Water Quality Assessment of Boreholes in Umuahia South Local Government Area of Abia State, Nigeria.

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ABSTRACT

Following a dire need for alternative source of water supply to replace the prevailing problematic surface supply system in Umuahia South, water boreholes began to spring up here and there within the local government area. Within the past one and half decades a renewed cry had been sustained doubting the quality of water from these boreholes. This is a problem that prompted this study to assess the water quality level and compare it with WHO standards for drinking water. Water samples were collected from boreholes and analyzed for different water quality variables. Results show that the water is fit for human consumption as most of the data obtained conform to WHO standards.

(Keywords: water quality guidelines, borehole, groundwater, potable water, hardness, correlation)

INTRODUCTION

Unsatisfactory water supplies and un-wholesome sanitation conditions can result in poor human health. This portends the fact that there are very strong links between water and health. Water is a natural resource whose scarcity or poor quality can cause a chain of unpleasant situations to mankind, especially in developing countries like Nigeria. There are many ways in which poor water quality and sanitary conditions can give rise to poor health. For instance, classical water-borne diseases which include cholera and other diarrhoeal diseases, as well as water-related parasitic diseases like schistosomiasis, guinea-worm, river blindness, hepatitis and malaria are very common (WHO, 1984 and WHO, 1992). Nitrate compounds, heavy metals pesticides, etc., that are contained in our drinking water can also constitute undesirable pollutants when they are not within World Health Organization guidelines for drinking water (WHO, 1984).

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 Umuahia South local government area of Abia State Nigeria to assess some aspects of the groundwater quality of the area. The study is significant and relevant because portable water is essential to life.

The parameters considered are temperature, pH, acidity, alkalinity, conductivity, and total hardness. Others are calcium hardness (Ca^{2+}), magnesium hardness (Mg^{2+}), total dissolved solids (TDS), and turbidity. The investigation covers the ten communities in the local government area. In the past one and half decades, communities in Umuahia South have depended on surface water supplies, mainly rivers/streams, ponds, and rainfall. The vulnerability of these water sources to contamination is very high. The need and demand for better water quality prompted the sinking of boreholes in the study area to the extent that the next problem becomes whether or not the groundwater is good for human consumption (Hunt, 1990).

LOCATION AND BRIEF GEOLOGY OF STUDY AREA

Geographically, Umuahia South is located within Lat.$5^0$26’- $5^0$34’N and Long. $7^0$22’-$7^0$33’E within the rain forest belt. The area is characterized by high temperatures of about 29^0 – 31^0C and has double maxima rainfall peaks in July and September. It is bounded in the north by Umuahia North, Isiala Ngwa in the south, Ikwuano in the east and the Imo River demarcates it with Imo State in the western part.

Geologically, Umuahia South is within the Benin formation which comprises of shale/sand sediments with intercalation of thin clay beds (Asseez, 1976 and Murat, 1972).

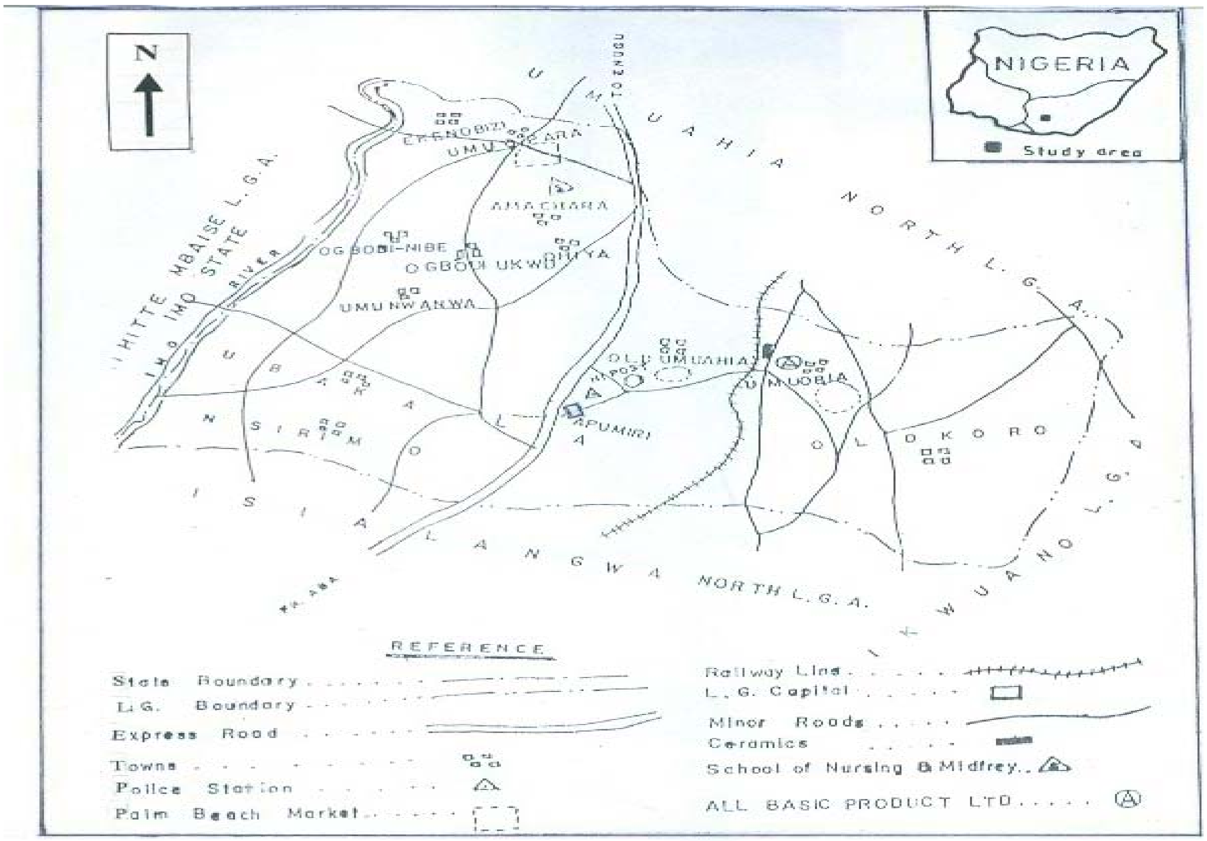

Figure 1: Map of Umuahia South Showing Sampling Points (not to scale).

It is a part of the coastal plain sands of the Cenozoic Niger Delta region of Nigeria.

METHOD OF ASSESSMENT

Ten boreholes were selected within ten designated communities that make up the study area. Groundwater reservoirs are contained in the voids of the sediment and rock underneath the earth surface. These aquifers range from relatively thin and shallow pools to thick and deep volumes many meters beneath the ground surface. The water stored is often abundant and of higher qualify compared to the conventional surface supply system. Theoretically, it is less vulnerable to contamination. It is protected by layers of sediment and rock, though contaminated or polluted water can find its way into the subsurface reservoirs un-noticed.

Ground water quality is assessed by measuring the amount of various constituents contained in water in a locality. The measurable parameters were assessed using the appropriate instruments.

Water samples were collected in sterilized plastic containers from boreholes in Ubakala, Ohiya, Amakama, Amachara, Umuopara, Old Umuahia, Nsirimo, Olokoro, Ogbodi, and Umunwanwa (see Figure 1). Analyses of the samples took place within hours after the collection and the field data obtained is shown in Table 1. Some of the measurements like temperature, pH, etc., were done in-situ.

DATA ANALYSES

The temperatures of the borehole water samples measured on the sites range between 27^{o}C (Ohiya) and 33^{o}C (Umunwanwa). The pH value which is a logarithmic measure of the concentration of hydrogen (H^+) indicates the degree of acidity or alkalinity of the water samples usually range from 4 to 7.

Table 1: Field Data Obtained from Study Area.

Location	Ubakala	Ohiya	Amakama	Amachara	Umuopara	Old Umuahia	Nsirimo	Olokoro	Ogbodi	Umunwanwa
Sample No.	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Temp. ºC	28.5	27	29	32	30	28.5	30.4	30	28	33
pH	4.7	5.2	5.8	5.3	5.6	5.4	5.2	5.2	5.2	6.1
Acidity	5	45	13	45	10	13	12	48	10	9
Alkalinity	3	1	1	20	5	3	2	2	14	7
Conductivity (Sm^{-1})	8.2	8.8	8.8	6.4	8.6	8.8	8.8	8.4	53	8.8
Total Hardness (mgl^{-1})	88	35	30	30	30	10	10	100	8	10
Ca^{2+} Hardness (mgl^{-1})	20	4	10	12	7	3	3	8	4	3
Mg^{2+} Hardness	68	31	20	18	23	7	7	92	4	7
TDS (mgl^{-1})	4.1	4.4	4.4	3.2	4.3	4.4	4.4	4.2	26.5	4.4
Turbidity (NTU)	7	15	3	4	2	1	1	3	3	2

From Table 1 and Figure 2 the values are within 4.7 and 6.1 showing that the samples are acidic – that of Ubakala being most acidic and Umunwanwa least.

The electrical conductivity of the samples are almost the same (8.2 – 8.8 siemens/m) except Amachara (6.4) and Ogbodi (53). These low values imply that the dissolved salts within are very minimal. The water molecule (H_2O) is strongly polar and thus is a powerful solvent. Groundwater therefore adopts the chemistry of the rocks/soil in which it resides (Blyth and de Freitas, 1984).

Total hardness is obtained by summing up the effects of the presence of dissolved minerals such as calcium or magnesium ions. Water hardness is experienced in limestone districts where the rock formation contains calcium carbonate. As we know, what makes water hard is the presence of Ca^{2+} and Mg^{2+} ions. In the field data of Table 1, Ubakala and Olokoro have high total hardness of 88 and 100 mg/l, respectively. A close study of the field data indicates that magnesium ions are more prevalent than calcium ions.

But for minor deviations, the data obtained for the total dissolved solids (TDS) appear to be uniform. However, the value of TDS from Ogbodi which was 26.5 mg/l is exceptionally high compared to others. Also, turbidity which is a measure of the cloudiness of water due to fine suspended colloidal particles of clay or silt, waste effluents or micro-organisms contained in water. This is measured in nephelometric turbidity units (NTU) based on the comparison of the scattering suspension of formazin (Shaw, 1994). With reference to this study, the lowest turbidity was obtained in samples SO6 and SO7 which were borehole samples from Old Umuahia and Nsirimo respectively. The highest turbidity value was Ohiya (Sample number 02) which was 15NTU followed by Ubakala (SO1) which had 7 NTU. Further analysis was done by correlating the measured parameters as shown in Table 2.

RESULT AND DISCUSSION

Generally, cool water is more palatable for drinking. However, high water temperatures enhances the growth of micro-organisms and hence, taste, odor, color and corrosion problems may increase. There is no guideline value recommended for temperature of drinking water. The temperatures of the sample locations vary possibly because of some factors like geology, nearness to a river, etc. The pH values are more acidic than the neutral (pH 7) as the acceptable pH for drinking water is between 6.5 and 8.5 as shown in Table 3 (WHO, 1984). Public acceptability of the degree of hardness of water may change considerably from one community to another depending on local conditions.

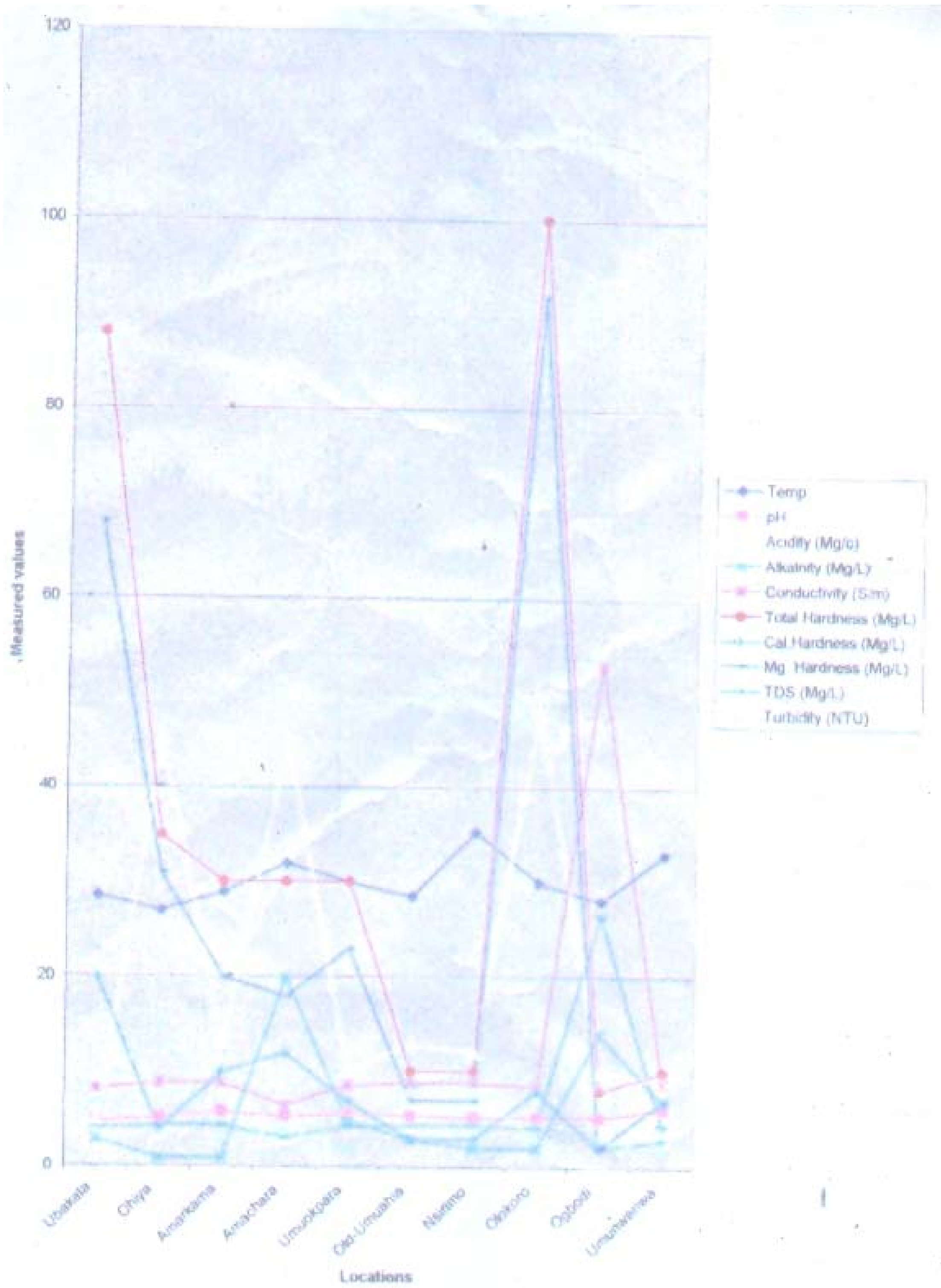

Figure 2: Graph of Measured Parameters Against the Various Locations.

Table 2a: Correlation between Measured Parameters.

		TEMPT (0C)	PH	ACIDITY (mg/l)	ALKALINITY (mg/l)	CONDUCTIVITY (s/m)	TOTAL HARDNESS (mg/l)	CAL. HARDNESS (mg/l)	Mg. HARDNESS (mg/l)	TDS (mg/l)	TURBIDITY (NTV)
TEMPT (0C)	Pearson Correlation	1	.279	-.105	.153	.143	-.265	-.201	-.259	-.297	-.650*
	Sig. (2-tailed)	.	.435	.773	.672	.693	.459	.577	.471	.404	.042
	N	10	10	10	10	10	10	10	10	10	10
PH	Pearson Correlation	.279	1	-.185	.006	.279	-.523	-.489	-.493	-.141	-.360
	Sig. (2-tailed)	.435	.	.609	.986	.436	.121	.151	.148	.697	.308
	N	10	10	10	10	10	10	10	10	10	10
ACIDITY (mg/l)	Pearson Correlation	-.105	-.185	1	.168	-.094	.370	-.009	.414	-.245	.377
	Sig. (2-tailed)	.773	.609	.	.643	.796	.293	.980	.234	.495	.283
	N	10	10	10	10	10	10	10	10	10	10
ALKALINITY (mg/l)	Pearson Correlation	.153	.006	.168	1	-.850**	-.280	.089	-.329	.412	-.256
	Sig. (2-tailed)	.672	.986	.643	.	.002	.433	.806	.353	.237	.476
	N	10	10	10	10	10	10	10	10	10	10
CONDUCTIVITY (s/m)	Pearson Correlation	.143	.279	-.094	-.850**	1	.139	-.114	.176	-.767**	.176
	Sig. (2-tailed)	.693	.436	.796	.002	.	.702	.754	.626	.010	.627
	N	10	10	10	10	10	10	10	10	10	10
TOTAL HARDINESS (mg/l)	Pearson Correlation	-.265	-.523	.370	-.280	.139	1	.678*	.991**	-.298	.129
	Sig. (2-tailed)	.459	.121	.293	.433	.702	.	.031	.000	.404	.723
	N	10	10	10	10	10	10	10	10	10	10
CAL. HARDINESS (mg/l)	Pearson Correlation	-.201	-.489	-.009	.089	-.114	.678*	1	.571	-.244	.028
	Sig. (2-tailed)	.577	.151	.980	.806	.754	.031	.	.084	.498	.939
	N	10	10	10	10	10	10	10	10	10	10
Mg. HARDINESS (mg/l)	Pearson Correlation	-.259	-.493	.414	-.329	.176	.991**	.571	1	-.287	.138
	Sig. (2-tailed)	.471	.148	.234	.353	.626	.000	.084	.	.421	.703
	N	10	10	10	10	10	10	10	10	10	10
TDS (mg/l)	Pearson Correlation	-.297	-.141	-.245	.412	-.767**	-.298	-.244	-.287	1	-.145
	Sig. (2-tailed)	.404	.697	.495	.237	.010	.404	.498	.421	.	.689
	N	10	10	10	10	10	10	10	10	10	10
TURBIDITY (NTV)	Pearson Correlation	-.650*	-.360	.377	-.256	.176	.129	.028	.138	-.145	1
	Sig. (2-tailed)	.042	.308	.283	.476	.627	.723	.939	.703	.689	.
	N	10	10	10	10	10	10	10	10	10	10

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

(a) Correlations

Table 2 b: Descriptive Statistics.

Parameter	Mean	Std. Deviation	N
TEMP	30,1400	2.59195	10
pH	5,370	.38601	10
ACIDITY	21,0000	17.42285	10
ALKALINITY	5.8000	6.33859	10
CONDUCTIVITY	8.0900	1.22606	10
TOTAL HARDNESS	35.1000	32.85135	10
Ca HARDNESS	7.4000	5.46097	10
Mg HARDNESS	27.7000	29.42429	10
TDS	6.43000	7.06148	10
TURBIDITY	4.8000	4.21110	10

Umuahia South communities are in consonance with this assertion as they have different degrees of hardness. Ubakala and Olokoro are moderately hard (Table 4) while the rest are soft according to Freeze and Cherry (1979) classification. Water hardness is caused by dissolved metallic ions mainly calcium and magnesium.

Guideline value is assigned to total hardness and not to individual levels of calcium or magnesium. Magnesium in association with sulphate ions may have laxative properties, the human body can, however, adapt to this effect. The hardness value of 500 mg/liter is based on taste and household use considerations.

Table 3: Range Values of Physico-Chemical Parameters for Drinking Water, WHO (1984).

Parameter	Highest Desirable Level	Maximum Permissible Level
pH	7 – 8	6.5 – 8.5
TDS (mg/l)	500	1500
T.H (mg/l)	100	500
Ca^{2+} (mg/l)	75	200
Mg^{2+} (mg/l)	50	150

Table 4: Hardness Classification of Water (after Freeze and Cherry, 1979).

Hardness (mg/l)	Water Class
0 – 75	Soft
76 – 150	Moderately Hard
151 – 300	Hard
> 300	Very Hard

For the total dissolved solids (TDS) the principal constituents are calcium, magnesium, sodium, bicarbonates, chlorides and sulphates. TDS has effect on the taste of our drinking water. The WHO (1984) standard for TDS is 500 – 1500 mg/l for drinking water, if this range is exceeded, the water becomes increasingly unpalatable. TDS and the electrical conductivity are closely related in the sense that the more salts are dissolved in the water higher the value of the conductivity. In this study the highest TDS value 26.5 mg/l recorded in Ogbodi had a corresponding highest conductivity of 53 siemens/meter.

Turbidity guideline value is 5 NTU. In this investigation the turbidity of the sampled borehole waters were low ranging from 1 to 4 with exception of Ohiya (15 NTU) and Ubakala (7 NTU). This high turbidity recorded in Ohiya is attributable (among other reasons) to the presence of Kaolinite ore deposit in the vicinity whose clay solubility causes colloidal suspension and filtration problems. As a matter of fact, clay conducts electricity very well.

The variables acquired in the study have some relationships with other variable parameters. Statistical analysis done on the data generated was observed to show a positive correlation between temperature and pH (0.279), alkalinity (0.153) and conductivity (0.143). This suggests that an increase in temperature leads to increase in these other parameters (See Table 2). It, however, showed a negative relationship with total hardness (-0.265), TDS (-0.297) and turbidity (-0.650) which means that an increase in temperature leads to a decrease in the other variables, etc.

CONCLUSION

The experimental investigation of the extent of the groundwater quality of Umuahia South local government area of Abia state, Nigeria has shown (judging from the physico-chemical variables measured) that groundwater in the vicinity is safe for drinking and other uses (WHO 1984). Thus, the study has helped to allay people's fear that the water here is sub-standard for drinking and domestic purposes. Groundwater is an important natural resource which is next alternative to the surface supply sources that are prone to easy contamination.

The correlation done was to ascertain the effect or relationship of one parameter to another. This research is still in progress whose next stage is to consider the biological features of the groundwater in the same boreholes. Information on microscopic, pathogenic and bacteriological conditions of the water would fully be established. At present this work is based on the assessment of the physical and chemical features only.

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SUGGESTED CITATION

Chukwu, G.U. 2008. "Water Quality Assessment of Boreholes in Umuahia South Local Government Area of Abia State, Nigeria". *Pacific Journal of Science and Technology*. 9(2):592-598.

Pacific Journal of Science and Technology