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Full Length Research Paper

Assessment of groundwater quality in unconsolidated sedimentary coastal aquifer in Lagos State, Nigeria

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This study assesses the quality of ground water from nine different borehole locations in Lagos State, Nigeria. Borehole water samples were carefully collected for physico – chemical analyses. Calcium, magnesium, iron, zinc, copper, manganese, aluminium, and silver, Nitrate, phosphate, fluoride, chloride, pH, conductivity, total dissolved solid, total suspended solid, hardness, summation of ions as well as the temperature and colour were assessed among the entire samples collected. The results shows that: temperature ranges from 26.6 - 27.8°C, pH (7.27), average conductivity (462.2 µs/cm), TDS (204.73 mg/l), Total hardness (18.48 - 297.70 mg/l) and Chloride concentration (343.3 mg/l). However a high value of chloride, 343.3 mg/l, was recorded in one of the water sample collected but, this is higher and above the limit of WHO guidelines of portable water (250 mg/l). This may be due to the proximity of the area where the sample was collected to the sea. Five samples of the water are is soft, that is, hardness was within a range of 0 – 75 mg/l recommended for safe drinking water, one is moderately hard while three samples are hard. Also the presence of metals such as zinc, manganese, sodium, copper and magnesium were also observed. Results show that not all the water samples are safe for drinking purposes.

Key words: Borehole water, physico – chemical parameters, water quality, Lagos state.

INTRODUCTION

Water and its management will continue to be a major issue with definite and profund impact on our lives and that of our planet earth (Herschy, 1999). Water is the most important natural resources without which life would be nonexistent. Availability of safe and reliable source of water is an essential prerequisite for sustainable development. Deserts are not habitable because of lack of water (Asonye et al., 2007).

Freshwater quality and availability remain one of the most critical environmental and sustainability issues of the twenty-first century (UNEP, 2002). Of all sources of freshwater on the earth, groundwater constitutes over 90% of the world's readily available freshwater resources (Boswinkel, 2000) with remaining 10% in lakes, reservoirs, rivers and wetlands.

Groundwater is also widely used as a source, for drinking water supply and irrigation in food production (Zekster and Everett, 2004). However, groundwater is not only a valuable resource for water supply, but also a vital component of the global water cycle and the environment. As such, groundwater provides water to rivers, lakes, ponds and wetlands helping to maintain water levels and sustain the ecosystems. Moreover, some field investigators indicate groundwater as a surprisingly important source of water and sole input to coastal waters (Lewis, 1987; Moore, 1996; Kim et al., 2003). Scientific findings on how coastal and oceanic chemicals interact with the ecosystem posses challenges to our understanding (Church, 1996). Saline intrusion into coastal aquifers has become a major concern (Batayneh, 2006) because it constitutes the commonest of all the pollutants to freshwater. Therefore, understanding of saline intrusion is essential for the management of coastal water resources (Ginzburg and Levanon, 1976).

Due to massive influx of people from other parts of Nigeria to Lagos metropolis, the population of Lagos has increased from ten to fifteen million in recent times and there is annual population increase of 3% (UNDP, 2006).

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Therefeore, there is an increase in the demand of water resulting in concomitant acute water shortage to meet the daily water consumption needs of the people. Most of the residents have resorted to depend on borehole water both for domestic and industrial usage (Adepelumi et al., 2008). The aim of this research is to compare the values obtained for the above stated hydro chemical parameters with W.H.O. standard values in order to determine the palatability or otherwise of borehole water for domestic purposes in Lagos, Nigeria.

METHODOLOGY

The methods employed for this study are sampling and laboratory analysis. A detailed field sampling exercise was carried out, while laboratory analyses of the water samples were carried out at Dana's water laboratory, Ibadan.

Samples used for determination of metals, physical properties, SO_4^{2-} and NO_3^- were collected in plastic bottles. Samples for NO_3^-, SO_4^{2-} and PO_4^{3-} were refrigerated and analyzed within 24 h. All plastics and glass wares utilized were pre-washed with detergent water solution, rinsed with tap water and soaked for 48 h in 50% HNO_3, then rinsed thoroughly with distilled deionized water. They were then air-dried in a dust free environment.

Sample collection

Water samples were procured from Nine Boreholes in different locations in Lagos State at different distances away from the Ocean and Lagoon. The samples were collected in sterilized white plastic containers. Samples used for determination of the quality assurance measure taken in carrying out the analysis was the "multiplicity of samples" approach. With all obtained results only very little variation was observed. This implies that the analysis was honestly carried out by the laboratory technologist. Metals, physical properties, SO_4^{2-} and NO_3^- were collected in plastic bottles.

Water analysis

Water quality parameters analyzed are physical properties such as: pH, colour, temperature, conductivity, total suspended solids (TSS), total dissolved solids (TDS), and hardness. Chemical parameters such as: sodium (Na), calcium (Ca), magnesium (Mg^{2+}), iron (Fe^{2+}), manganese (Mn^+), aluminium (Al^{3+}), zinc (Zn^{2+}), silver (Ag^+), copper (Cu^{2+}), chloride (Cl^-), fluoride (F^-), nitrate (NO_3^-), sulphate (SO_4^{2-}) and phosphate (PO_4^{3-}) were also analysed from each sample.

pH was analyzed using a pH meter. Cations were analyzed using an atomic absorption spectrophotometer (Perkin – Elemer AAS3110), while anions were analyzed using the colorimetric method with UV, spectrophotometer (WPAS110). Total dissolved solids (TDS) were analyzed using the gravimetric method (Ofoma et al., 2005).

RESULTS

The temperature ranges between 26.6 and 27.8. The pH of all samples taken range between 6.04 - 8.45.

For save drinking water, the highest desirable level is 7 – 8.5 (WHO, 1984; Range values of physical-chemical parameters standards for drinking water). However samples 1 to 4, namely Omole, Yaba, Magodo and Igando borehole samples fall below the 7.0 desir-able pH level. They also fall below the highest permi-ssible range 6.5 – 9.2 (WHO, 1984).

Sample 1, that is borehole water sample from Omole has the least conductivity while sample 7, that is borehole water sample from Eti-Osa has the highest conductivity of 1511.00 µs/cm. The least Total disolved solids (TDS) was observed in sample 1 (14.7 mg/l) while the highest TDS was observed in sample 7, that is Eti Osa (751 mg/l). The average TDS was 204.73 mg/l.

The chloride concentration is lowest in sample collected from sample 1 and 2 (that is omole and Yaba). This value was 15.84 mg/l. The highest chloride concentration of 343.20 mg/l was observed in sample 7, that is Eti Osa and the average chloride concentration in all the borehole samples 81.89 mg/l. Total hardness varies between 18.58 and 297 mg/l. 33.33% of the water samples are hard, about 55.55% are soft, while 11.11% are moderately hard.

DISCUSSIONS

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These results show a direct relationship between Chloride concentration, conductivity and the Total dissol-ved solid TDS. Variations exist among the conductivities, TDS and Chloride values obtained from two locations-Omole and Eti –Osa. This is because of the high population densities in these areas and the subsequent high rate of groundwater abstraction.

About 22 parameters were considered in this work. Tables 1a and 1b show the results of their physico-chemical analysis. Figure 1 is a graph showing the variations of each of the considered parameters. Figure

Table 1a. Hydrochemical parameters of borehole water samples from lagos aquifers.

SP/No	Temp (°C)	pH	Odour	Color	Ca_2^+ (mg/l)	Mg_2^+ (mg/l)	Fe (mg/l)	Conductivity µs/cm	TDS (mg/l)	TSS (mg/l))
SP/01	26.7	6.27	Unobject ionable	Colourless	32.6	17.90	0.01	31.90	14.70	11.0
SP/2	26.6	6.43	Unobject ionable	Colourless	46.1	15.27	0.09	63.20	29.70	Nil
SP/3	29.5	6.46	Unobject ionable	Colourless	8.8	9.68	0.00	198.80	95.10	12.0
SP/4	26.8	6.04	Unobject ionable	Colourless	32.1	19.00	0.18	437.00	211.00	22.0
SP/05	26.9	7.07	Unobjecti onable	Colourless	45.9	37.60	0.16	410.00	197.80	16.0
SP/06	27.8	7.04	Unobje ctionable	Colourless	109.0	97.00	0.28	617.00	300.00	12.0
SP/07	27.5	7.45	Unobjec tionable	Slightly coloured	189.0	108.00	0.29	1511.00	751.00	14.0
SP/O8	28.2	8.01	Unobject ionable	Slightly coloured	117.0	104.00	0.31	779.00	380.00	11.0
SP/09	27.0	7.68	Unobjec tionable	Colourless	10.3	12.10	0.01	112.10	53.30	18.0

Table 1b. Hydrochemical parameters of borehole water samples from Lagos aquifers.

SP/No	Zn^{2+} (mg/l))	Cu^{2+} (mg/l)	Mn^{2+} (mg/l)	Al^{3+} (mg/l)	Na^+ (mg/l)	Ag^+ (mg/l)	F^- (mg/l)	Cl^- (mg/l)	NO_3^- (mg/l)	PSO_4^{2-} (mg/l))	T.H (mg/l)	Sum of Anions (mg/l)	Sum of Cations (mg/l)	Sulphate (mg/l)
SP/01	Nil	0.01	17.9	0.001	0.0	0.000	0.05	15.84	1.0	0.01	50.5	16.9	50.72	0.0
SP/2	0.02	0.03	15.27	0.001	0.0	0.001	0.01	15.84	1.2	0.00	61.66	19.05	61.71	2.0
SP/3	0.01	0.03	9.68	0.000	0.1	0.001	0.08	30.80	10.4	0.00	18.58	42.28	18.72	1.0
SP/4	0.05	0.09	19.0	0.001	0.2	0.002	0.17	53.68	1.5	0.40	51.58	68.75	51.92	13.0
SP/05	0.04	0.06	37.6	0.001	0.2	0.002	0.19	58.08	1.3	0.42	83.86	68.00	84.16	8.0
SP/06	0.07	0.21	97.0	0.002	0.3	0.002	0.12	75.68	1.4	0.48	206.28	121.68	206.86	44.0
SP/07	0.08	0.25	108.0	0.003	0.8	0.005	0.18	343.20	1.1	0.67	297.70	417.15	298.83	72.0
SP/O8	0.06	0.10	104.0	0.002	0.4	0.002	0.13	121.00	1.9	0.50	221.51	183.97	222.07	60.0
SP/09	0.02	0.05	12.1	0.000	0.0	0.000	0.05	22.88	1.2	0.01	22.51	35.14	22.58	11.0

TDS –Total dissolved solid; T.H – Total Hardness; TSS- Total suspended solid.

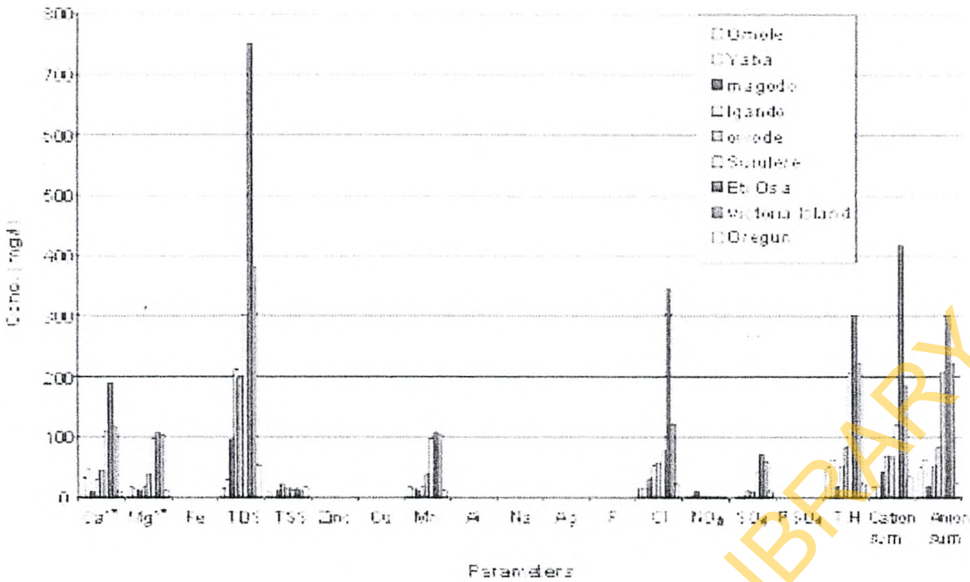

Figure 1. Diagram showing the variation of nineteen physico-chemical parameters of borehole samples collected from different locations in Lagos.

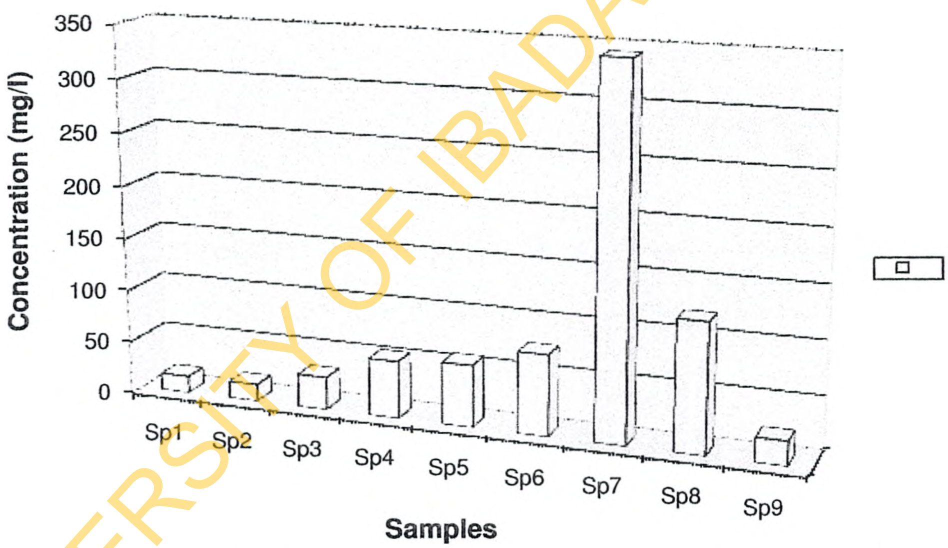

Figure 2. Chart showing the Conductivities of the Borehole samples from selected locations in Lagos.

2, shows the variation of conductivities in samples, Figure 3, shows the variation of chloride concentration in the samples. Tables 2a and 2b show the conductivities and the chloride concentrations in all the water sample respectively. Table 3 shows general hardness classification as well as the percentage hardness of water samples (Freeze and Cherry, 1979). The third column of Table 3 is the percentage hardness of the water classification of this work. Table 4 shows the WHO Range values of physical-chemical parameters standards for drinking water. Figure 4 shows the percentage hardness of the water samples.

Conclusion

Results show that some of the water samples considered in this work compares favourably with WHO (1984) water

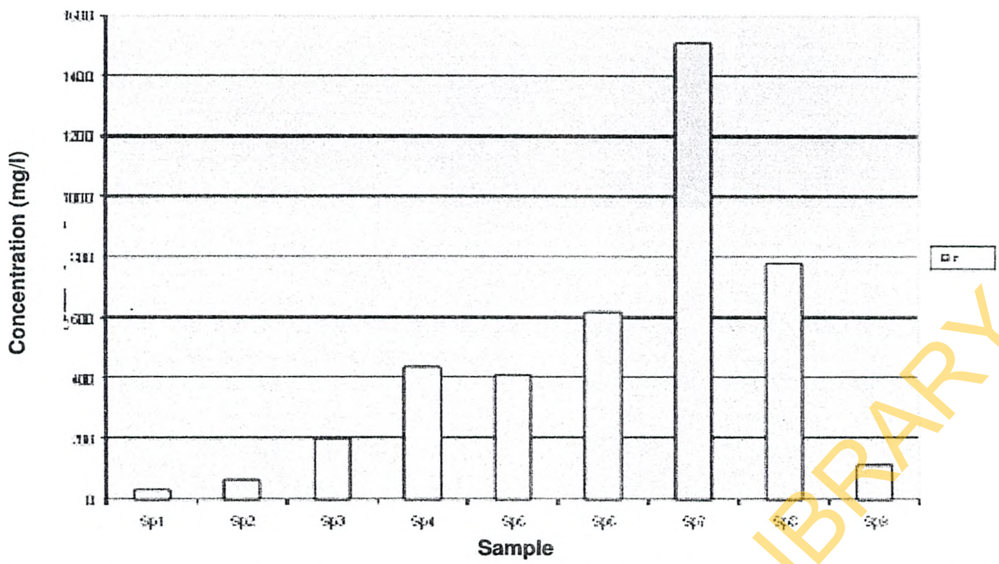

Figure 3. Chart showing the chloride concentration of the Borehole samples from selected locations in Lagos.
Note: Sp1-Omole; sp2- Yaba; sp3-Magodo; sp4- Igando; sp5- Owode; sp6- Surulere; sp7- Eti-Osa; sp8- Victoria Island; sp9- Oregun

Table 2a. Conductivities of borehole water samples from selected location in Lagos.

Samples	Sp1	Sp2	Sp3	Sp4	Sp5	Sp6	Sp7	Sp8	Sp9
Conductivities (µs/cm)	31.90	63.2	198.8	437.0	410.0	617.0	1511.0	779	112.1

Table 2b. Chloride concentration of borehole water samples from selected location in Lagos.

Samples	Sp1	Sp2	Sp3	Sp4	Sp5	Sp6	Sp7	Sp8	Sp9
Concentration (mg/l)	15.84	15.84	30.80	53.68	58.08	75.68	343.20	121.0	22.88

Table 3. Percentage hardness of the water samples (Freeze and Cherry, 1979).

Hardness $(Ca^{+}Mg\ CO_3^{2-})$ mg/l	Water Classification	% Result of this Study
0 – 75	Soft	55.55
75 – 150	Moderately hard	11.11
150 – 300	Hard	33.33
>300	Very hard	-

standard for drinking and domestic usages while some other samples of boreholes water fall short of this standard. We can therefore conclude that the borehole water in the selected locations is not totally portable.

Eti – Osa for example has the highest value of chloride concentration which is above the standard safety regulation for drinking. This may be due to high number of people living in this area which will translate to high abstracttion of groundwater and the subsequent intrusion from the sea.

Table 4. Range values of physical-chemical parameters WHO (1984) Standards for drinking water.

S/No	Concentration level	Highestdesirable level	Maximum permissible level
1	pH	7 – 8.5	6.5 – 9.2
2	Color (oH)	5	50
3	Total dissolved solids (TDS) Mg/l	500	1500
4	Total hardness (T.H) Mg/l	100	500
5	Na^{2+} Mg/l	-	-
6	K2+ Mg/l	-	-
7	Ca^{2+} Mg/l	75	200
8	Mg^{2+} Mg/l	50	150
9	Fe^{2+}Mg/l	0.1	1.0
10	PO4- Mg/l	-	-
11	NO_3^- Mg/l	45	50
12	SO_4^{2-} Mg/l	200	400
13	Cl^- Mg/l	250	600
14	CO_3^{2-} Mg/l	-	120
15	HCO_3^- Mg/l	-	-

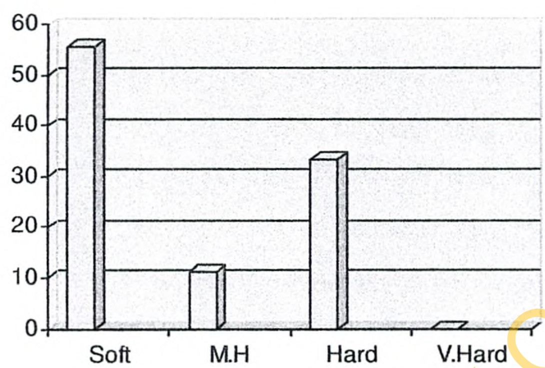

Figure 4. Chart showing the percentage classification of the hardness of th analysed Borehole water samples. Note: M.H means Moderately Hard; V. Hard means Very Hard.

More work need to be done in this area by means of extending the area of research to include the whole geographical location of Lagos in order to ascertain the extent of the conformity of groundwater to WHO safety standard.

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