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Physicochemical And Bacteriological Assessment Of Borehole Water In Umudike In Abia State

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Abstract: ***The physicochemical and bacteriological analyses were carried out on borehole water samples from four selected areas in Umudike axis within the period of five months (May to September) 2015 to investigate their quality using standard methods. The results obtained were compared with the World Health Organization (2004) and Nigerian Standard for drinking Water Quality (SON, 2007).***

Both physiochemical and bacteriological parameters studied showed positive (+), deviation from WHO and NSDWQ Standards (that is not exceeded the standards).Hence, borehole water studied are safe for drinking, laundry and other application.

It is therefore recommended that proper chlorination of water should be done before usage.

Keywords: Bacteriological analysis, physiochemical analysis, borehole water, chlorination, deviation.

I. INTRODUCTION

A significant proportion of the world's population use potable water for drinking, cooking, personal and home hygiene (WHO, 2004). Indeed water is life. According to Gore (1993), "Human beings are made of water, in roughly the same percentage as water is in the surface of the earth. Our tissues and membranes, brains and heart, our sweat and tears all reflect the same recipe for life, in which efficient use is made of those ingredients available on the surface of earth". Unequivocally, water is essential for the development and maintenance of the dynamics of every ramification of society (UNCSD, 2000). Availability of safe and reliable source of water is an essential prerequisite for sustained development (Asonye et al., 2007). Groundwater is one of the major sources of drinking water all over the world. Freshwater quality and availability remain one of the most critical environmental and sustainability issues of the twenty-first century (UNEP, 2002).

Before water can be described as potable, it has to comply with certain physical, chemical and microbiological standards so as to ensure it is safe for drinking. A borehole is a hydraulic structure which when properly designed and constructed, permits the economic withdrawal of water from an aquifer. It is a narrow well drilled with machine. Human settlement is a large extent dependent on the availability of reliable sources of water preferably in close proximity to the settled localities.

Groundwater is also widely used as a source, for drinking water supply and irrigation in food production (Zelkster and Everett, 2004). However, groundwater is not only a valuable resource for water supply, but also a vital component of the global water cycle and the environment. As such, groundwater provides water to rivers, lakes, ponds and wetlands helping to maintain water levels and sustain the ecosystems (Kim et al., 2003).

In Umudike community, certain anthropogenic activity like the improper waste disposal can contribute to ground water pollution. .

From an environmental health stand-point, there is a need to ascertain the level of water quality of a locality to avoid or

reduce some of these health hazards. Based on this, the present study is undertaken in Umudike community in Abia State Nigeria to assess some aspects of the borehole water quality of the area. The study is significant and relevant because portable water is essential to life. It is against this backdrop that we are carrying out this study, to determine whether these parameters meet the (WHO) World Health Organization and national drinking water quality standards for drinkable water, as well as to ascertain the possible causes of any contaminations in order to make appropriate recommendations.

However, it is necessary to ascertain the quality of water in the area because of the increasing population of the area due to the location of the following institutions; Michael Okpara University of Agriculture, Umudike (MOUAU), National Open University, Umudike (NOUU), Abia State University, Uturu Extension Umudike (ABSU), National Root Crops Research Institute, Umudike (NRCRI) and Government College, Umudike. The life of staff, students and workers of the universities and many secondary schools and primary schools and the host communities rely on the nature of borehole water consumed.

There is a gap in knowledge of anthropogenic, geological and hydrological factors impacting on borehole water quality and the patterns of borehole water consumption to identify areas with water stress. There is therefore a need to ascertain the characteristics of borehole water being used in Umudike. The study is aimed at ascertaining the quality of borehole water supply in the study area as well as to ascertain the possible causes of any contaminations in order to make appropriate recommendations which will help to solve the problems of water related issues. The study will also serve as a guide for borehole water development in the area and beyond.

The main objectives of this study were to analyze data collected from the water samples from boreholes in order to ascertain.

- ✓ The range of some physico-chemical and bacteriological parameters present in the samples.
- ✓ The range of conformity to the World Health Organization (WHO) water standard for drinking in Umudike Abia State
- ✓ The range of treatment needed to improve the water from the boreholes before drinking.

II. MATERIALS AND METHODS

A. LOCATION OF THE STUDY AREA

Umudike is located in Ikwuano local government area of Abia state Nigeria. It is located at approximately 50 25' 60" degrees North of the equator and about 70 34' 0" degrees East of the Greenwich meridian.

B. SAMPLE COLLECTION

The grab and composite sampling methods were used in collecting water samples from the pumped boreholes water quantities at various locations.

Water samples were collected from twelve different borehole sampling points in the same day, the date of sampling (11/05/15) and the average sampling time was 9am.

C. PHYSIOCHEMICAL ANALYSIS

The physicochemical properties of the water samples were determined according to standard methods. The physicochemical properties determined include Chloride, Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Nitrate, Sulphate, Dissolved Oxygen (DO), Temperature, Electrical Conductivity (EC), Total Dissolved Solid (TDS), Total Suspended Solid (TSS), Salinity, pH, Turbidity, Total Hardness (TH), Acidity, Alkalinity, Zinc, Lead, Nickel, Manganese, Residual Chlorine, Colour, and Iron Presence of minerals (such as magnesium and calcium). Fast changing parameters (pH, temperature, turbidity, conductivity, DO, BOD and TDS) were measured in-situ using a multi-parameters water quality monitor (Orion Model 1260). Cations were analyzed using an atomic adsorption spectrophotometer (Perkin-Elmer AAS 3110) while anions were analyzed using the colorimetric method with UV spectrophotometer (WAPS 110). All methods of analysis were consistent with known standard methods (APHA, 1992; DPR, 2000; WHO, 1984).

D. BACTERIOLOGICAL ANALYSIS

Bacteriological characteristics of the water samples were analyzed as in accordance with EPA (2002). The most probable numbers (MPN) multiple tube technique was adopted for *Coliform* enumeration. All plates were incubated at 35 0C for 24 h. Presumptive colonies were confirmed by Gram staining and biochemical reactions and each plate was given to positive or negative score (Asuquo and Etim 2012).Isolates were also confirmed by some conventional biochemical test.

E. DETERMINATION OF WATER QUALITY PARAMETERS

PH: The pH was carried out in-situ using the Hanna microprocessor pH meter. It was standardized with a buffer solution of pH range between (4-9).

TEMPERATURE: This was carried out at the point of sampling using a mobile thermometer. This was done by dipping the thermometer into the sample and recording the stable reading.

CONDUCTIVITY: This was done using a conductivity meter. The probe was dipped into the container of the samples until a stable reading was obtained and recorded.

ACIDITY: This followed the procedure in the American society for testing and materials (1982), (acidity was determined by titration), 50mL of the sample was pipetted into a clean 250mL conical flask. Two drops of phenolphthalein indicator were then added and the solution titrated against a standard 0.01M NaOH solution to a pink end-point.

Calculation:

$$\text{Acidity (mg/l)} \frac{(V \times M \times 100{,}000)}{ml\ of\ sample\ used}$$

Where,

V = volume of NaOH used
M = molarity of NaOH used.

ALKALINITY: 50mL of the sample was pipetted into a clean 250ml conical flask. Two drops of methyl red indicator were then added and the solution titrated against a standard 0.01M HCl solution to a pink end-point.

$$\text{Total alkalinity (mg/l)} = \frac{(V \times M \times 100{,}000)}{ml\ of\ sample\ used}$$

Where,
V = volume of acid used.
M = Molarity of acid used.

TURBIDITY: This was determined using a standardized Hanna H198703 Turbidimeter. The samples were poured into the measuring bottle and the surface or the bottle was wiped with silicon oil. The bottle was then inserted into the turbidimeter and the reading was obtained.

TOTAL SOLIDS (TS): This was determined by Gravimetric Method.10ml of the samples were measured into a pre-weighed evaporating dish which was then dried in an oven at a temperature of 103 to 105 C for two and half hours. The dish was transferred into a desiccators and allowed to cool room temperature and was weighed. The total solid was represented by the increase in the weight of the evaporating dish.

$$\text{Total solids (mg/l)} = \frac{[(W2 - W1)mg \times 1000]}{ml\ of\ sample\ used}$$

Where,
W_1 = initial weight of evaporating dish.
W_2 = Final weight of the dish (evaporating dish + residue)

TOTAL DISSOLVED SOLIDS (TDS): This was determined using by Gravimetric Method. A portion of water was filtered out and 10ml of the filtrate was measured into a pre-weighed evaporating dish. Following the procedure for the determination of total solids above, the total dissolved solids content of the water was calculated. Total dissolved solids (mg/l) =.

$$\frac{[(W2 - W1)mg \times 1000]}{ml\ of\ filtrate\ used}$$

Where,
W_1 = initial weight of evaporating dish.
W_2 = Final weight of the dish (evaporating dish + residue).

TOTAL SUSPENDED SOLIDS (TSS): The total suspended solids were easily obtained by simple calculation, i.e.

$$Total\ suspended\ solids = \text{Total solid} - \text{Total dissolved solid}$$

DISSOLVED OXYGEN: This was done using Winkler's method. In this procedure, an excess of Manganese (II) salt, iodide (I-) and hydroxide (OH) ions were added to the samples causing a white precipitate of Mn $(OH)_2$ to form. This precipitate was then oxidized by the dissolved oxygen in the water sample into a brown Manganese precipitate

Calculation:

$$\text{DO (mg/L)} = \frac{(1600 \times M \times N)}{\left(\frac{V}{V^2}\right)}$$

Where,
M = Molarity of thiosulpahte used.
V = volume of thiosulphate used for titration
V_1 =Volume of bottle with stopper
V_2 = Volume of aliquot taken for titration.

BIOCHEMICAL OXYGEN DEMAND (BOD): The method involves filling the samples to overflowing level in an airtight bottle of the specified size and incubating it at the specified temperature for 5days. Dissolved oxygen (DO) was measured initially and after incubation and the BOD were computed from the difference between initial and final (DO). Because the initial (DO) was determined shortly after the dilutions was added, all oxygen uptake occurring after this measurement was included in the BOD measurement.

CHEMICAL OXYGEN DEMAND (COD): 250ml of borehole water was warmed to 27°C and transferred to cleaned flask. 10ml of $KMnO_4$ 0.0125M was added and 10ml of 20% $\frac{V}{VH2SO4}$ was added. It was mixed gently and incubated at 27°C for 4 hours. The mixture was examined at intervals, when the pink colour of permanganate tends to disappear, 10ml of KMnO4 was added. After 4 hours, 1ml KI solution was added and titrated with 0.0125M $Na_2S_2O_3$ using starch as an indicator, until the blue colour just disappeared.

Calculation: COD (mg/l) =

$$\frac{[(\text{ml of blank} - \text{ml required of sample}) \times 1000]}{A \times volum\ of\ sample\ used}$$

Where,
A = Total Volume of $KMnO_4$ 0.0125M added to samples.

SALINITY (CHLORIDE ION TEST): To a 50ml of the sample was added 5 drops of a phenolphthalein indicator solution and neutralized with 0.1N sulphuric acid to the colourless side of phenolphthalein. 1ml of potassium chromate indicator solution was added before titration with standard silver nitrate solution to a pinkish-yellow endpoint. A reagent blank titration was carried out in parallel to the sample titration.

Chloride quality was calculated as follows:

$$\text{Chloride, mg/l} = \frac{[(A-B)(N)(35.45)]}{V} \times 100$$

A = Silver nitrate solution, in ml for sample titration.
B = Silver nitrate solution, used for blank titration (in ml)
N = Normality of the silver nitrate solution
V = Sample volume (in ml).

TOTAL HARDNESS: 25ml of the samples was placed in different clean 250ml conical flasks. To this were added 3ml of ammonium chloride in concentrated ammonia buffer and 2 drops of Eriochrome Black T indicator. This was titrated against 0.01M EDTA solution until there was a colour change from violet to blue.

Calculation:

$$\text{Hardness in mg/l } CaCO_3 = \frac{V \times M \times 1000}{\text{ml of sample used}}$$

Where M =Molarity of EDTA Used V=Volume of EDTA used.

NITRATE: A photometric method was used for the determination, $NO3^-$. Analytical water test tablets prescribed for Palintest Photometer 5000 (Wagtech, Thatcham. Berkshire, UK) series were used.

TOTAL VIABLE BACTERIA COUNT (TVB): The Pour Plate Technique was used and the culture medium was Nutrient Agar. One milliliter of the sample from 10^{-2} test tube was aseptically transferred into sterile Petri dishes using sterile pipette. The Nutrient Agar was prepared according to the manufacturer's instruction and allowed to cool to 45^0C.

Twenty milliliters of the culture medium was poured into the Petri dish and properly mixed with the sample. This was done in triplicates

TOTAL COLIFORM COUNT (TCC): Total Coliform Count was obtained using the three tube assay of the most probable number (MPN) technique (Speck, 1976). Presumptive coliform test was perfumed using MacConckey broth (oxoid). The first set of three tube was sterile 10ml double strength broth and the second and third set had 10ml single strength broth.

ESCHERICHIA COLI COUNT (ECC)

Sterilization of Glassware: All glassware used for this study was sterilized in a hot box oven at 160^{o}C for one hour.

Serial Dilution of Samples: Nine milliliters of sterile water was transferred into 5 sterile tubes labeled 10^{-1} to 10^{-5}. One milliliter of the sample aseptically transferred into the first test tube (10^{-1}) with a sterile pipette and mixed. From the first test tube, one millimeter was equally transferred to the test tube labeled 10^{-2} and mixed using fresh pipette. This was repeated until the test tube labeled 10^{-5}.

Streptococcus (STC): Streptococcus presence is the most reliable indicators of bacterial contamination of surface and groundwater waters in different countries.

Technique: The Pour Plate Technique was used and the culture medium was Nutrient Agar. One milliliter of the sample from 10^{-2} test tube was aseptically transferred into sterile Petri dishes using sterile pipette. The Nutrient Agar was prepared according to the manufacturer's instruction and allowed to cool to 45^{0}C. Twenty milliliters of the culture medium was poured into the Petri dish and properly mixed with the sample. This was done in triplicates. A control was equally prepared, but without adding the sample. The plates were labeled, allowed to solidify, inverted and finally incubated at 37^{0}C for 24-48 hours. The plates were observed for development of bacterial colonies.

III. RESULTS AND DISCUSSION

A. PHYSICOCHEMICAL CHARACTERISTICS OF BOREHOLE WATER

The results of physicochemical analysis of water samples taken from selected areas in Umudike axis are presented in Table 1. According to Table 1, all the parameters measured were within the standards of WHO and NSDWQ. The present study shows the temperature of the sampled borehole water ranged between 30.40 to 30.60°C as shown in Table 1. These values obtained are similar to those reported by Obi and Okocha, (2007) and Chukwu, (2008). Cold water is generally more potable for drinking purposes, because high water temperature enhances the growth of micro-organisms and hence, taste, odour, colour, and corrosion problem may increase (Okoye and Okoye, 2008). The pH values obtained ranged from 7.52 to 8.47. The pH values of all the samples were within the pH range assigned by WHO and NSDWQ as the standard for drinking water which ranges from 6.5 - 8.5 (WHO, 2004, SON, 2007).

In the case of turbidity, the values ranged between 0.90 to 1.01NTU, which are within the limit 5NTU (Table 1). The low values of turbidity in these samples can be attributed to the fact that the total suspended solids in the water samples were very low. The electrical conductivity (EC) for all samples is within the permissible limit of 500 pS/cm set by WHO/NSBWQ. EC is an indicator of water quality and soil salinity, hence the relatively low values observed in all the water samples showed low salinity; thus the water is very suitable for domestic and agricultural use.

Total dissolved solid (TDS) values are generally below 250mg/l which was within the WHO/NSBWQ permissible limit for potable water; this showed that borehole water in the area was quite fresh in most locations. The presence of these total dissolved solids (TDS) in water samples indicates the presence of solid materials or solutes in water.

The total suspended solids (TSS) values are generally within WHO permissible limit 30mg/l, ranged from 0.11 to 0.21mg/l.

The alkalinity values of all the sampled water fall within the stipulated limit 100 mg/l by WHO (Table 1). They ranged from 7.28. to 8.94 mg/l ..

The biochemical oxygen demand (BOD) values ranged from 1.15 to 1.28 mg/l and Dissolved Oxygen (DO) from 33.24 to 4.54 mg/l all generally are within WHO/NSBWQ permissible limit respectively. COD values fall within WHO/NSBWQ permissible limit. They ranged between 2.18 to 2.48mg/l.

Salinity (chloride ion) which is in form of chlorine is one of the major anions in water, it is known for maintenance of acid-base balance, and hence excess of it might cause edema. The values obtained for chloride ranged from 18.27 to 24.70 mg/l. These values obtained are well within the recommended standard value of 250 mg/l by WHO/NSBWQ (Table 1); they are also within the range of values reported by Obi and Okocha, (2007). Nitrate values in the samples ranged from 0.53 to 0.86mg/l. The values are within the WHO/NSBWQ recommended limit of 10.0 mg/l.

Parameters	**Government College Umudike**	**National Root Research Institute, Umudike**	**Umudike Primary School**	**Michael Okpara University of Agriculture Umudike**	**WHO/NDWQS**
Chloride (mg/l)	18.85	17.22	16.71	17.24	100
COD	2.25	2.40	2.18	2.48	7.5mg/l
BOD	1.18	1.26	1.15	1.28	6-9mg/l
Nitrate (mg/l)	0.53	0.76	0.69	0.86	
Sulphate (mg/l)	1.78	2.06	1.34	3.45	
Dissolved oxygen	4.54	3.24	3.29	4.48	7.5mg/l
Temperature	30.40	30.55	30.45	30.60	30 – 32^{0}C
Conductivity (us/cm)	50.1	35.40	49.05	37.9	90.00
Total Dissolved Solid (mg/l)	0.73	0.86	0.90	1.10	259 – 500
Total Suspended Solid	0.11	0.21	0.18	0.19	30mg/l

Salinity	19.27	18.68	24.70	18.27	
pH	8.47	7.52	8.38	7.59	6.50 – 8.50
Turbidity (NTU)	0.9	1.01	0.67	0.83	5.00 NTU
Total Hardness	8.80	5.20	7.35	3.65	30.0 0
Acidity	2.58	1.49	2.24	1.23	
Alkalinity	7.81	7.28	8.94	8.65	100 mg/l
Zinc (mg/l)	0.00	0.03	0.03	0.13	
Lead (mg/l)	0.00	0.00	0.00	0.00	
Nickel (mg/l)	0.00	0.00	0.00	0.00	
Manganese (mg/l)	0.00	0.00	0.00	0.00	30
Residual Chlorine (mg/l)	0.00	0.00	0.00	0.00	
Color (ILU)	5.00	5.00	5.00	5.00	15 TCU
Iron (mg/l)	0.03	0.05	0.05	0.04	0.10

Table 1: Physiochemical parameter Results

B. BACTERIOLOGICAL CHARACTERISTICS

The range of results obtained from parameters such as Total Viable Bacteria Count (TVB), Total Caliform Count (TCC), Escherichia Coli Count (ECC) and Streptococcus (STC) are under the bacteriological analyses and the results obtained are (0 to 0.00050) cfu and were non-significant in the samples due to the appearance of the physical environment which was clear from the main origin of pollution like; chemical dump from factory, discharge of untreated raw sewage from households and factories and the rising use of synthetic organic substance from agricultural pollution of contamination all were absent in the samples location.

Nevertheless, from the WHO/NSDWQ standards for drinking water, (Table 2) all parameters studied are within permissible limit.

SAMPLES	TVB	TCC	ECC	STC	WHO/NDWQS
GOVT.COLLEGE	0.00000	0.00050	0.00000	0.00000	0
NRCRI	0.00000	0.00000	0.00050	0.00000	0
UMUDIKE PRIM.SCHOOL	0.00050	0.00000	0.00000	0.00000	0
MOUAU	0.00000	0.00050	0.00000	0.00000	0

Table 2: Bacteriological Parameters Result

IV. CONCLUSION

The physicochemical and bacteriological parameters studied in the four water samples in Umudike were within the NSDWQ/WHO standards for drinking water. This implies that the potable water in Umudike is not polluted with organic and inorganic substances and therefore fit for drinking at its present state.

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