. High level of conductivity in water increases ionic load and corrosive nature of water. However, according to NSDWQ, (2007),(EC) does not pose any deleterious health effect on humans. In the present study, the value of EC is the range of 45-731 µs/cm which is within the accepted value of NSDWQ

Table 1: Comparison Of Borehole Water Quality with Potable Water Standards.

Parammeters	NSDWQ	USPH	WHO	Present study value
pH	6.5-8.5	6.5-8.5	6.9-8.5	6.4-6.6
EC	1000	300	300	45 – 731
TDS	500	500-1500	500	45 – 346
Turb.	5	-	-	0.2100 - 0.5400
Alka.	100-200	-	-	1.20 - 28.80
CaH	75	-	80	30.0 - 146.0
MgH	0.2	-	60	-96.0 - 130.0
TH	500	500	100-500	44.0 - 160.0
DO	1.0-5.0	-	-	0.080 - 2.100
Cl^-	250	250	200-600	-0.0200-0.2000
NO_3^-	50	-	40-50	-0.02000-0.04000
NO_2^-	0.2	-	3	-0.00700-0.00100
SO_4^{2-}	1000	250	200-250	-7.0 - 1.0
F^-	1.5	2.0	1-1.5	0.1300 - 0.4900
Fe	0.3	0.3	0.3	-0.0800 - 0.0700

Total Dissolved Solid (TDS) is a measure of the level of dissolved solid in water and also influences the taste of drinking water, Anyanwu and Okoli, (2012). The present study shows the value of TDS to be within the range of 45-345mg/L which is well below the recommended value by NSDWQ, USPH and WHO,(Ibrahim and Ajide (2012).

Turbidity (Turb.) is the cloudiness of water as a consequence of inadequate filtration. According to NSDWQ, 2007, turbidity does not pose any health problem. The present study value of 0.2100 to 0.5400 NTU is well below the permissive NSDWQ value of 5NTU. However, turbidity higher than this value is as a result of soil run off which can be associated with disease causing bacteria.

Alkalinity (Alka.) of water may be due to the presence of one or more ions including hydroxides, carbonates and bicarbonates. Moderate concentration of alkalinity is desireable in most water supplies to balance the corrosive effect of acidity. The alkalinity value of 1.20-28.80Mg/L in the present study is well within the recommended value of NSDWQ.

Total Hardness is imparted to water mainly due to Calcium and Magnesium ions, although other cations like Barium, Iron, Manganese and Zinc can also contribute. Hard water is generally undesirable because it forms precipitate with soap, produces scales in boilers on heating and causes increase in boiling point which is unsuitable for cooking. However, direct effect of hardness on human health according to Sharmer et al (2004) is yet to be proven scientifically. According to Table 1 the total hardness of 44-160 Mg/L is well within the recommended value of NSDWQ, USPH and WHO.

Dissolved (DO) is a very important water quality parameter and also an index of physical and biological processes going on in water. Dissolved oxygen does not pose any adverse health effect but speeds up corrosion in water pipes. The DO value of water samples range from 0.080-2.100 Mg/L which is within the NSDWQ value.

Chloride (Cl^-) ion is present in appreciable amounts in all natural waters. According to Annoh(1997), excess chloride ion content imparts bad taste and cause corrosion in intestinal walls when consumed. All the water samples contain chloride ion range of -0.0200 -0.2000 Mg/L which is well below the NSDWQ, USPH and WHO recommended value.

NO_3^- and NO_2^-: Nitrate in ground water is normally low but can reach high level if there is leaching or run off from agricultural fertilizers or contamination from human and animal faeces. Nitrite is formed as a consequence of microbial activity. High Nitrate and Nitrite levels can cause methaemoglobinaemia or blue baby syndrome. Nitrate and Nitrite level in the sample ranges from -0.02000 -0. 04000 Mg/L and -0.00700 – 0.00100 Mg/L respectively indicating that their values are beyond detection.

Sulphate ($SO_4^{2-)}$ content of 1000Mg/L recommended by NSDWQ tends to give water a bitter taste though it does not pose any threat on human health. The sulphate value of -7.0 to 1.0Mg/L is well below the recommended value of NSDWQ , USPH and WHO. Some Fluoride(F^-) compounds such as Sodium Fluoride(NAF) and Fluorosilicate, dissolve easily into ground water as it moves through gaps and pore spaces between rocks. High Fluoride concentration causes fluorosis, skeletal tissue (bone and teeth) morbidity according to NSDWQ(2007). However, low fluoride content of 1.5 Mg/L is beneficial for calcification of dental enamel. The fluoride content of the test samples ranges between 0.1300 – 0.4900 Mg/L which is well below the NSDQ, USPH and WHO recommendations.

Iron (Fe) in water is only considered as a nuisance even in excessive quantity Budhathoki, (2010). However iron toxicity occurs when there is free iron in the body cells which react with peroxides to produce free radicals which are highly reactive and can damage DNA, proteins, lipids and other cellular compounds. The Iron content of the test samples range between -0.0800- 0.00700Mg/L which is well below the NSDWQ, USPH and WHO recommendations.

Table 2 shows that the Coefficient of Variation were observed to be high for TH(58.73%), TDS(73.35%), Alka(77.57%), DO(78.48%), EC(81.11%), Cl^-(134.64%), NO_3^-(232.89%),NO_2^-(-176.07%), SO_4^{2-}(-218.07%), F^- (359.61%), Fe (-505.96%) while those for Turb.(32.53%) and CaH(44.59%) were observed to be low and narrow

Table 2:Physico-chemical Characteristics of Analyzed Water Samples.

Variable	Mean	SE Mean	St Dev	Variance	CoefVar	Minimum	Maximum
pH	6.4667	0.0333	0.0816	0.0067	1.26	6.4000	6.6000
EC	336	111	273	74306	81.11	45	731
TDS	166.6	49.9	122.2	14931.4	73.33	45.0	346.0
Turb.	0.3667	0.0487	0.1193	0.0142	32.53	0.2100	0.5400
Alka	13.20	4.18	10.24	104.83	77.57	1.20	28.80
CaH	99.0	18.0	44.1	1948.4	44.59	30.0	146.0
MgH	-24.3	32.7	80.1	6411.9	-329.07	-96.0	130.0
TH	74.7	17.9	43.8	1922.7	58.73	44.0	160.0
DO	1.047	0.335	0.821	0.675	78.48	0.080	2.100
Cl-	0.0633	0.0348	0.0852	0.0073	134.60	-0.0200	0.2000
NO^{3-}	0.00833	0.00792	0.01941	0.00038	232.89	-0.2000	0.04000
NO^{2-}	-0.00200	0.00144	0.00352	0.00001	-176.07	-0.00700	0.00100
$SO4^{2-}$	-1.50	1.34	3.27	10.70	-218.07	-7.00	1.0
F-	-0.0617	0.0905	0.2218	0.0492	-359.61	-0.4900	0.1300
Fe	-0.0100	0.0207	0.0506	0.0026	-505.96	-0.0800	0.0700

According to Table 3, high positive correlation were observed between EC and TDS (0.998), TH and MgH(0.909), SO_4^{2-} and CaH (0.916), evidently, their distribution were significantly correlated, r>0.5.

High negative correlation coefficient were seen between F^- and Alka (-.848), NO_2^- and pH (-.765).

Bacteriological parameters, especially *Escherichia coli* (*E.coli*) and Total coliform (T.c) have been used to determine the general quality of drinking water Worldwide (Ashbolt, 2004; Nevondo and Cloete, 1999; JMP. 2008). The *E. coli* in particular has been found to be the most specific indicator of faecal contamination in drinking-water. The presence of *E. coli* in drinking water poses a serious threat to health of individuals since it is an intestinal parasite that may indicate faecal contamination Rose *et al*;(1993). High content of *Escherichia coli* is dangerous to health. The presence of total coliform in water indicates contamination(CAWST 2009). Contaminated water with pathogens causes diarrhea, cholera, typhoid, shigellosis and hepatitis A and E. The permissible limits of NSDWQ and WHO for E, coli is 0CFU/100mL.The result in Table 4 shows that there is no trace of *E. coli* in most of the water samples except S_4 and S_5 borehole water. The result also shows that the Total coli form for all the water samples are not within the permissible limits of WHO and NSDWQ of (10cfu/100ml); indicating that all the sample water are contaminated

Table 3: Correlation Coefficients among Borehole Water Quality Parammeters.

Variable	pH	EC	TDS	Turb.	Alka.	CaH	MgH	TH	DO	Cl	NO3	NO2	SO4	F	Fe
pH	1														
EC	-.031	1													
TDS	-.077	.998	1												
Turb	.479	.425	.380	1											
Alka	-.431	.013	.019	-.328	1										
CaH	-.566	.820	.841	.170	.300	1									
MgH	.695	-.628	-.657	-.166	-.063	-.911	1								
TH	.700	-.322	-.352	-.132	-.187	-.656	.909	1							
DO	-.151	-.323	-.347	-.366	.414	-.040	-.031	-.098	1						
Cl	-.211	.303	.342	-.022	-.506	.367	-.512	-.566	-.462	1					
NO3	-.163	-.343	-.372	.222	.266	-.161	.041	.088	.754	-.721	1				
NO2	-.765	-.326	-.312	-.267	.552	.183	-.328	.414	.643	-.360	.732	1			
SO4	-.599	.635	.646	.333	.365	.916	-.897	-.717	.351	.194	.173	.431	1		
F	.206	-.357	-.353	.233	-.848	-.388	.047	-.304	-.043	.534	-.108	-.231	-.302	1	
Fe	-.612	-.241	-.250	-.389	.870	.027	.413	.882	.424	.844	.594	.820	.229	-.775	1

Table 4: Result of Bacteriological Analysis of Water Cultured at 24 hours per 100ml

SAMPLE	TYPE	NA	MAC	EMB	FACTOR 10^{-1}	AVERAGE	TOTAL
SI	**E.coli**	**0**	**0**	**0**	**10-1**	**0**	**0**
	T.c	**174**	**64**	**86**		**108**	**1080**
S2	**E. coli**	**0**	**0**	**0**	**10-1**	**0**	**0**
		23	**17**	**22**		**24**	**240**
S3	**E.coli**	**0**	**0**	**0**	**10-1**	**0**	**0**
	T.c	**53**	**26**	**20**		**33**	**330**
S4	**E.coli**	**1**	**0**	**1**	**10-1**	**1**	**10**
	T.c	**10**	**6**	**12**		**9**	**90**
S5	**E.coli**	**2**	**0**	**2**	**10-1**	**1**	**10**
	T.c	**29**	**10**	**36**		**60**	**360**
S6	**E.col. Tc**	**0**	**0**	**0**	**10-1**	**0**	**0**
		8	**10**	**11**		**9**	**90**

4. Conclusion

The results of the physico-chemical parameters like pH, Turb. Fe, EC, TDS, NO_3-, NO_2-, Total hardness, CaH, MgH, Total Hardness, Alka., Cl-, F-, DO, $SO_4$2- determined from samples of borehole water in Ikot Akpaden and the surrounding villages show that their values were within the range of the recommended NSDWQ , USPH and WHO values indicating that the water were free from physico-chemical contaminants. The Correlation Coefficient analysis show very good relationship between these parameters at r.>0.5

From the bacteriological aspect, the results depict that E. coli was detected in borehole water samples from sites S_4 and S_5. However, the Total coli form was found in all the water samples. Though E.coli was not found in some of the water samples but the presence of Total coli form in all the water samples renders them unfit for human consumption.

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