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Physico-Chemical Analysis of Selected Borehole Water In Umuihi, Town Imo State, Nigeria

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ABSTRACT

Study of water quality tells about present status of useable water for domestic as well as industrial use. Indiscriminate and wasteful water consumption and improper waste disposal practices have led to deterioration in the water quality. This study was aimed to determine water quality parameters in borehole water Samples from three different boreholes in three different locations in Umuihi town. The water Samples were collected on the 17th day of March 2014, and analysed using different types of analytical techniques. The parameters analysed include; Electrical conductivity, Turbidity, pH, TDS, TSS, SS, calcium hardness, magnesium hardness, total hardness, Temperature and Alkalinity, using standard methods of analysis. The data provided by this investigation will be useful in designing water quality management issues.

Keywords: Physicochemical, analysis, borehole, water and locations.

1.0 INTRODUCTION

Water is abundant in nature and is an important part of the earthly environment, covering about (75%) of the earth surface. It occurs as surface water in lakes, streams, rivers, ponds, shallow aquifers, oceans, seas, ice caps, glaciers, etc, and as ground water (when it accumulates in the ground) which is obtained as spring water, well water, and borehole water (Chandra etal, 2012). Small amount of gases like N_2, O_2 and CO_2 in the atmosphere are contained in all natural water (Borne, 1978). Water is made up of two element, hydrogen and oxygen and is the most popular solvent as it has the ability to dilute many chemicals. Water also has tremendous heat absorbency and plays an important role in the physiology of both flora and fauna (plant and animals) and also in their metabolic processes (Golterman, 1978).

Water takes part in many reactions including those with complex organic compound like amino acids. It is vital in industrial and manufacturing activities and various agricultural aspects, especially irrigation. Water is essential natural resources as it is impossible for life to exist without water and most manufacturing industries cannot function in its absence. An essential pre-requisite for the establishment of a stable community is the presence of safe and reliable sources of water (Erah etal, 2002). Historically, (Okonkwo etal, 2009) water scarcity has led to severe conflict, migration and change in agricultural patterns.

Human activities often result in water pollution making such water unfit for use. Water pollution is a change in the quality of water which renders it unstable or dangerous as regards foods, man and animal health, industry, agriculture, fishing or leisure (Ademorati, 1996). However, before the advent of industrialization, the degree of contamination of water by pollutant was low. New age activities like manufacturing process led to pollution of service water source. Typical example is the location of chemical industries at river banks with effluent released into the river. Sewage disposal into water bodies, as is practiced in Lagos lagoon, leaves streams and rivers polluted (Okonkwo etal, 2009).

Agricultural processes involving the use of fertilisers, herbicides and pesticides produce toxic substances that are transported as effluents into water sources and these pollute water bodies (Obi etal, 2007). Similarly, textile industries emit waste water that contains organic dyes which introduce different ions into water that can alter it's composition (Olowe etal, 2005). Oil spills pollute water bodies and form a film on the water surface that cuts off oxygen supply. This leads to anaerobic condition and death of fish and other life forms in the water (Edward, 1980). In oil drilling activities, ground water supplies are often contaminated by the introduction of certain ion or compounds into water and these, in turn, reduce the water quality (Lind,1959). When surface and ground water are contaminated, the presence of poisonous ions is evident. However, some ions introduced into water bodies may combine with other compounds to form insoluble compounds which, when introduced into the body system course serious harm (Hutton, 1981).

This work is needed to increase our awareness on issues concerning water quality. Across Umuihi town, water is used in houses for activities such as cooking, washing and gardening. Fishing is also done in some streams in the town and farming is the occupation of many people in the town. The farms use water daily in feeding and washing up processes. Cottage industries like bakeries, restaurants, mills, clinics and hospitals require water for their daily uses.

Although natural water is never pure, ground water sources are expected to be the purest sources of water. Nevertheless, underground pollution occurs from surface water sources into nearby ground water sources. The water quality parameters taken into consideration include: temperature, pH, conductivity, total dissolved solids, total suspended solids, water hardness, calcium hardness, magnesium hardness, alkalinity, and temperature (Hammer etal, 1981).

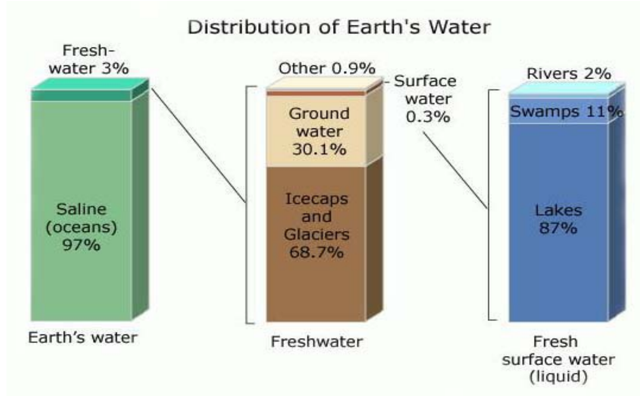

Fig.1: The distribution of Earth's water (Source: U.S. Geological Survey)

1.1 JUSTIFICATION OF THE STUDY

Although some of these pollutants are essential, others are toxic to animals, man and plants. When these pollutants accumulate beyond the recognized and recommended limits, they become toxic to living organism (man, animals and plants) (Borne, 1978). The consumption or use of water from polluted water sources is capable of causing water or chemical related diseases. It is on these bases that an attempt is being made to determine the extent of underground pollution of ground water sources in Umuihi Town.

1.2 AIMS AND OBJECTIVES

To determine the extent of underground water pollution from a farmland to nearby ground water sources (wells and boreholes) based on certain physicochemical parameters of interest such as; total dissolved and suspended solid, temperature, conductivity, pH, alkalinity, total hardness, magnesium hardness and calcium hardness.

OBJECTIVES:

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a. Comparing the values obtained from analysis with that of national and international standards with a view to improve the quality of potable water.

b. To ascertain the pollution of ground water from farmland.

c. To sensitize the public on the dangers and consequences of consuming or using polluted water.

1.3 WATER QUALITY CONTROL

The use of water for industrial, agricultural and domestic, purposes causes deterioration in quality. This polluted water is harmful to the environment if not treated before its release back into use.

Water quality control includes the removal of;

i. Excessive colour, test and odour.
ii. Objectionable dissolved matter.
iii. Aggressive constituents.
iv. Bacterial indication of faecal pollutants.

However, different water samples contain different level of contaminant. Therefore, parameters defining the quality are diverse and they vary with the corresponding water samples or use to which the water is put.

1.4 PARAMETERS FOR DEFINING WATER QUALITY

The properties of water can be best on: its physical, chemical and biological properties.

1.4.1 Physical properties/characteristic

i. **Electrical conductivity**: this is a quantitative measure of the ability of water to conduct electric current. It can also be defined as a numerical expression of the ability of an aqueous solution to carry an electric current (Lind, 1959). Electrical conductivity is influenced by the presence of dissolved salts such as sodium chloride and potassium chloride which produce ion that migrate in solution and then generate electric current. Electrical conductivity is also a measure of the total dissolved solid (TDS) or salinity (Lind, 1959).

ii. **Turbidity:** is a measure of the loss of transparency of a solution. The presence of colloidal solid gives water a cloudy appearance which reduces its transparency.

iii. **Taste and odour**: when impurities are dissolved in water, the taste and odour become objectionable.

iv. **Solids (Total dissolved and suspended solids)**

Total suspended solid (TSS): these are discrete particles that can be measured by filtering the sample through appropriate filters. The magnitude of these solid depends on the type of filter (paper or sintered glass used), the pore size, the physical nature and the size of the particles (ASTM, 2004, APHA, 1985). Increase in suspended solid in water is proportional to the increase in the extent of pollution and also account for odour and colour (Golterman, 1978). The materials deposited on the filter are the principal factors affecting separation of suspended solid from dissolved solid.

Total Dissolved Solid (TDS): total dissolved solids are due to soluble materials. These refer to the portion of total solid that pass through the filter and is express in Mg/L (APHA, 1985). High water with high dissolved solid is generally of inferior palatability and may induce an unfavourable physiological reaction in the transient consumer (ASTM 2004; APHA, 1985). High concentration of dissolved solid in water is also responsible for hardness, turbidity, odour, taste, colour and alkalinity (ASTM, 2004). The maximum permissible concentration of TDS is 500mg/L in potable water.

v. **Colour**: good water should be transparent and clear. The colour of water is expressed in Hazen units which correspond to the colouration of a series of platinum/cobalt.

vi. **Temperature:** the temperature of water is not the main issue when considering it as physical parameter, but its effect on other properties e.g. changing solubility of gases.

Table 1: Main Physical Properties of Pure Water (Kirk-oltmer, 1964)

S/N	PROPERTY	Value
1	Relative molecular mass	18.0152
2	Boiling point	100^0C
3	Freezing point	0^0C
4	Dielectric constant at 20^0C	77.94
5	Sound velocity	$1496.3ms^-$
6	Specific heat at 0^0C	$4.179jg^-$
7	Heat of formation at 18^0C	$-285.89kjmol^-$
8	Heat of ionization	$+55.71kjmol^-$
9	Heat of fusion at 0^0C	$-6.010kjmol^-$
10	Heat of vaporization at 100^0C	$+40.651kjmol^-$
11	Density	$1.0gml^-$ (at 4^0C)
12	pH	7.0
13	Colour	Colourless
14	Odour	Odourless
15	Taste	Tasteless

1.4.2 CHEMICAL PROPERTIES/CHARACTERISTICS

i. **pH Value:** pH measures the level of acidity or alkalinity of the water sample. The pH is indicated by the concentration of hydrogen ion present (Edward, 1980). It is expressed on a scale of 0-14 where 7 is neutral, below 7 is acidic and above 7 is basic. Practically, every phase of water treatment such as softening, precipitation, coagulation, disinfection and corrosion are pH dependent (ALPHA, 1985). Natural water has pH values in the range 4 to 9 and most are slightly basic due to the presence of bicarbonate and carbonates of alkali and alkaline earth metals (ALPHA, 1985).

ii. **Hardness:** hardness of water is a phenomenon which occurs when soap does not lather easily with water, scales are produced in pipes and boilers/kettles. Hardness is caused by metallic salt (ion) of Calcium and Magnesium and sometimes Fe. These salts are usually in the form of bicarbonate, sulphates and chlorides (ALPHA, 1999). Water hardness could be temporary or permanent. Temporary hardness is caused by dissolved calcium and magnesium bicarbonates. It can be removed by boiling. Permanent hardness is caused by sulphate and chloride of calcium and magnesium and it cannot be removed by boiling but by addition of sodium carbonate or ion exchange methods. Water hardness is usually expressed as $mgl^{-1}CaCO_3$.

Table 2: Qualitative classification of water according to hardness

Description	Mg/l or ppm
Soft	**0 - 17.1**
Slightly hard	**17.1 - 60**
Moderately hard	**60 - 120**
Hard	**120 - 180**
Very hard	**180 & over**

Source: U.S. Department of Interior and the Water Quality Association

iii. Dissolved Oxygen (DO): it is a measure of the oxygen content in water. Different life forms in water need oxygen for survival. Water low in dissolved oxygen has an unpleasant smell while waters high in dissolved oxygen are good for drinking purposes.

iv. Biological oxygen demand (BOD): is oxygen used by microorganism per unit volume of water at a given time.

v. Chemical oxygen demand (COD) is the amount of oxygen required to decompose/oxidize the oxidizable compound of waste water.

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vi. The presence of element nitrogen and chlorine: nitrogen is a very important element and all biological reaction begins when it is present. Thus the concentration of nitrogen can be used to determine the quality of water samples. The chloride content in water is another important factor for water quality analysis.

vii. Alkalinity: the presence of hydroxides, carbonate and bicarbonate in natural water cause alkalinity. Alkalinity is defined by (Ademorati, 1996) as a measure of the ability of water samples to neutralize strong acids to an arbitrary pH or an indicator end-point.

2.0 METHOD

Physical tests such as Colour, Turbidity, Total solids, Dissolved solids, Suspended Solids, Odour and taste were carried out using standard instrument.

2.1 CHEMICAL TESTS

2.1.1 Preparation of Samples; samples of water were obtained from three water boreholes in three different locations (wards) in Umuihi town.

2.1.2 pH Test

The pH of water was measured using pH meter and it measured the acidity and alkalinity of the different boreholes water from different wards. The pH was expressed in pH unit, and it is a measure of the hydrogen ion concentration (H^+) as

$$pH = -\log(H^+)$$

Jenway pH meter model was rinsed with de-ionised water and dried with soft tissue paper. 100cm^3 of the sample was measured and placed in a sample bottle after which the electrode was placed in the water sample, and meter reading was recorded. The procedure was repeated for the other samples and the results obtained are shown in the table below.

Table 3: pH table

S/N	PARAMETER	WARD 1	WARD 2	WARD 3
1	pH	6.1	6.0	5.7

Key: Ward 1 - Umuowushi in Umihi
Ward 2 – Umuelem in Umuihi
Ward 3 – Umuezeokwa in Umuihi

2.1.3 Procedure for Turbidity Measurement

The turbidity of the water was measured daily and hourly. The turbidity of raw water was measured daily before jar test analysis while the turbidity of other three types of water were measured every hour.

The turbidity of water was determined by the use of turbidity meter through the following procedures;

- The water sample was poured in the sample bottle to the mark on the bottle.
- The blank sample was placed in the cell holders on the meters; the blank sample was the distilled water in the blank sample bottle.
- The meter was put on followed by pressing PRG 95 followed by Enter, then zero, the meter showed zero NTU.
- The water sample in the sample bottle was placed in the cell holder after removing the blank sample and the read button was pressed thereafter, the meter displayed the turbidity of the water in NTU.

2.1.4 SUSPENDED SOLID DETERMINATION (SS)

On the turbidity meter was pressed program select the program number 94, and measured 25mls of the sample

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was shaken to homogenise, and the standard removed. The sample was inserted, followed by pressing read button and the meter automatically displayed the result.

2.1.5 TOTAL SUSPENDED SOLID (TSS) DETERMINATION

In order to obtain the total suspended solid (TSS) the values of TDS and SS were added;

TDS + SS = TSS.

2.1.6 TDS Test (Total Dissolved Solids)

The TDS test was carried out with the same procedure and meter with that of conductivity test, and its value was selected from the conductivity meter.

2.1.7 Procedure for Alkalinity Test

100 mls of final water was measured into the conical flask where phenolphthalein indicator was added. The colour remains unchanged. A methyl orange indicator was added which changed the colour to yellow. 0.1M HCl was titrated against the mixture in the conical flask up to the attainment of reddish coloration which marked the end-point of the first titration, where the reading was taken. The mixture in conical flask was boiled and allowed to cool where the same 0.1M HCl was again titrated against the mixture i.e. the second titration up to the formation of faint yellow coloration, the second reading was taken. The first reading and the second were summed and multiplied by (50) which is the approved standard conversion factor to obtain the total alkalinity of the final water expressed in mg/l.

2.1.8 Procedure for Conductivity Test

The conductivity test was carried out using conductivity meter. The conductivity of both raw and treated water were carried out. The water(s) were obtained in beakers where the electrode of the conductivity meter was rinsed in distilled water and placed in the water sample. The read button on the meter was pressed which displayed the conductivity of the water sample, either raw or treated. It is expressed in NTU.

2.1.9 Test for Hardness

50 ml of raw and final water were measured into separate conical flask. 2 ml of buffer solution were added to each sample, the colour remained unchanged. A small amount of eriochrome black T was added to each sample, a pink colouration was observed.

The samples were titrated with ethylenediamminetetraaceticacid (EDTA) up to the observance of blue colouration. The titre values of both raw and final water samples were multiplied with (44.892) as the approved conversion factor where the hardness of both raw and final water were expressed in mg/L.

Classification	Concentration of $CaCO_3$ (ppm)
Soft water	< 75
Moderately hard	75 – 150
Hard	150 – 300
Very hard	> 300

Table 4: The hardness classification in mg/l or ppm of total hardness of $CaCO_3$.

Concentration (ppm)

Source: U.S. Department of Interior and the Water Quality Association

2.2.0 Test for Calcium

50 ml of both raw and final water were measured into separate conical flasks and 2 ml of 0.1M NaOH were added

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to the samples, their colours remained unchanged. A small amount of meroxide was added to the samples and violet colouration was obtained. The samples were titrated with ethylenediamminetetraacetic acid (EDTA) to permanent pink colour. The titre values of both raw and final water were multiplied with (18.025) as the standard conversion factor, the concentrations were expressed in mg/L.

2.2.1 MAGNESIUM HARDNESS

In order to determine the magnesium hardness, immediately after the end point of calcium hardness, to the same sample was added 3ml of 5.0M HCl then 6 ml of concentrated NH_3 solution was also added and small amount of eriochrome black T indicator, titrated with EDTA until a faint blue colour appeared then the colour indicator changed from wine-red to blue.

2.2.2 PREPARATION OF THE SOLUTIONS

2.2.3 PREPARATION OF 0.1M EDTA

3.72g of disodium dihydrogen-ethylenediammnetetraacetate dehydrate was dissolved in water and the resulting solution was transferred into a litre volumetric flask, and de-ionised water was added to the mark (Vogel, 1961).

2.2.4 PREPARATION OF BUFFER SOLUTION (pH=10):

17.5 g of ammonium chloride was weighed and 142 ml of concentrated ammonia solution was added, and the resulting mixture was diluted to 250 ml with distilled water. (Vogel, 1961)

2.2.5 PREPARATION OF 0.1M NaOH:

4 g of sodium hydroxide was dissolved in a beaker and then transferred into 1000 cm^3 volumetric flask and the volume was made to the mark with distilled water.

2.2.6 PREPARATION OF ERIOCHROME BLACK INDICATOR:

1 g of eriochrome was dissolved in 100ml of ethanol.

2.2.7 PREPARATION OF MEROXIDE INDICATOR:

1g of meroxide indicator was dissolved in 100ml of methanol.

3 RESULTS AND DISCUSSION

Table 4.0: RESULTS AND DISCUSSION

S/N	PARAMETERS	WARD 1	WARD 2	WARD 3	WHO	NAFDAC
1	pH	6.1	6.0	5.7	7.0 - 8.5	6.5 – 8.5
2	CONDUCTIVITY (µs/cm)	1136	1572	333		
3	TDS (mg/l)	576	787	97.3	500	500
4	TSS(mg/l)	569	788	98.3	-	-
5	SS(mg/l)	2	1	1	-	-
6	TURBIDITY (NTU)	0.61	1.45	3.05	5	-
7	CALCIUM HARDNESS (mg/l)	99.15	169.44	14.42		
8	MAGNESSIUM HARDNESS (mg/l)	19.72	36.14	7.21		
9	TOTAL HARDNESS(mg/l)	327.71	570.12	53.87	-	-
10	COLOUR (HAZEN)	5	5	5	6	15
11	ODOUR	ODOURLESS	ODOURLESS	ODOURLESS		
12	TASTE	TASTELESS	TASTELESS	TASTELESS		
13	ALKALINITY (mg/l)	60	80	60	80	

3.1 **DISCUSSION**

The mean TDS (Total Dissolved Solid) value in all the three boreholes were found to range between 97.3m g/l to 1572 mg/l which is at the range of the national and international standard for world health organisation (WHO); so the water is good for drinking.

The conductivity values in this study area in all the three boreholes ranged between 333uscm^{-1} to 1572 uscm^{-1} as the ionic concentration increases the conductance of the solution also increases. Therefore conductivity measurement provided an indication of ion concentration.

The TSS (Total Suspended Solid) values in the study area in all the three samples from the three wards were between 569mg/l, 788mg/l and 98.3mg/l respectively.

The mean pH values of all the three sampling stations ranging from 5.7 to 6.1 were found to be acidic. This could be due to the underground pollution caused by agricultural activities in the farmland. All the values are at within the permissible level of 6.5 to 8.5 as recommended by the World Health Organisation (WHO).

4.0 CONCLUSION

The importance of access to good quality water cannot be overemphasized. Increase in population coupled with the

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rise in human activity pose a great pressure on provision of safe drinking water. Effective water quality monitoring could assist in checking how our daily activities affect the quality of our water and impact of the introduction of pollutants on water quality. In general ground water quality of Umuihi town in Imo State is not harmful to human beings, since the ground water which were taken from the various wards of Umuihi town were analyzed and the analysis showed that the water quality parameters like pH, Electrical Conductivity (EC), Chloride content (Cl^-,) TDS, Ca^{2+} Mg^{2+} and Hardness lies within the maximum permissible limit prescribed by WHO. Also, the study revealed that the distribution pattern of the studied physico–chemical parameters of the borehole water were within the permissible limit set by World Health Organization. Hence this report explains that the ground water in Umuihi town is suitable for drinking and agricultural purposes.

5.0 RECOMMENDATIONS

[1] From the result obtained water quality monitoring should be a continuous process that should be encouraged.

[2] Proper sanitation should be strictly observed around the vicinity of the boreholes.

[3] Proper and appropriate treatment should be done according to seasonal variation with respect to the important physico-chemical parameters.

[4] Further analysis should be carried out on organic pollutants like pesticides, aldehydes, phenols and other toxic element such as mercury and arsenic.

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