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PHYSICO-CHEMICAL CHARACTERISTICS OF GROUNDWATER AND SEDIMENTS IN PARTS OF CENOZOIC NIGER DELTA OF NIGERIA

G.U. Chukwu

Department of Physics, Michael Okpara University of Agriculture, Umudike P.M.B. 7267, Umuahia, Nigeria

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ABSTRACT

The need to investigate the physical and chemical properties of groundwater quality of boreholes and type of sediments in parts of the Niger Delta region of Nigeria has been of paramount importance. This is because of the indiscriminate and uncontrollable manner by which individuals and groups of persons embark on borehole development ventures within the area. Severe water scarcity, particularly during the dry season, has compelled community dwellers to search for potable groundwater in place of not-readily available, pollution-prone and disease-stricken surface water of the area. The nature of subsurface sediments affects the portability or otherwise of groundwater; thus, this study is aimed at investigating the physico-chemical characteristics of borehole water and sediment types of the area using borehole data acquired from the zone. Results from analyses and comparison with World Health Organization (WHO) standards show reasonable conformity with fine-grained to coarse-grained sediments.

INTRODUCTION

Sporadic outbreaks of water-borne diseases like typhoid, cholera, dysentery, diarrhea in some parts of Umuahia, Abia State of Nigeria which is located within the north-eastern (NE) flank of the Cenozoic Niger Delta region. The issue of water in Nigeria as a whole has been problematic; ranging from severe scarcity to contaminated or polluted supply. Within the area of investigation, cases of water-related parasitic diseases (Warner and Laugen, 1992) such as malaria and hepatitis are common. Since the area is a predominantly agricultural community, it is believed in some quarters that application of fertilizer may have given rise to addition of nitrate compounds, heavy metals, pesticides, insecticides, etc to the soil and indirectly to surface water supply. These, for sure, might constitute some undesirable pollutants if they are not within the World Health Organization (WHO) guidelines for drinking water (WHO, 1984a). After the advent of borehole technology groundwater supply, the people's health problem persists; though, to much lesser extent than before.

Considering the level of peoples' speculation bordering on water supply quality (Asch and Seneca, 1980) of the area particularly groundwater supply, it is expedient to carry out research to verify the authenticity of unbridled speculations. The specific objective of this study is to investigate if the groundwater from boreholes in the study conforms to WHO standards (WHO, 1984; Lester and Woodward, 1972) of drinking water. In this regard it is important to see the significance of the study to be appropriate. Of the basic necessities of life, water ranks next to air; followed by food and shelter.

Therefore, to carry out a systematic and scientific investigation about procurement of potable water for mankind for sustainability of life and growth is a worthy venture; here lies the relevance of the work.

The physico-chemical parameters (Kannathasan and Rajendran, 2010; Nair et al., 1983; Ramaraju et al., 1987) that area considered are either exogenous or endogenous or both. Considerable data of information are available on exogenous factors such as temperature, pH, turbidity fluctuations, total hardness and calcium hardness (Ca^{2+}). Others are magnesium hardness (Mg^{2+}), total dissolved solids (TDS), acidity, alkalinity, conductivity, and GPS data of the borehole locations. The investigation covers ten communities who had hitherto depended on surface water supplies for their drinking water and other domestic/agricultural purposes. These sources are rivers/streams, ponds, and rainfall which are very vulnerable to easy contamination. The need and demand for better water quality prompted the sinking of boreholes in the area to the extent that the next problem envisaged becomes whether or not the groundwater is good for human consumption (Chukwu, 2008 and Hunt, 1990). Hence, the present study of investigation on the physico-chemical characteristics of water from the boreholes and the sediments in the north-eastern part of the Niger Delta region, Nigeria is located within Latitude 5^o 28′- 5^o 34′ NS and Longitude 7^o 22′ - 7^o 31′ EW (GSN, 1985). Geologically, the study area lies within the Benin Formation. Specifically, it is located at the upper part of the formation otherwise known as coastal plain sands (Asseez, 1976 and Murat, 1972).

* Corresponding author: +2348025691478
E-mail address: chukwug@yahoo.com

MATERIALS AND METHOD

Fresh borehole samples were collected in sterilized clean polythene bottles and labeled appropriately from ten selected boreholes within ten designated communities that make up the area under investigation. Groundwater reservoirs are contained in voids of the sediments and rocks (Blyth et al., 1984) underneath the earth surface. The thickness of the aquifers is not uniform, there is evidence of variation in thickness noticed everywhere. The water obtained is of considerable quality compared to the conventional surface supply system. Theoretically, it is less vulnerable to contamination. It is protected by layers of sediments and rocks; however, contaminated or polluted water can still find its way into the subsurface reservoirs un-noticed depending on the geological formation.

Determination of groundwater quality involves the assessment of the amount of various constituents contained in the water sample from a particular borehole using appropriate instruments. Some of the measurements like pH and temperature were done in-situ. The GPS measurements were necessary in order to obtain the actual geographical coordinates of individual boreholes and, of course, their elevations. As soon as the data acquisition process was through; in a swift, the collected-and-labeled samples were transported to the laboratory for analysis. Analyses of the samples took place within a few hours whose field data were recorded in Table1.

any electrolyte in any formation usually assumes the geochemistry of the host rock.
Total hardness (T.H) is obtained by summing up the effects of the presence of dissolved minerals in the sample. The considerations in the study are calcium (Ca^{2+}) and magnesium (Mg^{2+}) 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 Table1, Ubakala and Olokoro (BH_8) have high total hardness of 88 and 100 mg/l, respectively. A closer observation of the field data indicates that magnesium ions are more prevalent than calcium ions.

But for minor deviations, the data obtained for 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 other boreholes. 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 work, the lowest turbidity was obtained in samples BH_6 and BH_7 which were borehole samples from Old Umuahia and Nsirimo respectively. The highest turbidity value recorded was Ohiya (borehole sample number 02) and that was 15 NTU followed by Ubakala (BH_1) which was 7 NTU. Further analysis was done using descriptive statistics on the measured parameters shown in

Table 1 Field data of physico-chemical parameters from study area

Borehole location	Borehole Sample No	Latitude °N	Longitude °E	Elev. (m)	T °C	pH	Acidity	Alka-linity	Conducti-vity (S/m)	T.H. (mg/l)	Ca^{2+} (mg/l)	Mg^{2+} (mg/l)	TDS (mg/l)	Turbidity (NTU)
Ubakala	BH_1	5° 28.17′	7° 24.91′	164	29	4.7	5	3	8.2	88	20	68	4.1	7
Ohiya	BH_2	-	-	-	27	5.2	45	1	8.8	35	4	31	4.4	15
Amakama	BH_3	5° 28.13′	7° 30.53′	169	29	5.8	13	1	8.8	30	10	20	4.4	3
Amachara	BH_4	5° 32.15′	7° 27.91′	138	32	5.3	45	20	6.4	30	12	18	3.2	4
Umuopara	BH_5	5° 33.11′	7° 26.32′	123	30	5.6	10	5	8.6	30	7	23	4.3	2
Old muahia	BH_6	-	-	-	29	5.4	13	3	8.8	10	3	7	4.4	1
Nsirimo	BH_7	5° 28.03′	7° 23.76′	131	30	5.2	12	2	8.8	10	3	7	4.4	1
Olokoro	BH_8	5° 29.20′	7° 29.04′	151	30	5.2	48	2	8.4	100	8	92	4.2	3
Ogbodi	BH_9	-	-	-	28	5.2	10	14	53.0	8	4	4	26.5	3
Umunwanwa	BH_{10}	5° 29.89′	7° 23.92′	102	33	6.1	9	7	8.8	10	3	7	4.4	2

DATA ANALYSIS

The temperature of the borehole water samples measured at the sites range between 27°C (Ohiya, BH_2) and 33°C (Umunwanwa, BH_{10}). The pH value which is a logarithmic measure of the concentration of hydrogen ion (H^+) indicates the degree of acidity or alkalinity of the water samples usually range from 1 to 14 on the pH scale. From Table 1 the recorded values are within 4.7 and 6.1 showing that the samples are acidic: that of Ubakala (BH_1) being most acidic and Umunwanwa least.

The electrical conductivity of the samples are almost the same ranging from 8.2 to 8.8 Siemens/meters except Amachara (BH_4) 6.4 S/m and Ogbodi (BH_9) which is extra ordinarily high 53 S/m. These low values imply that the dissolved salts within are very minimal. The water molecule (H_2O) is strong polar and as such it is a powerful solvent. Groundwater therefore adopts the chemistry of the rock/soil in which it resides. Blyth and de Freitas (1984) maintained that

observation from the core drilling samples of the boreholes depict that the sediments are sand, sandstone, sandy-clay with intercalation of thin clay beds (Oral communication, 2009; Asseez, 1976 and Murat, 1972). The table displays the standard deviation in the physico-chemical quantities measured i.e. the amount by which measurements in a set vary from the mean value for the set.

Table 2 Descriptive statistics of measurable quantities

Parameter	Mean	Std. Deviation	N
Temperature	30.1400	2.59195	10
pH	5.370	0.38601	10
Acidity	21.0000	17.42285	10
Alkalinity	5.8000	6.33859	10
Conductivity	8.0900	1.22606	10
TOT.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

RESULT AND DISCUSSION

There is spatial variation of borehole locations within the study area which actually the GPS data in Table 1 vividly show. As such the temperatures of the sampled locations vary significantly possibly because of some factors like geology, nearness to river, topography, etc. There is no guideline value recommended by WHO for temperature of drinking water. However, generally, cool water is more palatable for drinking than warm water. Again, high water temperature enhances the growth of micro-organisms and hence, taste, odor, color, corrosion problems as well as the pathogenic and bacteriological conditions of the water may be on the increase.

The pH values are more acidic than the neutral (pH 7) as the acceptable standard 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 the other depending on local prevailing conditions. Communities in south-southeastern part of Umuahia area fall in consonance with this assertion as they have different degrees of hardness.

Table 3 Range values of physico-chemical parameters for drinking water.

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

Source: WHO (1984).

From Table 4, Ubakala and Olokoro are moderately hard while the rest of the other boreholes are soft according to Freeze and Cherry (1979) classification of water hardness. Water hardness is caused by dissolved metallic ions mainly calcium and magnesium. Guide value 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/l is Mg^{2+} (mg/l) based on taste household use considerations.

Table 4 Hardness classification of water

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

(after Freeze and Cherry, 1979)

For the total dissolved solids (TDS) the principal constituents are calcium, sodium, magnesium, 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 (Table 3) for drinking water, if this range is exceeded, the water becomes increasingly un-palatable. TDS and the electrical conductivity are closely in the sense that the more salts are dissolved in the water, the higher the value of the conductivity. In this study, the highest value of TDS recorded was 26.5 mg/l in Ogbodi which also had a corresponding highest conductivity of 53 S/m. This is a good example of high quality data of high resolution.

WHO (1984) turbidity guideline value is 5 NTU. In this investigation the turbidity of the sampled borehole specimens were low ranging from 1 to 4 NTU with exception of Ohiya and Ubakala which have 15 and 7 NTU, respectively. This high turbidity recorded in Ohiya is attributable to (among other reasons) the presence of kaolin ore deposit in the vicinity whose clay solubility causes colloidal suspension and filtration problems in the area. As a matter of fact, clay conducts electricity very well. This is another evidence of superbly acquired quality data.

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 is suggestive of the fact that an increase in temperature leads to increase in these other parameters. It is however, ascertained that a negative relationship with turbidity (-0.650), total hardness (-0.265) and TDS (-0.297) which means that an increase in temperature leads to a decrease in the other variables, etc.

CONCLUSION

The experimental investigation of the extent of groundwater quality of the ten communities in south-southeastern part of Umuahia located within the Niger Delta area of Nigeria has shown, from the physico-chemical measurements carried out, that the groundwater from the boreholes in the vicinity is safe for drinking and other uses. Thus, the study has gone a long way to allay community dwellers' fear as to the sub-standard nature of their drinking water. Groundwater is an important natural resource which is the next appropriate alternative to the surface supply sources that are prone to easy contamination. For the sediments, the area under investigation is within the coastal plain sands which are primarily made up of sands, sandstones and clays with fine-grained to coarse-grained sediments.

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