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Assessment of the Quality of Water Resources by Integrating Physico-chemical Analysis Result with Geoelectric Survey Information in Federal University of Technology Owerri, Nigeria.

KEYWORDS Surface water, Groundwater, PhysIco-Chemical Parameters, Contamination, Water quality.

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ABSTRACT *Analyses of the physico-chemical parameters of surface water and groundwater systems were carried out within Federal University of Technology Owerri (FUTO) and integrated with available Geoelectric survey information to assess their quality. Twelve parameters were determined using a standard test method, the fresh water aqua cultural test kit. The groundwater samples were extracted from existing boreholes. The values of the parameters varied across the water sample stations. The average chloride content of surface water is 15ppm while that of groundwater is 6.9ppm. For hardness of surface water, the average value is 45 while that of groundwater is 38. The average turbidity value for surface water and groundwater are 3.7NTU and 0.28NTU respectively. In all the samples, it was observed that the hardness of surface water is higher than that of groundwater. This study indicates that Otamiri River has abnormally high level of hardness which has economic cost implication for its use for laundry by students and other residents on campus. The chloride content of the surface water sample is higher than that of groundwater. However, the measured values did not exceed the World Health Organization (WHO) standard, implying that available water for use in FUTO is safe. Groundwater is found to be of better quality than surface water. Integrating the available geoelectric information, it can be inferred that the better quality of groundwater within the area could be due to drilling of the existing wells within the prescribed safe depth with respect to contamination.*

INTRODUCTION

Water is one of the most important natural resources and without it there would be no life. Unfortunately, it is becoming increasingly scarce owing to increasing demand and deteriorating quality due to pollution (Ayoade and Oyebande, 1978). Water is highly polluted by harmful pollutants arising from increase in human population, industrialization, use of fertilizer and man-made activities (Patil et. al., 2012). Good water gives good health and bad water causes bad health due to its associated diseases and sicknesses such as typhoid and diarrhea diseases. According to World Health Organization (WHO) such diseases like water borne diarrhea accounts for an estimated 4.1% of total daily global burden of diseases and cause about 1.8 million human deaths annually. Hence, it is imperative that quality of drinking water should be checked at regular time intervals since human population suffers from varied forms of water born diseases (Patil et. al., 2012). The inhabitants of the study area are skeptical about the safe condition of available water. The two main sources of water in FUTO are Otamiri River and groundwater.

Many authors have discussed extensively the application of physico-chemical parameters in determination of water quality and management. They include Adefemi and Awokunmi (2010); Navneet et. al. (2010) and Manjure et.al. (2010). Fella et. al. (2013) in a study of physico-chemical parameters of water samples from Chiffa River at Blida, North West of Algeria determined the monthly variation from April to August 2006 of the pH, electrical conductivity, Nitrate, Nitrite, Calcium, Magnesium and Bicarbonate. The study showed that the parameters almost exceeded the maximum permissible limit of WHO and Algerian water quality guideline.

Within the neighborhood communities of FUTO, a number of studies have also been carried out. Studies of human activities and water quality: around Otamiri River have shown that there are constant increases in the presence of salt and mineral content of the river which can occur as a result of sand excavation and discouraged indiscriminate sand excavation. Fresence of hardness component of the water, which has an economic cost implication has been linked to the activity of man in introduction of the hardness inducing elements such as calcium and magnesium especially by waste disposal. Umunnakwe et.al.(2011) carried out such study on the influence of land use patterns on Otamiri River. The result gave an insight into how activities in mechanic workshop, landfill, sand and gravel mining impacts on the environment and water bodies (both aquifer system and surface water). Most of the parameters analyzed exceeded the limits set by World Health Organization Standard. Hence these activities rendered the water unfit for drinking and domestic usage. Iwuoha and Osuji (2012) surveyed the changes in surface water physico-chemical parameters as a result of dredging of Otamiri and Nworie Rivers, Imo River near Owerri and noted some physico-chemical changes of the water body particularly pH, turbidity, conductivity acidity and alkalinity. This indicates that dredging has a strong negative impact on water bodies with respect to its physico-chemical parameters.

Geophysical and geological assessment of the neighborhood communities of FUTO shows that the area has a near surface aquifer with average depth of 50m or 164ft (Nwachukwu et. al., 2012). They observed that the system of water supply through substandard and shallow wells and from Otamiri River is unsustainable and of serious health consequences. Akaolisa and Selemo (2009) in a study of sand and gravel deposits around the study area warned against construction of sewage system in the area as the aquifer is prone to contamination since their study shows there is no impermeable unit overlying the aquifer. In a study of causes and control of selective pollution of shallow wells by coliform bacteria in Imo River basin Nigeria using geological and vertical electrical sounding techniques, Nwachukwu et. al. (2010) pointed out that the primary source of this contaminant is attributed to continuous littering of human excrements around mechanic villages, littering of cattle excrements along grazing routes and surface application of sewage excavated from household septic tanks to condition the soil for farming. They noted that microbes from these wastes contaminate surface and groundwater causing water related diseases.

Nwanebu et al. (2011), similarly carried out a related study on the chemical and silt-induced eutrophication syndrome at Otamiri River Owerri, Nigeria. The result showed that due to high level of cow dung and wastes from the nearby abattoir, a high level of anions such as PO_4^{3-}, SO_4^{2-} NO^{3-} NO^{2-} were obtained as they may have helped to activate the partial eutrophication phenomenon observed. They remarked that Otamiri generally showed clear evidence of pollution. Ogbuagu (2013) carried out a study for the in situ yield in primary productivity of sand mined ponds of Otamiri River and observed higher turbidity in actively mined areas than non-mined locations.

In view of the worrisome health implication of results of these studies carried out in the neighborhood communities and taking cognizance of the teaming population of students (majority living in school hostels) and staff of FUTO including the University Primary and Secondary schools, food vendors, campus motor parks and commercial shop operators, it becomes absolutely imperative to carryout this present study in the University to determine how potabile the available water is and compare the qualities of surface water and groundwater.

LOCATION, PHYSIOGRAPHY AND GEOLOGY OF THE STUDY AREA

Federal University of Technology Owerri is in Imo State of Nigeria and is about 25 kilometers south of Owerri sharing common boundaries with communities of Ihiagwa, Obinze, Eziobodo and Nekede (Fig 1). The area lies between latitude $5^0$39″N and longitude 6059″E covering a minimum land area of Ten thousand (10,000) acres or 4,048 hectares. FUTO has a student population of over 22,000 presently. The Otamiri River runs from Egbu through Nekede, Ihiagwa. Eziobodo, FUTO campus and finally to Etche, Rivers State of Nigeria from where it finally drains into the Atlantic ocean. The major roads include Port Harcourt-Obinze express road and Ihiagwa-Nekede road. The terrain is characterized by high undulating ridges of land forms having steep slopes by its drainage analysis, which aids the flow of the surface water (Fig. 1).

The geology of the area shows that FUTO lies within the Benin Formation of the Niger Delta sedimentary environment which consists of unconsolidated yellow and white Coastal Plain Sands with gravel beds, occasionally pebbly with grey sandy clay lenses. .Nwachukwu at.al. (2010) explained that the Benin Formation is continental in origin and represents the delta plain facies in which many aquifers with potable water occur. The study shows that shallow aquifers at depth less than 70m are the main sources of potable water in the study area for both domestic and commercial uses. The annual heavy rainfall over the area ensures adequate groundwater recharge, the annual replenishment being about 2.5billion cubic metres per year (Maduagwu, 1990; Nwosu et. al., 2013).

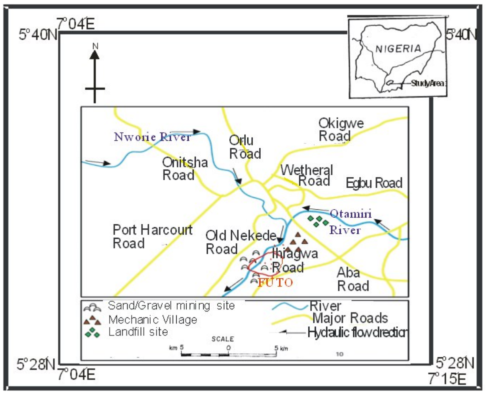

Fig. 1: Map showing the study area and environs (Adapted from Umunnakwe and Nnaji, 2011)

PHYSICO-CHEMICAL PARAMETERS

ALKALINITY: This is the measure of the capacity of any solution to neutralized acids. It determines how buffered the water is against sudden change in pH. The important compounds in water that determine alkalinity include the carbonite (Co^{2-}) and bicarbonate (HCO^{3-}) ions. Source of Alkalinity is presence of Calcium carbonate ($CaCO_3$) which is dissolved in water flowing through geologic unit that has limestone, alkaline salts, plant activities and waste water.

CARBON DIOXIDE (CO_2): This is a gas that forms carbonic acid and is found in atmosphere (about 0.03% of air), lakes, oceans, stream and ponds. It is the end product of organic carbon degradation in almost all aquatic environment. The gas is almost the most important greenhouse gas on earth and its fluxes across the air-water or sediment-water interface are of important concerns in global change studies (Patil et. al., 2012). Sources of the gas include exhalation by man and by-product of respiration by organisms. Most of the carbon dioxide in Rivers are produced by bacteria. Increased carbon dioxide makes the pH of the water more acidic according to the following equations:

$$H_2O + CO_2 \longrightarrow H_2CO_3$$

High level of carbon dioxide indicates that there is a lot of dead materials undergoing decomposition.

AMMONIA (NITROGEN): This is a gas that is found in water (lake, river and ocean) which decreases the acidity of the water when in higher concentration. Ammonia is commonly found in surface water and rainwater. Groundwater generally contains low concentration of ammonia. Ammonia could result from septic tank in-seepage of waste into the well. Fertilizers used for farming has ammonium salt as one of its major components which affect nearby water body through runoff. It is naturally produced and metabolized by human body. Patil et. al. (2012) reported that potential health effect of ammonia nitrogen is corrosion of zinc and copper alloys by forming complex ions.

CHLORIDE: Chloride is the salt of an element chlorine which is widely distributed in nature as salts of sodium (NaCl), potassium (KCl), and calcium ($CaCl_2$).. Chloride in ground and surface water result from both natural and anthropogenic sources such as run-off containing road de-icing salts, the use of inorganic fertilizers, landfills and septic tank effluents. Generally, the toxicity of chloride depends on the cation present and its excessive intake. For instance, it has been reported to be responsible for hypertension due to the sodium ion concentration in sodium chloride (NaCl) as reported by Background document for development in WHO Guideline for drinking water quality. Chloride increases the electrical conductivity of water and thus increases its corrosivity in metal pipes.

Electrical Conductivity: The test for the electrical conductivity of water is done to determine or measure the level of salt content of water. Salts such as chloride increases electrical conductivity of water...

Dissolved Oxygen: Oxygen is one of the most important gases for the survival of living organisms. Its abundant presence in rivers indicates good condition of water body and good aquatic environment.

Hardness: This is caused by the presence of high mineral content in water usually formed when water percolates through deposits of calcium and magnesium containing minerals such as limestone, chalk and dolomite. Hard drinking water is generally not harmful to human health but has strong negative effect on company's use. Dissociation of calcium carbonate in water is reversible forming equilibrium as follows:

$$CaCO_3(s) + CO_2(aq) + H_2O(l) \rightleftharpoons Ca^{2+}(aq) + 2HCO_3^-(aq)$$

Use of hard water in laundry wastes soap forming white precipitate (scum) with soap instead of forming leather that is essential for washing.

$$\underset{\text{Soap}}{2C_{17}H_{35}COO^-(aq)} + Ca^{2+}(aq) \longrightarrow \underset{\text{scum}}{(C_{17}H_{35}COO)_2Ca(s)}$$

pH: It is a scale of numbers from 0 to 14 indicating the level of alkalinity and acidity. Determination of pH of water is very necessary because when the pH is too high or to low, it is no longer potable water rather it is now either alkaline solution for pH greater than 7 or acidic solution for pH less than 7. Besides, if pH of water is too high or too low, the aquatic organisms in water may not survive because most aquatic organisms prefer pH range of 6.5 – 9.0. Low pH value increases the corrosivity of water. Acid rain, waste water, mining discharge and CO2 concentration affect pH of water.

TEMPERATURE: Temperature measurement is an in situ test due to variation of temperature with environment. The United States Geological Survey (USGS) - Water Properties remarked that temperature governs the kind of organisms that can live in rivers and lakes. Temperature exerts a major influence on biological activity and growth. It is necessary to always measure the temperature of water to determine the living condition of these organisms.

TURBIDITY: Water is said to be turbid when it looks cloudy or opaque thus it is no longer easy to see through the water. Turbidity is measured by shining light through the water. It is measured in Nephelometric Turbidity Unit (NTU). When light is being shined through the water sample, the higher the intensity of scattered light, the higher the turbidity.

Substances that cause turbidity of water are clay, algae, silt, soluble colored organic compounds, planktons and microscopic organisms. Turbidity can provide food and shelter for pathogens like mosquitoes which is dangerous to human health.

MATERIALS AND METHODS

INSTRUMENTATION: The instruments used in this study include Personal protective equipments (PPE), Fresh water aqua cultural test kit, Boat, Cans for sample collection, Mercury–in-glass thermometer, Pocket size pH meter, Microprocessor turbidity meter and EC scam low water conductivity meter.

TEST KIT: This is the apparatus used in carrying out the test of the parameters for water. Fresh water aqua cultural test kit is a standard and economic kit for obtaining the results of each parameter from the water samples. It has reagents titration tools and graduated apparatus for measurement. It also contains precautions and procedure.

PROCEDURE: Surface water samples were collected from the two extreme locations of Otamiri River within FUTO. Similarly, groundwater sample were collected from different borehole locations as listed in Table 2.

The water samples were subjected to test analysis from which phyisco-chemical parameters were determined as shown in Table 1.

Table 1: Summary of Techniques for Measurement of Parameters

S/No.	Physico-chemical Parameter	Technique Adopted
1.	Colour	Visual test was employed and colour acceptable.
2.	Odour	Perceived using physiological sense and found acceptable.
3.	Hardness	To about 13ml of water samples in test tube 0608 was added 5 drops of hardness reagent 5 followed by 5 drops of hardness reagent 6 in turn. Then using titrator coded 0382, titre values when titrated with hardness reagent 7 to obtain a clear blue colour was recorded.
4.	Turbidity	Measured using instrument HANNAHI 93703 Micro-processor meter which was inserted into test tube containing 10mls of water samples.
5.	Alkalinity	Measured using fresh water aqua-cultural test kit, 5ml of water samples were in turn placed in test tube 0608 and 4 drops of BCG-MR added, mixed, and inverted to observe a dark green coloration. This was followed by titration with reagent B to obtain pink colour (Acid-base titration).
6.	pH	To about 10ml of water sample was added 8 drops of wide range pH indicator coded 2218 and then inserted into octa-slide viewer to record the pH value.
7.	Temperature	Measured using mercury–in-glass thermometer inside
8.	Dissolved oxygen	Sample solution after fixing +8 drops of Winkler solution B + 8 drops of H_2S0_4 (1:1) to obtain yellow colouration. 8 drops of starch indicator was then added to obtain blue or blue-black colouration and titration continued till the colour disappeared. (Redox titration).
9.	Ammonia (Nitrogen)	4 drops of ammonia reagent 1 were added to 5ml of water sample followed by 12 drops of ammonia reagent 2, then tested with octa-slide viewer for colour matching.
10.	CO2	Measured by testing with phenolphthalein indicator and titrated using titrator coded 0380 with CO2 B (4253DR) reagent to obtain a blue coloration.
11.	Chloride	15mls of water samples were treated with 1 drop of phenolphthalein indicator and it turned colourless. Then using titrator coded 0308, it was titrated with chloride reagent 2 until yellow colouration changed to orange or orange red.
12.	Electrical conductivity	Measured using EC scan low water conductivity meter/fresh water aqua cultural kit.

RESULTS AND DISCUSSION

RESULTS

This summary of the result for all the parameters of water sample is shown in Table 2 below with corresponding measure of World Health Organization (WHO) Standard presented in Table 3. This study reveals variable results of parameters across the sample stations as shown in Table 3. The average chloride

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content of surface water is 15ppm while that of groundwater is 6.9ppm. For hardness of surface water, the average value is 45 while that of groundwater is 38. The average turbidity value for surface water and groundwater are 3.7NTU and 0.28NTU respectively. Turbidity of surface water is very much higher than that of groundwater with a difference in average of 4.6. This is attributed to surface water being exposed to human activities such as dumping of waste and dredging. In all the `samples, it was observed that the hardness of surface water is higher than that of groundwater which could be attributed to surface water being more exposed to runoff carrying much geologic deposits like calcium from limestone and magnesium from dolomites although groundwater is much more in contact with these geologic units and formations carrying the ions for a longer period than surface water. This study however clearly indicates that Otamiri River has abnormally high level of hardness which has economic cost implication for its use in laundry by students and other residents in the campus. The study also revealed that the chloride content of the surface water sample is higher than that of groundwater. The electrical conductivity of surface water samples SW1 and SW2 are much higher than those of groundwater (GW) samples. Conductivity of water is as a result of the salt content of the water. The higher the salt content, the higher the conductivity. Table 4 is the geoelectric survey result of the study by Nwachukwu et.al.(2010) in Ihiagwa, the host community of FUTO. The study recorded that the area lies on a highly weathered topsoil of thickness 7m. The study further revealed that the pH is 4.3 with moisture content ranging from 20 to 70% and concluded that this condition encourages migration of microbes that can cause pollution of groundwater. The underlying lithologic units of sand/gravel constitute the aquifer having resistivity of up to 3000Ωm to a depth greater than 22m.

Table 2: Summary of the sample results for all parameters

Parameters	LOCATION										
	Otamiri River		Afri Hub	SOHT Lecture Hall	SOET Building	Hostel E	Library	Hostel D	750 Capacity Building.	1000 Capacity Building	FUTO Consultant
	Sw_1	Sw_2	Gw_1	Gw_2	Gw_3	GW_4	GW_5	GW_6	Gw_7	Gw_8	Gw_9
Alkalinity (PPM)	24	40	40	30	35	25	35	30	35	25	30
Ammonia Nitrogen (PPM)	0.6	1.0	0.4	0.4	0.6	0.4	0.4	0.4	0.4	0.6	0.6
Carbon dioxide (PPM)	16	25	30	25	25	35	50	35	30	38	20
Chloride(PPM)	16	14	8	6	8	6	8	6	8	6	6
Dissolved oxygen (PPM)	5.4	5.5	5.8	6.2	6.0	6.8	6.2	6.0	5.6	6.0	5.5
Electrical conductivity Scm^{-1}	39	35	15	14	9	16	10	12	10	10	8
Hardness (PPM)	40	50	35	40	45	30	40	38	40	32	42
Ph	6.5	6.1	5.5	5.6	5.5	5.6	5.4	5.1	5.6	5.3	5.6
Temperature ^{0}C	29.2	29.0	27.4	28.0	29.2	28.4	27.6	28.0	27.0	29.4	28.8
Turbidity NTU	4.80	2.61	0.13	0.00	0.00	1.92	0.00	0.50	0.00	0.00	0.00

SW = Surface water GW= Ground water

Table 3: Summary of World Health Organization (WHO) Standard of Water Parameters (2003).

Parameters		WHO Standard
Alkalinity	(mg/l)	600.00
Temperature	^{0}C	20-30
Turbidity	NTU	50.00
Dissolved oxygen	(mg/l)	10
Chloride	(mg/l)	250
Ammonia Nitrate	(mg/l)	10
Ph		1.55 8.50
Conductivity	μscm^{-1}	100.00
Hardness	(mg/l)	500

Table 4: Vertical Electrical Sounding (VES) data of Ihiagwa, the host community of FUTO (Nwachukwu et. al., 2010).

Resistivity ρ(Ωm)	Depth (m)	Lithologic Unit
1040	7.0	Top soil
3020	22.4	Sand/Gravel
683	84.0	Sand/Gravel
1800	106.0	Sand

With respect to contamination, the survey result prescribed a safe depth for shallow water to be 48m deeper than the water table in areas where weathered base is above water table and 66m deeper where it is below the water table.

Figure 2 is the distribution of relative values of the parameters for both ground and surface water samples while Fig. 3 shows the WHO standard for tested parameters. The results of this study reveals certain level of contamination which agrees with the works of Nwachukwu et. al, (2010) and Nwanebio et.al.(2011) in their study of Otamiri River and neighbourhood communities. However, the degree of contamination observed in this study within FUTO is not life threatening as the measured values do not exceed the WHO standards.

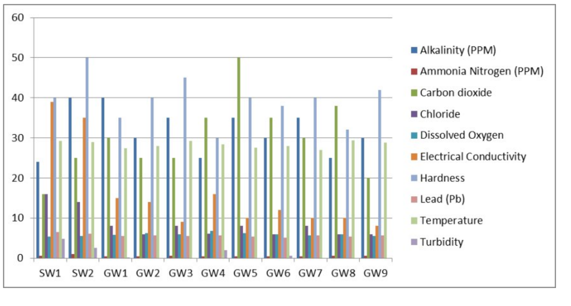

Fig.2: Distribution of measured parameters of ground and surface water in FUTO.

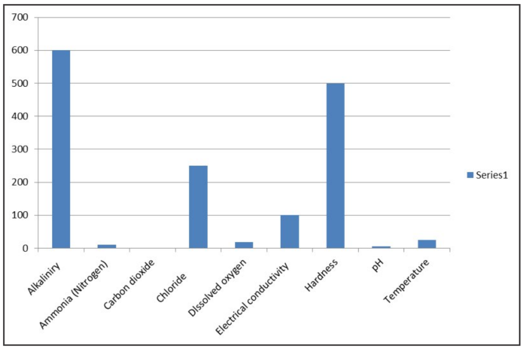

Fig.3 : WHO Standard for measured parameters.

For surface water, this could be attributed to the part of the river within FUTO not being within the actively mining zone (Ogbuagu, 2013). In the case of groundwater, the relatively better quality could be due to the boreholes being drilled to depths within the safe depth prescribed by geoelectric survey of the host communities.

Interestingly, it is observed that both the surface water and groundwater are safe for use in FUTO as the physico-chemical parameters did not exceed the WHO standard.

CONCLUSION

In general, the results obtained for ground water samples varied and this could be due to factors such as difference in depth of well, stratification of rock and presence of contaminants. Though the surface water is not heavily polluted when compared with WHO standards, the fluctuation of the investigated parameters could be as a result of human activities such as farming, bathing, discharge of waste water and materials. Similarly, the borehole water is safe for drinking. However, it is recommended that policies should be formulated to regulate human activities that pollute surface water while construction of septic tank in the path of ground water flow should be discouraged.

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