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ASSESSMENT OF GROUNDWATER QUALITY IN OSUN STATE SECRETARIAT, OSOGBO, SOUTH-WESTERN NIGERIA

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ABSTRACT

Some physico-chemical analyses of water samples from nine boreholes in Osun State Secretariat, Osogbo, South-Western Nigeria were carried out. The aim of the study was to evaluate the suitability of the groundwater for drinking and other purposes. In all, nine (9) representative Boreholes (BHs) were studied. Each of these has been designated by corresponding subscripts as BH_1, BH_2, BH_3, BH_4, BH_5, BH_6, BH_7, BH_8, and BH_9 respectively. The range of values of the respective parameters obtained from the analyses were: temperature: 29.9-35^{0}C; pH :4.7 – 7.1; PO_4^{3-} : 0.13 – 0 .19mgl^{-1}; Mg^{2+} : 5.0 -26.0 mgl^{-1}; NO^-_3 : 0.02 – 17.0mgl^{-1}; Cl^- : 0.4 – 56mgl^{-1}; Fe^{2+} : 0.0l – 5.0mgl^{-1} and Hardness: 8.0 – 146mgl^{-1}. These analyses showed that the level of potability of the tested groundwater is not generally acceptable when viewed against the National Agency for Food and Drug Administration and Control (NAFDAC), World Health Organisation (WHO), and National Primary Drinking Water Regulation (NPDWR) standards. The concentration level of Fe^{2+} in BH_1, BH_2 and BH_5 are above the recommended maximum permissible limit of 0.3mgl^{-1}. The sources of Fe^{2+} in these boreholes may be due to the geology of the location because some of them are located on Ferruginized formations. It may also be due to the quality of steel pipes used in the distribution of the water. The pH of the studied samples in the area falls within range 4.7 –7.1 with a mean value of 5.5. This is generally below the permissible ranges of 6.5-8.5, 7.0-8.5 and 6.5-8.5 for NAFDAC, WHO and United States' NPDWR respectively. The pH values of almost all the water samples (88.9%) except BH_3 fall within the acidic range (less than pH 7.0), suggesting that the geological formation of the area is acidic. The total hardness of the samples tested in the study varied from 8.0 - 146mgl^{-1}. Only samples from BH_1 and BH_2 are moderately hard (75-150mgl^{-1}) while others are purely soft waters (less than 75mgl^{-1}).

Keyword: Borehole, groundwater, physico-chemical parameters, quality.

INTRODUCTION

With increase in infrastructure and socio-economic growth, there is need for supply of adequate potable water. The objective of this study is to assess some geochemical aspects of groundwater in the study area with a view of determining its suitability for human consumption, municipal and industrial purposes.

The quality of groundwater is determined by its physical, chemical and bacteriological characteristics. Variation in the quality may render the groundwater hazardous to human health and unsuitable for industrial usage. Wells and boreholes should be sited far away from refuse, dumps graveyard, abattoir, oil deposit, soak-away pit and any possible source of contamination (Ojoawo and Akinyele, 2005). The purpose to be served by the groundwater is determined by the quality standard set by the World Health Organization (WHO, 1984).

The area of investigation lies within latitudes 6^0 56^1 N and 8^0 06^1 N and longitudes 4^0 60^1 E and 5^0 04 E. The study area is mainly composed of undifferentiated metasediments. Its mean daily maximum temperature ranges between 29.9°C and 35.9 °C. The area is mainly flat and covered by vegetation and buildings. Vegetation is a typical Guinea Savannah that is characterized by grasses with wooded patches.

METHODS

Groundwater samples from boreholes in Osun State Secretariat, Osogbo were sampled for analyses of some of the dissolved ions. Table 1 indicates the sample number, date of collection, locality name and the time the samples were collected. These samples were examined for physical, chemical and bacteriological qualities. A rubber container was used to draw water samples from the study area. The samples were stored in a clean well-drained polyethylene bottles previously rinsed out with distilled water and thereafter taken to the laboratory for analyses.

Physical parameters like temperature, total dissolved solids (TDS), pH were determined by probe methods using standard calibrated meter. Total hardness, calcium hardness, total alkalinity and chloride were determined using titrimetric methods as prescribed by American Public Health Association (APHA). Also aluminum, fluoride, iron, nitrate were determined with Hanna (100 serial no 193992 UK) bench spectrophotometer using Hanna chemical reagents.

RESULTS AND DISCUSSION

The results of the hydro-chemical parameters are shown in Table 2. The water quality in the study area was evaluated in terms of their concentrations level with respect to the Drinking water standards [World Health Organisation (WHO), Nigeria's National Agency for Food and Drug Administration and Control (NAFDAC) and the United States' National Primary Drinking Water Regulation (NPDWR). These are presented in Table 3.

Temperature

Results from the study area indicate that the temperature of the water samples range from 29.9^{0}C to 35.9^{0}C showing that the groundwater does not reflect geothermal effects.

Colour and Taste

Amongst the samples tested in the study area, only BH_1, BH_2 and BH_5 have an objectionable colour and taste. Other samples have normal organoleptic properties. Colour in water is attributable to materials in solution.

pH

The pH of groundwater is caused by a particular set of chemical conditions. The pH of the studied samples in the area falls within range 4.7 – 7.1 with a mean value of 5.5. This is generally below the permissible ranges of 6.5-8.5, 7.0-8.5 and 6.5-8.5 for Nigeria's NAFDAC, WHO and United States' NPDWR respectively. The pH values of almost all the water samples (88.9%) except BH_3 fall within the acidic range (less than pH 7.0), showing that the geological formation of the area is acidic (Raju, 1995 and Hammer, 1992).

Turbidity

The water samples tested fall within 0.15 N.T.U this range is less than the WHO Maximum level of 25 N.T.U.

Nitrate

The concentrations of nitrate in the water samples range from 0.02 mgl^{-1} to 17. 0mgl^{-1}. The values still fall within the recommended standard of the World Health Organization.

Fluoride

Fluoride concentration varied from 0.29 - 0.88mgl^{-1}. Fluorides not greater than 1.50mgl^{-1} concentrations are regarded by many as a beneficial constituent of drinking water that aids in the reduction of dental decay, though excessive concentrations may be quite harmful in drinking water. Samples tested were below the recommended limit of 1.5mgl^{-1} permissible maximum limits.

Phosphate

Phosphates are generally low with values ranging from 0.13 - 1.19mgl^{-1}. Sample tested are generally below 10mgl^{-1} standard recommended limits in drinking water.

Hardness

Hardness in water is caused by calcium and magnesium ions resulting from water coming in contact with the geological formation. Generally, groundwater is found to be more hard compared to surface water. Public acceptance of hardness varies, although there are objections to water harder than 150mgl^{-1}(Hammer, 1977). The total hardness of the samples tested in the study varied from 8.0 - 146mgl^{-1}. Only samples from BH_1 and BH_2 are moderately hard (75-150mgl^{-1}) while others are purely soft waters (less than 75mgl^{-1}). A reasonable number of research works supports moderately hard waters for human consumption.

Comparative analyses of pH, Fluoride and Total Alkalinity values for the samples indicated that linear relationship exists between the pH and Flouride, and pH and Total Alkalinity. The relationships are linearly correlated and are expressed as follows:

$F^- = -1.3996 + 0.3611pH$ ***(r = 0.93)*** and

$TA = -271.034 + 60.066pH$ ***(r = 0.90)***

Where F^- is the fluoride value, TA is the Total Alkalinity and *r* is the correlation coefficient.

Total iron

Iron concentrations range from 0.01 - 4.0mgl^{-1}. The WHO Maximum Permissible level is 0.5mgl^{-1}. BH_1, BH_2 and BH_5 show slightly high iron concentration of up to 4.0mgl^{-1}, 3.5mgl^{-1} and 3.0 mgl^{-1} respectively. High concentrations of iron could cause staining of laundry, plumbing fixture and cause an undesirable taste in beverages (Olanrewaju et al, 1997). Water containing more than 0.2mgl^{-1} of iron is objectionable for most industries (Todd, 1980). It is observed that BH_1, BH_2 and BH_5 may not be suitable for human consumption and industries without proper treatment.

Bacteriological Test

Bacteriological test carried out in the study area does not reveal any faecal contamination. Tested samples contained no concentration of coliforms.

Table 1: Location of Water Samples in the Study Area

Sample No.	Date of Collection	Borehole Type	Locality Name (All in Osogbo Osun State of Nigeria)	Time
1	October 2002	BH_1	Ministry of water Resources	1^{20} pm
2	October 2002	BH_2	Ministry of Land	1^{50} pm
3	October 2002	BH_3	Ministry of Information	12^{05} pm
4	October 2002	BH_4	Ministry of Trade and Commerce	1^{30} pm
5	October 2002	BH_5	Ministry of Works and Transport	2^{10} pm
6	November 2002	BH_6	Ministry of Local Government	11^{12} a.m
7	July 2003	BH_7	Ministry of Agriculture and Natural Resources	4^{38} pm
8	August 2003	BH_8	Ministry of Education	11^{05} a.m
9	August 2003	BH_9	Ministry of Finance and Economic Planning	11^{35} a.m

Table 2: Hydrochemical Data of Ground Water Samples in the Area

Samp No	Taste and Odour	Temp (^{0}C)	pH	Turbidity (N.T.U)	Conductivity (Vmho/gm)	Cl^- [mg/l]	F- [mgl]	Fe^{3+} (mgl)	Al^{3+} [mg/l]	Mg^{2+} [mg/l]	PO_4^{4-} [mg/l]	No_3^- [mg/l]	Total Hardness [mg/l]	Calcium Hardness [mg/L]	Total Alkalinity [mg/l]	Bacterio-logical Test
BH_1	Objection-able	30.7	5.8	>10	0.20	130	0.53	4.0	0.03	26.0	0.57	0.9	114.0	88.0	74.0	N. G
BH_2	Objection-able	30.3	5.0	>10	0.11	56.0	0.29	3.5	0.00	20.0	0.13	0.4	146.0	126.0	56.0	N. G
BH_3	None	34.5	7.1	>10	0.39	0.4	1.28	0.09	0.04	12.0	0.35	0.9	72.0	60.0	148.0	N. G
BH_4	None	35.9	4.8	<10	0.07	11.0	0.42	0.10	0.12	0.0	0.15	17.0	8.0	8.0	20.0	N. G
BH_5	Objection-able	35.0	6.2	>10	0.36	0.4	0.88	5.0	0.02	8.0	0.31	0.02	48.0	40.0	144.0	N. G
BH_6	None	31.9	4.7	<10	0.13	19.0	0.42	0.15	0.04	0.00	0.29	5.0	10.00	10.00	12.00	N. G
BH_7	None	29.9	5.9	<10	0.18	20.0	0.63	0.10	0.32	5.0	0.61	3.0	30.0	25.0	52.0	N. G
BH_8	None	30.1	5.2	<10	0.25	15.0	0.4	0.08	0.03	10.0	1.19	10.0	48.0	36.0	22.0	N. G
BH_9	None	30.1	5.0	<10	0.11	10.0	0.5	0.02	0.0	0.0	1.03	2.0	22.0	22.0	18.0	N. G

Table 3: Guidelines on Drinking Water by World Health Organization (WHO), National Agency for Food and Drug Administration a nd Control (NAFDAC; NIGERIA) and National P rimary Drinking Water Regulation (NPDWR; US).

S/No	Test Physical parameters	Max. Acceptable Conc. (WHO)	Max. Allowable Conc. (NAFDAC)	Max. Contaminant Level NPDWR (US)
1.	pH. Range	7.0 – 8.5	6.5 – 8.5	6.5 – 8.5
2.	Turbidity Units	5NTU	-	5 (NTU)
3.	Odour	Unobjecttionable	Unobjectionable	3Threshold Odour No.
4.	Taste	Unobjectionable	Unobjectionable	Flat (tasteless)
5.	Temperature	29°C	26 - 30°C	30°C
	Inorganic Constituents			
6.	Total Alkalinity	100mg/l	100mg/l	100mg/l
7.	Iron (Fe)	00.5 – 0.3mg/l	-	Not exceeding 0.3mg/l
8.	Calcium (Ca)	75 – 200mg/l	75 – 150mg/l	75 – 150mg/l
9.	Magnesium (Mg)	50mg/l	30mg/l	50mg/l
10.	Chloride (Cl)	200mg/l	200mg/l	Not exceeding 250mg/l
11.	Fluoride (F)	1.5mg/l	-	4.0mg/l
12.	Aluminum	0.5mg/l	-	0.05 – 0.2mg/l
13.	Nitrate as NO_3	50mg/l	-	10mg/l
14.	Carbon Dioxide (CO_2)	50mg/l	-	50mg/l
15.	Phosphate (PO_4)	10mg/l	10mg/l	10mg/l
16.	Total Hardness (TH)	75 – 150mg/l	75 – 150mg/l	60 – 120mg/l
	Microbiological Standards			
17.	Aerobic mesophilic count/ml			
	Coliform count/ml	-	10^2 (Max)	-
18.		Must not be detectable in any 100ml per sample. Must not be present in 95% of sample taken though out any 12 months period. Must not be detectable in any 100ml per sample.	1 (Max)	No more than 5% samples total coliform – positive in a month.
19.	*E. coli* anumeration/ml	No Growth	0 (Max)	No more than 5% samples total coliform – positive in a month
20.	Bacteriological Test		*No Growth*	No Growth

Source: NAFDAC (2001)

CONCLUSIONS

Groundwater samples from Osun State Secretariat, Osogbo SW Nigeria have been analyzed for ionic concentrations. BH_1, BH_2 and BH_5 have an objectionable colour and taste. Almost all the water samples were acidic except BH_3 that exhibited neutral properties. Apart from samples taken from BH_1 and BH_2, which are moderately hard, other samples in the study area are very soft.

With the exception of the samples taken from BH_1, BH_2 and BH_5, all the iron concentration levels for the tasted water indicate that borehole waters in the study area are chemically suitable for drinking. There is a correlation between the iron concentration and colour and taste of the tested water samples BH_1, BH_2 and BH_5. Higher concentrations of iron in water can cause staining of laundry, plumbing fixture and an undesirable taste in beverages.

With respect to bacteriological analysis, there is observable absence of coliform bacterial in the tested water making them to be safe for drinking.

Based on these, it is concluded that the groundwater from the study area can be said to be of good quality. It is however necessary to use standard materials in borehole installation and have regular servicing to eliminate the iron concentration of the borehole water.

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