The Mineral Effects of Sedimentary Layers on Groundwater in Choba, Rivers State, Nigeria.

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ABSTRACT

Four functional boreholes were sampled from the highly populated study area and analyzed using standard laboratory techniques in order to determine the quality status of groundwater in the area. The Choba water was found to be tasteless and without odor. The color ranges from 3.8 to 5.3 mg/l while the average turbidity (NTU) is 2.3. Also, the results show that the groundwater in the area is acidic with a pH range of 4.32 – 4.43. This falls below the World Health Organization (WHO) standard for drinking water, and hence the need to treat the borehole water in the area to make it more potable. Water treatment will also help to reduce the concentration level of constituents' elements in the water. The waters have low to moderate conductivities (11.82 – 61.20mg/l) and have Cl^- as the dominant anions, with a mean value of 2.5mg/l. This value shows absence of salt water intrusion in the area. Also, the highest recorded value of 50mg/l for hardness is indicative of soft groundwater in the area.

(Keywords: mineral effects, physic-chemical, borehole, wells, groundwater, water quality, potable water)

INTRODUCTION

The Choba town in the Eastern Niger Delta, Nigeria has abundant groundwater potentials. The area which houses the University of Port Harcourt is however, prone to water contamination arising from industrial activities and oil field operation within the region. One of the prerequisites of everyday activity and any sustainable development program is the presence of an adequate supply of quality water for human consumption. Groundwater constitutes over 90% of the world's readily available freshwater resources with remaining 10% in lakes, reservoirs, rivers and wetlands (Baswinkel, 2000, Asonye et al., 2007). Freshwater quality and availability remains one of the most critical environmental and sustainable issues of the 21st century (UNEP, 2002).

This study is aimed at determining how the dissolved aquiferous sedimentary rock minerals from different sedimentary layers affect the quality of the analyzed water samples. Surface or underground water is never really chemically pure as water invariably dissolves some of the minerals it comes in contact with at any given time (Etu-efeotor, 1998). These dissolved minerals are contained in the groundwater which influences its hydrogeochemistry and ultimate quality. In this study, four water borehole samples located in Choba, Rivers State Nigeria were assessed for quality checks by physicochemical analysis of the samples in the laboratory. The values of the physicochemical parameters like pH, conductivity, hardness, total dissolved solids (TDS), presence of heavy metals, acidity, alkalinity, color etc, were correlated with the World Health Organization (WHO, 1993). The quality of water, and therefore its usability is determined by the composition of these chemicals on it.

GEOLOGY AND HYDROGEOLOGY OF THE STUDY AREA

The Choba town with a population of about 12000 is located in the mangrove belt in Eastern Niger Delta in Rivers State, Nigeria. Its geographical location is latitude $4^0 48'$N and longitude $7^0 00'$S, covering a land mass of approximately 1.3 square kilometers (Figure 1). The Niger Delta region is composed of three formations which includes the Benin Formation, the Agbada Formation and the Akata Formation. The Benin Formation is generally water bearing and stands out as the main source of potable groundwater in the study

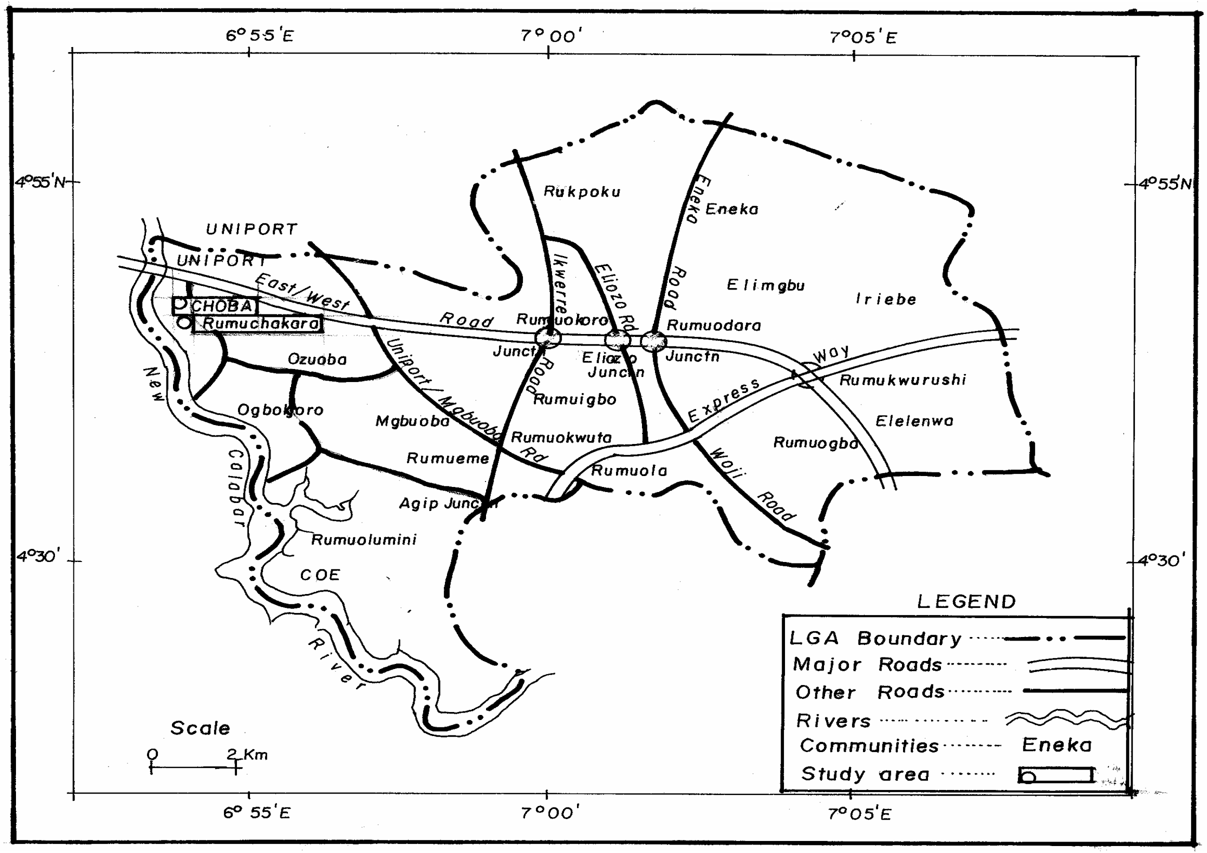

Figure 1: Map of Obio/Akpor Local Government showing Study Area.

area (Figure 2). It consists mainly of unconsolidated sand and gravel with thickness ranging from 0 – 2100m (Reyment, 1965).

The area has an average temperature of 27^0C and annual precipitation of about 1500mm during the rainy season (Amadi, 2004, Ehirim and Nwankwo, 2010). Two climatic regimes consisting of wet season between March and October followed by a shorter dry season is usually recorded. It is characterized by moderate vegetation, and aquifers are at depths of between 46.1m and 92.18m (Ehirim and Nwankwo, 2010).

Geoelectric survey and pumping tests results in the area show a transmissivity value of 1.34×10^4 – 1.64×10^5 Ωm^2, longitudinal conductance of overburden rock materials ranging from 4.68×10^{-3} – 1.52×10^{-2} Siemens and aquifer porosities varying from 39.31-90.2%.

METHODS OF STUDY

Water samples were carefully collected from four existing boreholes in Choba town. The samples collected in clean plastic bottles were taken to the laboratory for treatment and analysis using the various analytical techniques (Table 1).

Table 1: Summary of Analysis Methods Used.

Determination	Analysis method
Total hardness, Total acidity, Ca^{2+}, Mg^{2+}	Titration
Colour	Lovibond comparator
Turbidity	Turbidimetric
pH	pH meter
Conductivity, TDS, salinity	Conductivity meter
Heavy metals	Spectrophotometer

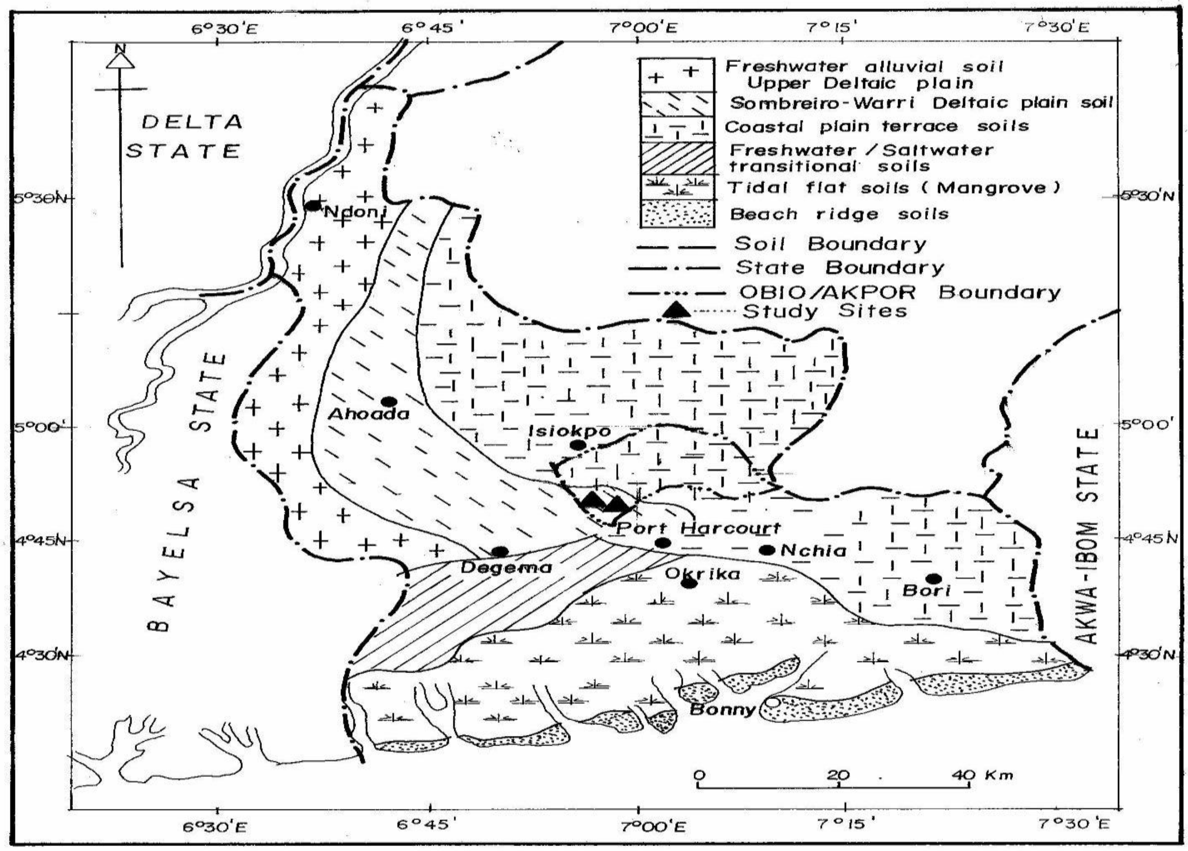

Figure 2: Geologic Map of the Study Area (Adapted from Ehirim and Nwankwo, 2010).

RESULTS AND DISCUSSION

Table 2 shows the results of the physicochemical analysis of some selected borehole water samples. The obtained parameters were compared with the WHO standards for drinking water. The Table shows physico-chemical analysis result from study area compared with WHO standards.

Color, Odor, and Appearance

All the water samples were tasteless and odorless while the color indices range from 3.8 to 5.3 mg/l indicating the absence of colloidal substances, suspended and decomposed vegetation, thereby falling within the placed standards. All the samples in the area meet the WHO highest desirable color limit of 15mg/l and therefore needs no color treatment. However, the percentage color observed from the analysis may be associated with ferric hydroxides formed from oxidation of ferrous iron in the water or due to humic acids in the soil. Turbidity has a range of 1 – 4 Formation Turbidity Units (FTU) while WHO standard is 5 FTU. This confirms the low iron content in the water of the area. Higher turbidity (above 25 FTU) can cause gastrointestinal problems.

Hardness

The total hardness of the groundwater in the study area ranges from 28 – 50mg/l in concentration. The water in the area is therefore soft and requires no treatment for domestic use. The analysis also shows the presence of calcium in the basement rocks. Dissolution of these elements by percolating water can account for fairly moderate hardness of the groundwater in the area.

Table 2: Results of the Petrochemical Analysis.

S/N	TEST PARAMETERS	SP1	SP2	SP3	SP4	WHO
1	Total Dissolved Solid (mg/l)	28.9	5.5	5.1	6.6	1000
2	Total Hardness (mg/l)	32	28	40	50	500
3	Calcium Hardness (mg/l)	68	42	44	36	200
4	Magnesium Hardness (mg/l)	BD	BD	BD	BD	-
5	Conductivity (mg/l)	61.20	12.66	11.84	13.20	100
6	Turbidity (mg/l)	2 nut	1 nut	4 nut	2 nut	5 ntu
7	Salinity (mg/l)	0.1	0.1	0.1	0.1	0.1
8	Acidity (mg/l)	2.00	1.40	1.24	0.80	1.0
9	Alkalinity mg/l)	20.4	15.6	24.0	36.0	200
10	Color (mg/l)	5.0	3.8	4.5	5.3	15
11	Odor	OL	OL	OL	OL	OL
12	Taste	TL	TL	TL	TL	TL
13	PH	4.32	4.41	4.43	4.39	6.5-8.5
14	Aluminum (mg/l)	0.01	0.01	0.01	0.01	0.2
15	Barium (mg/l)	5	3	3	2	0.3
16	Cadmium (mg/l)	0.001	0.001	0.001	0.001	0.003
17	Chloride (mg/l)	0.3	0.3	0.3	0.1	600
18	Chromium (mg/l)	0.01	0.02	0.01	0.01	0.05
19	Copper (mg/l)	0.06	0.07	0.08	0.06	2.0
20	Cyanide (mg/l)	0.001	0.001	0.001	0.001	0.005
21	Fluoride (mg/l)	BD	BD	BD	BD	1.5
22	Iron (mg/l)	0.06	0.06	0.04	0.02	1.0
23	Lead (mg/l)	0.005	0.004	0.003	0.003	0.01
24	Manganese (mg/l)	0.007	0.008	0.005	0.002	0.5
25	Nitrate (mg/l)	0.03	0.03	0.02	0.02	50
26	Nitrite (mg/l)	0.006	0.005	0.005	0.005	50
27	Ammonia (mg/l)	0.007	0.007	0.006	0.006	0.025
28	Phosphate (mg/l)	1.0	1.0	1.0	0.07	
29	Sulphate (mg/l)	6	4	3	3	500
30	Selenium (mg/l)	0.04	0.03	0.02	0.02	0.01
31	SiO (mg/l)	0.004	0.0I6	0.018	0.017	
32	Phenol (mg/l)	0.008	0.006	0.007	0.007	0.001
33	Suspended Solids (mg/l)	4	4	3	2	

Where OL means Odorless, TL means Tasteless and BD means Below Demand.

pH, Conductivity, and TDs

The pH values in all the locations reveal an acidic groundwater in the area. A pH range of 4.32 – 4.43 was analyzed which fall below the WHO standards for potable water. The acidity may have resulted from landfill gases arising from the decomposition of waste materials from existing nearby dumpsites into the high porous subsurface. The geo-electric survey result has shown that the Choba area has high transmissivity and high hydraulic conductance (Ehirim and Nwankwo, 2010). The low pH (high acidity values) could also be as a result of the amount of dissolved carbondioxides and bicarbonates present in the aquiferous rock. More so, acid rain resulting from gas flaring within the region infiltrates through the soil to the aquifer thereby reducing its pH value and making it more acidic.

A fairly low conductivity range of 11.82 – 61.20mg/l obtained for the water in the study area is an indication of the absence of objectionable tastes in the water. It shows that the salinity of the water is low and consequently constant low mineral contents. Hence the borehole waters are not in contact with much inorganic constituents within the aquiferous materials of the decomposed basement rocks. Values of Total Dissolved Solids (TDS) range from 5.1 to 28.9. These low values are an indication of the presence of low impurities in the waters. The water is therefore fresh and suitable for irrigation.

Chloride

The recorded chloride concentrations for the 3 out of the 4 sampled wells are 0.3mg/l. These values are low when compared with the WHO (2007) recommended upper permissible value of 600mg/l for drinking water. This low concentration of chloride can be attributed to absence of source rocks that can host salts. Chloride contents greater than 40mg/l in coastal aquifers indicate salt water contamination (Udom et al., 1998).

Lead and Copper

Both Copper and Lead were detected in all the sampled boreholes although the concentrations were extremely low. However, no geologic inference can be drawn from these observed low concentrations. There are no known copper mineral occurrences in the Nigerian basement as of now (Etu-efeotor, 1998).

Iron and Manganese

The iron and manganese content occur in a range of 0.02 – 0.06mg/l and 0.002 – 0.008mg/l, respectively. All the samples show values below the highest desirable level. Iron actually presents no health hazards even in excess concentration except for imparting a metallic taste to water if the concentration is high above 1.8mg/l. The highest permissible limit by WHO has remained 1.0mg/l. Iron is easily found in iron-bearing minerals of igneous, metamorphic and sedimentary rocks. It could therefore be derived from the lateritic soil zone of Benin Formation. Filtration of these materials can concentrate iron in groundwater. Manganese can substitute for iron, magnesium or calcium in silicate structures thereby become concentrated in the water. The calcium content of the sampled boreholes are relatively high with a value range of 36 – 68mg/l against WHO standard value of 72 – 200 mg/l. Probable source of calcium is silicates and feldspars that characterize the Benin Formation.

Aluminum, Barium, Fluoride and Cadmium

These heavy metals were present in all of the sampled boreholes, though their values are within the purity of potable drinking water. Presence of these metals which are often characteristics of municipal landfill leachates (Cherry et al., 2007) can be harmful to health. The concentration of fluoride is below demand while barium and phenol are above the set standard. Barium occurs naturally in both igneous and sedimentary rocks and soil. Its solubility increases with low pH (USEPA, 1994). People who drink water containing small amount of barium for a short period may experience vomiting, abdominal cramps, and diarrhea, difficulties in breathing and increase or decrease in blood pressure. It also causes paralysis in human (WHO, 2004). Phenol can reach the water table through infiltration of industrial hazardous waste. This must have been the case in this study area, as a very large dumpsite is situated less than 400m from the location of the sampled boreholes. Ingestion of liquid products containing concentrated phenol can cause serious gastrointestinal damage and even death (EPA, 2000).

Water Treatment

The results presented show a serious threat on groundwater quality in the area. Water samples from all the boreholes with the low pH values should be treated before consumption. This can be done by passing the waters through dolomite granules. The granules slowly dissolve as water passes through them. Though hardness is increased during this process, the amount may not be of serious concern.

CONCLUSION

The ground water in the area are slightly mineralized. This is connected with the geology of the area which has great influence on the hydrogeochemistry of these waters. The waters are colorless, soft, potable and suitable for domestic and other purposes. However, the sampled boreholes show high acidic content with pH values ranging between 4.32 and 4.43 as against WHO standard of 6.5 to 8.5 for potable water. The low pH values of the borehole water are probably due to industrial activities or landfill gases resulting from the decomposition of waste materials from the nearby existing dumpsite. These gases diffuse through the permeable layers of the formation to form weakly acidic solutions which are washed down into the aquifer thereby contaminating the groundwater. All the water samples in the area should therefore be treated, while PVC pipes and other non corrosive material should be used for well construction.

This work has also revealed high concentrations of Barium in the water. This is possibly due to high acidic content of water in the area. This implies that the inhabitants of this area are susceptible to suffering from abdominal cramps, diarrhea, blood pressure fluctuation, gastrointestinal and neuromuscular effects. The ground waters are virtually free from Nitrate, phosphate and sulfate contaminants as their analyzed values fall far below the low permissible limit.

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