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A Comparative Study of Borehole Water Quality from Sedimentary Terrain and Basement Complex in South-Western, Nigeria

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Abstract: Analytical study of boreholes water quality in both sedimentary terrain and basement complex were carried out with 16 samples from different boreholes, collected from two different States (regions) representing the lithology in South Western Nigeria. It is in no doubt that the composition of a terrain has influence on the water quality and from both terrains, it was observed that the pH ranges from 5.30 to 7.60, Iron, Nitrite, Nitrate and Manganese contents have maximum values of 2.70, 2.00, 7.30 and 0.10 mg L^{-1}, respectively. Total alkalinity ranges from 12.00-155.0 mg L^{-1}, total hardness ranges from 21.00-275.00 mg L^{-1}, salinity ranges from 15.00-566.00 mg L^{-1}, chloride ranges from 5.50-70.00 mg L^{-1}, but sulphate is absent in all the water samples. The obtained results showed how elemental compositions vary with lithology and how water qualities in the two zones are almost suitable for use/consumption of the populace. Although, some samples from the Sedimentary basin have slight high Iron content, this calls for attention.

Key words: Sedimentary, basement, comparative study, water quality, geochemistry

INTRODUCTION

Water is of fundamental importance to human life, animals and plants, it is of equal importance with the air we breathe in maintaining the vital processes to life and it makes up about 60% of body weight in human being.

Among the various sources of water, groundwater is known to be more appropriate and often meets the criteria of quality of water, the most widely used as sources of water in most African countries, Nigeria inclusive. The quality of groundwater is the resultant of all the processes and reactions that act on the water from the moment it condensed in the atmosphere to the time it is discharged by a well or spring and varies from place to place and with the depth of the water table (Jain *et al*., 1995; Todd, 1980). Ground waters have unique features, which render them suitable for public water supply (Alexander, 2008; Offodile, 1983). They have excellent natural quality, usually free from pathogens, color and turbidity and can be consumed directly without treatment (Jain *et al*., 1996). It's widely distributed and can frequently develop incrementally at points near the water demand, thus avoiding the need for large-scale storage, treatment and distribution system (Alexander, 2008). Groundwater is particularly important as it accounts for about 88% safe drinking water in rural areas, where population is widely dispersed and the infrastructure needed for treatment and transportation

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of surface water does not exist. Nevertheless, there are various ways groundwater may suffer pollution e.g., land disposal of solid wastes, sewage disposal on land, agricultural activities, urban runoff and polluted surface water (Jain *et al*., 1995).

The chemistry of rocks and soils and the rock geological conditions in any borehole has a great influence on the quality of water which determines the concentration of introduced cations and anions such as Na^+, K^+, Mg^{2+}, Fe^{2+}, NO_3^-, CO_3^{2-}, SO_4^{2-}, Cl^- and so on.

The comparison of hydro geochemistry of the borehole water will help to ascertain the water quality in those terrains, however, the assessment of groundwater quality will be based on the physical and chemical characteristics while the physical characteristics of groundwater includes the electrical conductivity, Total dissolve solids, pH value, color, turbidity and hardness. The interplay between turbidity and contour current processes on the Columbia Channel fan drift, Southern Brazil Basin.

Thus, this study was aimed at determining the physicochemical parameters concentrations in the boreholes which is one of the main sources of water supply in Oyo and Lagos States and at the same time sets to review and compare the qualities of borehole water in the said studied areas.

MATERIALS AND METHODS

Study Areas

The two study areas are located in South-Western, Nigeria. Oyo State is lies between latitude 7° and 10°N and longitude 2° and 5°E (Fig. 1a). on the other hand Lagos State is lies between latitude 6° and 7°N and longitude 2° and 5°E (Fig. 1b).

Geology of the Study Areas

Five tectonic events were recognized using radiometric dating in the West African craton to which the Nigerian Basement complex belongs. Basement complex underlines virtually every part of the country, but occur mainly in the South-Western, Eastern and North Central part of Nigeria. It also extends Western-wards and is apparently continuous with the Precambrian rocks of Dahomey (Omatsola and Adegoke, 1981). The basement complex rocks of Nigeria, based on their petrology are composed predominantly of five classes namely: Migmatite gneiss, Schist, Charnockitic rocks, older granites and non-metamorphosed dolerite dykes.

Sedimentary rocks predominantly compose of sands, sandstones and limestone; cover about half of the surface of Nigeria. Crystalline igneous and metamorphic rocks generally referred to as the basement rock cover the rest of the country.

Oyo State is underlain by Pre-Cambrian rocks which forms part of the Basement complex of South Western Nigeria. On the other hand, Lagos is located on sedimentary rock of the southwestern part of Nigeria, it lies within the Dahomey basin, which termed the Benin basin (Adegoke, 1969; Agagu, 1985; Aseez, 1971) (Fig. 2, 3).

Experimentation

The study was conducted over a period of 6 months, precisely between August 2007 and Feb. 2008 between two main States representing the sedimentary and basement formations (Lagos and Ibadan respectively) within the South-Western part of Nigeria.

Eight water samples were collected in four LGAs in Oyo State with 1 sampling point each in Lagelu, Ibadan North, Ibadan North-West and 5 sampling points in Ibadan South-West.

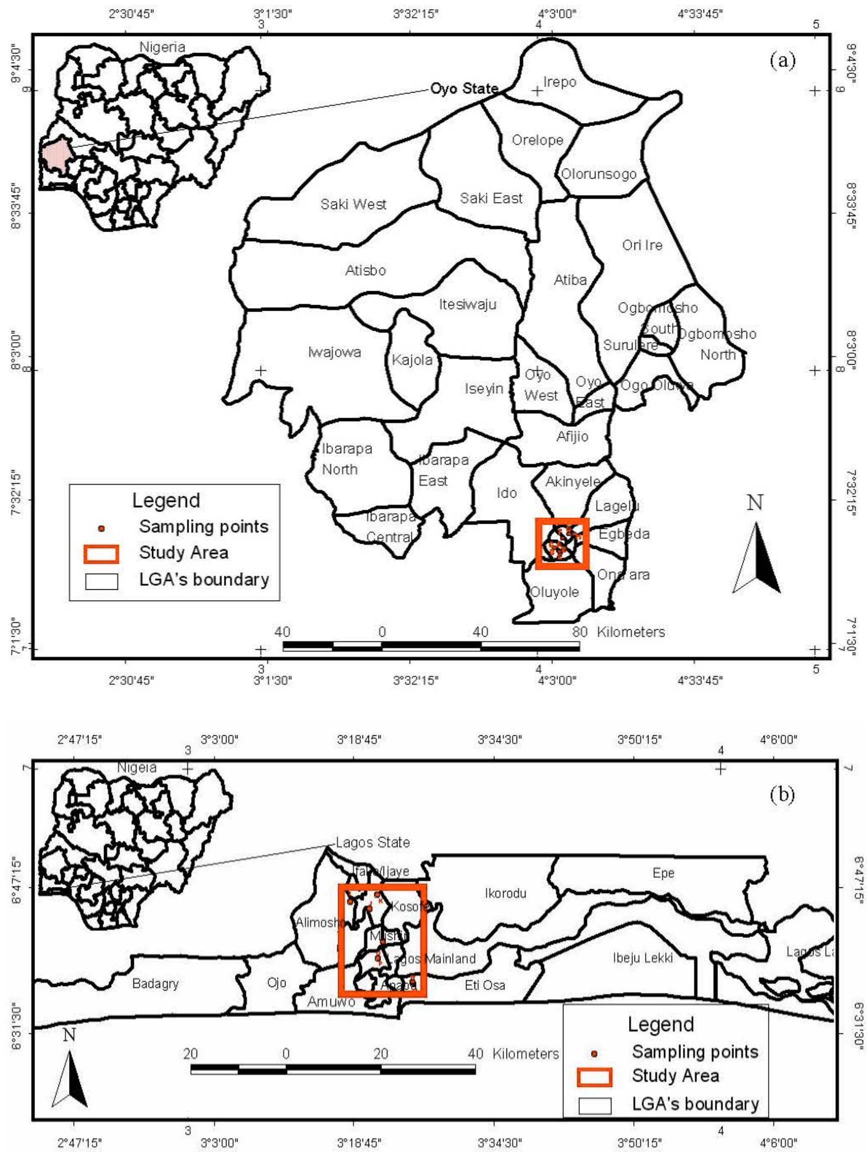

Fig. 1: Study area of Nigeria, (a) Oyo State and (b) Lagos State

The samples were taken from boreholes in areas like Ring Road, Felele, Adeoyo State Hospital, Lajoogan House, Idi-Ape, Iwo Road. On the other hand, in Lagos State, 1 sampling points each in Alimosho and Surulere LGAs, 2 each in Eti-Osa, Ikeja and Somolu LGAs. The samples were taken in the following area; Shasha, Ikeja, Alausa, Shomolu, Ikoyi and Surulere.

The samples were taken with 2 L container and transported to the laboratory the same day. The geochemical analysis were carried out according to the approved standards.

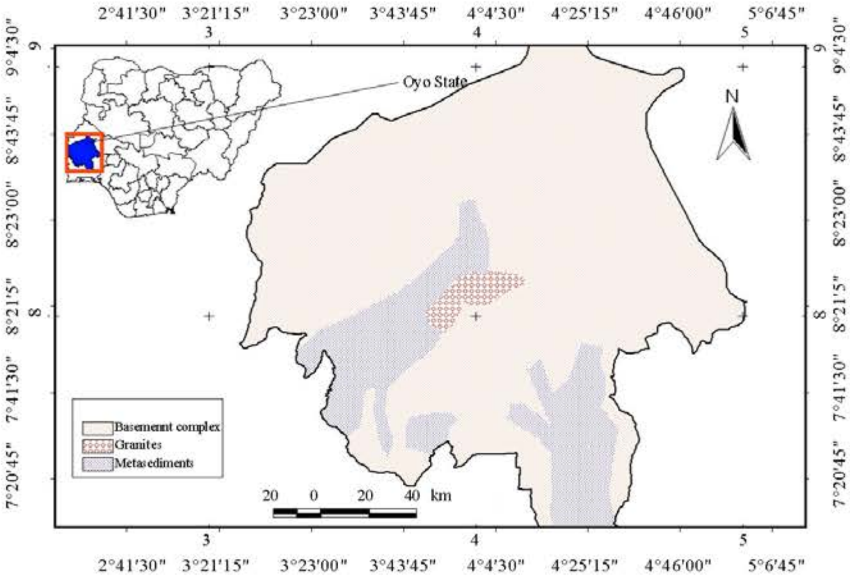

Fig. 2: Geological setting of Oyo State, Source: After Balogun (2000)

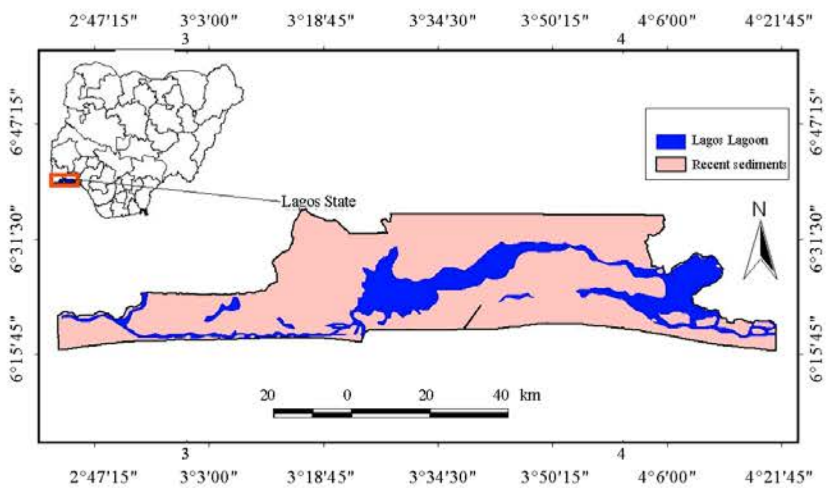

Fig. 3: Geology setting of Lagos, Source: After Balogun (2000)

RESULTS AND DISCUSSION

It w as observed that all the water samples were odorless, tasteless and colorless (Table 1). The color values are found to be between 5 and >10 TCU. Turbidity is generally low and between 1.4 and 9.7 NTU in the two zones except point K which is extremely high of about 140 NTU (Table 1, Fig. 4b). On the average the results of conductivity, turbidity,

Table 1: Borehole sampling parameters results

S/N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
Easting	596838	596581	596228	597968	598173	599568	602245	604186	534208	538229	539738	540910	547350	547210	539986	539928	
Northing	812946	812830	812918	811745	811620	816664	818457	818320	729628	728243	731031	721688	713269	713654	718374	718323	
Sampling code	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	WHO (2003)
Sampling points	Ring Road, Ibadan	Ring Road, Ibadan	Ring Road, Ibadan	Felele, Ibadan	Felele, Ibadan	Adeoyo State, Hospital, Ibadan	Lajoogan House, Idi-Ape, Ibadan	Adogba Shopping Complex, Iwo Road, Ibadan	ShaSha, Lagos	Ikeja, Lagos	Alausa, Lagos	Shomolu, Lagos	Ikoyi, Lagos	Ikoyi, Lagos	Surulere, Lagos	Surulere, Lagos	
Geology	Basement	Basement	Basement	Basement	Basement	Basement	Basement	Basement	Sedimentary	Sedimentary	Sedimentary	Sedimentary	Sedimentary	Sedimentary	Sedimentary	Sedimentary	
Altitude (Ft)	598	630	520	612	600	725	826	819	189	206	161	115	66	59	85	76	
Depth (Ft)	100	110	120	110	90	130	120	130	174	132	102	123	240	228	234	231	
Appearance	Clear and colourless	Clear and colourless	Clear and colourless	Clear and colourless	Clear and colourless	Clear and colourless	Clear and colourless	Clear and colourless	Clear and colourless	Clear and colourless	brownish	Clear and colourless	Clear and colourless	Clear and colourless	Clear and colourless	Clear and colourless	
Colour (TCU)	5	<10	<10	<10	10	<10	5	5	5	5	>10	10	<10	<10	5	5	
Turbidity (NTU)	1.4	3.1	2.9	2.8	5.5	7	2	1.8	2.9	1.8	140	9.7	7.4	4.8	2	2	5
Conductivity (μsec)	259	107	251	336	287	133	245	340	34	38	56	37	293	291	35	38	
TDS (mg L^{-1})	212	88	215	226	234	1000	178	300	22	24	39	24	241	260	21	27	500
Iron	0	0.2	0	0.1	0.1	0.1	0	0	0.2	2.7	1.5	0	0.4	1.4	0.8	0.8	0.3
Total alkalinity (mg L^{-1})	48	38	38	44	155	80	74	128	12	12	30	15	50	41	30	33	
($CaCo_3$) hardness (mg L^{-1})	73	48	72	85	124	275	84	140	25	35	23	24	50	51	21	24	
Calcium hardness (mg L^{-1})	50	26	50	60	100	190	62	100	16	27	15	17	28	30	14	15	
Magnesium hardness (mg L^{-1})	23	22	22	25	24	75	22	40	9	8	8	7	22	21	7	9	
Nitrite (mg L^{-1})	0	0	0	0		0	0	2	0	0	0	0	0	0	0	0	
Nitrate (mg L^{-1})	7.3	0	5	3.9	0	5.8	0	0	0.6	4.2	7.3	1.1	1.7	0.2	0.4	0.5	10
pH	6.8	6.9	5.7	7.2	7.5	6.4	6.8	7.6	5.4	5.3	6.4	6.3	6.2	6	5.5	5.4	8.5
Salinity (mg L^{-1})	130	54	126	168	143	566	127	170	17	19	28	19	147	145	15	19	
Manganese (mg L^{-1})	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	
Chloride (mg L^{-1})	24	8	33	24	13	70	10	28	7.5	5.5	7.5	6	47	44	6.5	6.8	250

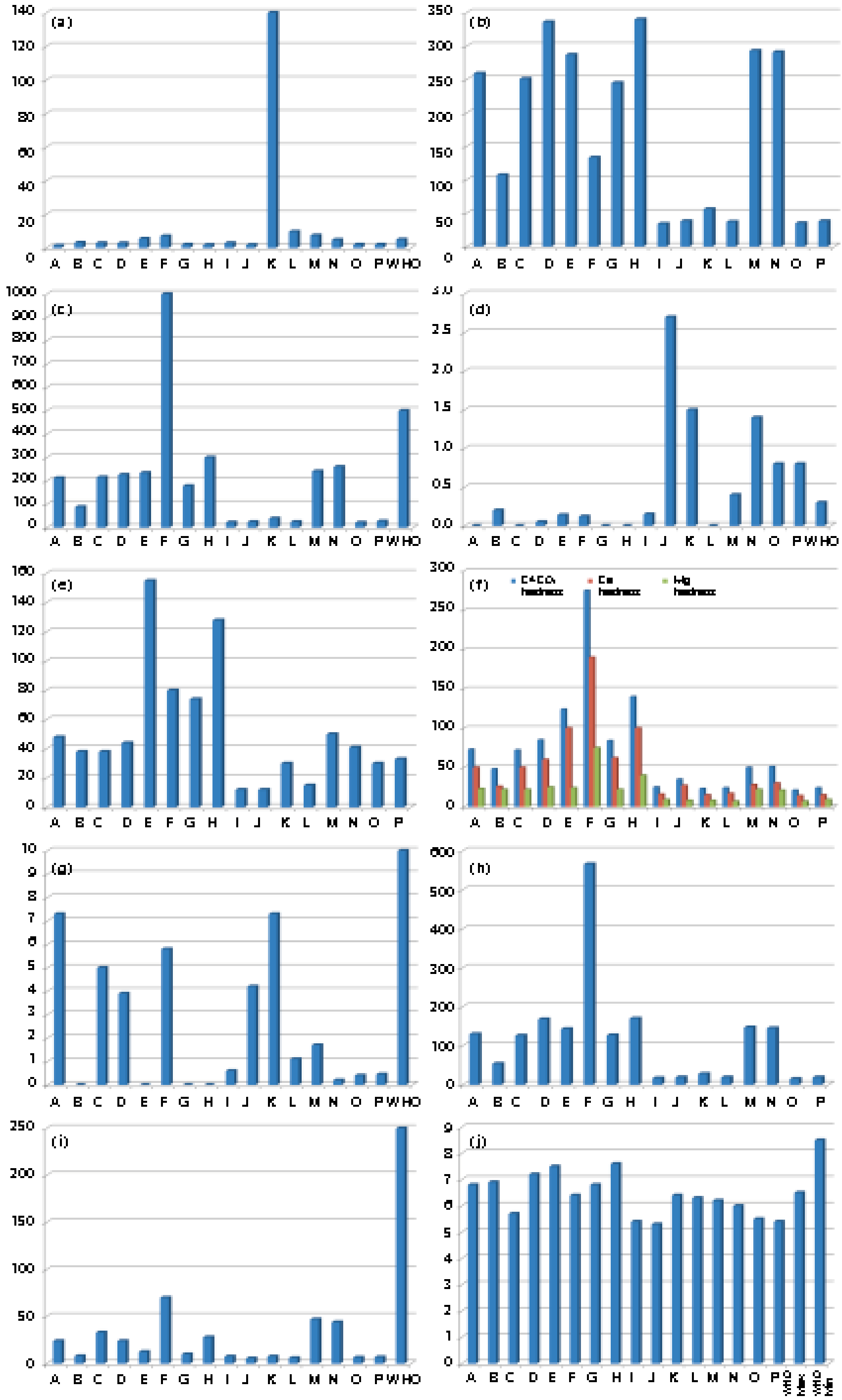

Fig. 4: Distributions of the various analyzed parameters, (a) Turbidity, (b) Conductivity, (c) Total Dissolve Solid (TDS), (d) Iron (Fe), (e) Total alkality, (f) Hardness, (g) Nitrate, (h) Salinity, (i) Chloride and (j) pH

Total Dissolve Solid (TDS), total alkalinity, hardness ($CaCO_3$, Calcium hardness and Magnesium hardness), Nitrate, Salinity, Chloride and pH are lower in sedimentary zone than the basement complex (Table 1, Fig. 4b, c and e-j, respectively). Electrical conductivity values ranged from 34 to 340 μs. TDS values in the 2 zones are generally below WHO limits except

Table 2: Lithology of the Boreholes and their distances apart

S/No.	Samples	Geology	Location	Co-ordinates (UTM)		Altitude (Ft)	Depth (Ft)	Distance between B/H (m)	Lithology (Ft)	
1	A	Basement	Ring road, Ibadan	596838	812946	598	100		0-4	Lateritic topsoil
									5-11	Sand/gravel
									12-28	Weathered basement
									29-40	Gravel/fractured basement
2	B	Basement	Ring road, Ibadan	596581	812830	630	110	282	0-3	Lateritic topsoil
									4-16	Sand/gravel
									17-33	Weathered basement
									34-42	Fairly weathered basement
3	C	Basement	Ring road, Ibadan	596228	812918	520	120	363.8	0-10	Lateritic topsoil
									11-20	Lateritic clayey sand
									21-30	Highly weathered formation
									31-40	Weathered formation
4	D	Basement	Felele, Ibadan	597968	811745	612	110	2098.5	0-3	Lateritic topsoil
									4-8	Sandy clay
									9-20	Gravel/coarse material
									21-30	Clayey sand
5	E	Basement	Felele, Ibadan	598173	811620	600	90	240.1	0-10	Lateritic topsoil
									11-20	Weathered basement
									21-30	Basement granite gneiss
									31-40	Granite gneiss
6	F	Basement	Adeoyo State Hospital, Ibadan	599568	816664	725	130	5233.4	0-10	Lateritic topsoil
									11-20	Clayey sand
									21-30	Clayey sand
									31-40	Clayey sand
									41-50	Weathered basement
7	G	Basement	Lajoogan House, Ide-Ape, Ibadan	602245	818457	826	120	3222.0	0-3	Lateritic topsoil
									4-12	Clayey sand
									13-34	Gravel
									35-40	Weathered basement
8	H	Basement	Adogba Shopping Complex, Iwo Road, Ibadan	604186	818320	819	130	1945.8	0-5	Lateritic topsoil
									6-20	Clayey sand
									21-30	Sand/gravel
									31-40	Weathered basement
9	I	Sedimentary	ShaSha, Lagos	534208	729628	189	174	112974.3	0-6	Fine sand
									6-9	Clayey sand
									9-12	Sandy clay
									12-18	Fine to medium sand
10.	J	Sedimentary	Ikeja, Lagos	538229	728243	206	132	4252.80	0-6	Clayey sand
									6-9	Dark grey clay
									9-12	Fine clayey sand
									12-15	Fine to silt sand
11	K	Sedimentary	Alausa, Lagos	539738	731031	161	102	3170.20	0-9	Sandy caly
									9-12	Fine red clayey sand
									12-24	Silty, clayey sand
									24-30	Clay
12	L	Sedimentary	Shomolu, Lagos	540910	721688	115	123	9416.20	0-9	Laterite
									9-12	Sandy clay
									12-24	Fine, silty sand
									24-30	Fine sand
13	M	Sedimentary	Ikoyi, Lagos	547350	713269	66	240	10599.70	0-6	Fine yellowish sand
									6-12	Clayey peat
									12-24	Sandy clay
									24-30	Whitish clay
14	N	Sedimentary	Ikoyi, Lagos	547210	713654	59	228	409.70	0-6	Fine yellowish sand
									6-9	Sandy clay
									9-12	Peat
									12-30	Whitish clay
15	O	Sedimentary	Surulere, Lagos	539986	718374	85	234	8629.30	0-3	Fine sand
									3-6	Sandy peat
									6-12	Sandy clay
									12-24	Fine to medium sand
16	P	Sedimentary	Surulere, Lagos	539928	718323	76	231	77.20	0-3	Clayey sand
									3-6	Fine grain sand
									6-12	Clay
									12-24	Fine sand

point F. Iron in basement complex was observed to be lower than sedimentary zone on average (Table 1, Fig. 4d). Samples from basement had iron contents within the WHO recommendations while some of the water samples in sedimentary have Iron contents higher than the World Health Organization (2003) recommendation which may be due to iron encrustation which is caused by ferrous iron which is soluble in water and are deposited as ferric iron. Similarly, Manganese may form encrusted when the bicarbonate reacts with oxygen to form insoluble Manganese Hydroxide.

According to Gibbs (1970), water chemistry is mainly influenced by dilution and slightly from weather product of the rock type.

The relatively high levels of turbidity and variation in color could be attributed to the presence of decaying organic matter (Hiscott *et al*., 1997; Coulibaly and Rodriguez, 2003; Rim-Rukeh *et al*., 2006). While the groundwater in the two zones (Basement and sedimentary) varies between slightly acidic and slightly alkaline, according to the classifications of Ezeigbo (1988) but rather falls within the range of WHO recommendation standard for pH value within 5.30-7.50.

From this study, it can be seen that the chemical analysis revealed the water quality from basement complex and sedimentary terrain to have almost the same quality and is good for purposes such as drinking and domestic use, it was also noticed that some of the water from Lagos, that is sedimentary have slightly higher iron content. Meanwhile, as water seeps through the ground and adds to its mineral content, much of its suspended matter, color and bacteria content are filtered out. Thus, a deep well is likely to produce water that is clear, colorless and low in bacteria count as found in the two zones of study. In conclusion, it's apparent that the composition/lithology (Table 2) of a terrain has no matter how little-influence on the borehole water quality.

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