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PRELIMINARY ASSESSMENT OF THE ENVIRONMENTAL IMPACTS OF LANDUSE PATTERNS ON GROUNDWATER QUALITY

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ABSTRACT

This work evaluated the variational impacts of landuse patterns on groundwater quality in Ogbomosho and its environs. Two representative samples each, were obtained from locations closest to areas, where hospitals, car wash, mechanic workshop, market, motor park, burial ground, farming, refuse dump site, soak away, petrol station, cottage industries (block making and saw- mill), and residential areas were observed. Samples were subsequently subjected to standard analytical procedures.

The ranges of results for the physico-chemical and biological parameters analyzed include pH (5.0-8.6),TDS (149.38-833.03 mg/1),Ca hardness (26.0-194.0mg/1),Mg hardness (10.0-181.0 mg/1,Ca^{2+} (7.8-18.6 mg/1, and Mg^{2+} (2.24-45.0 mg/1. Others include HCO_3 (40.0-160.0 mg/1, SO_4^{2-} (0.1-99.0 mg/1), Total Fe (0.1-5.4 mg/1, Mn^{2+} (0.01-0.12 mg/1), $C1^-$ (3.43-686 mg/1) and total coliform (0-1100 MPN/100ml). The analytical results how that major ionic concentrations fall below the highest desirable limits of global drinking water standards. However, low average pH values were observed in samples obtained from refuse dump sites (5.1), soak-away (5.7) and petrol stations (6.0), while high average total iron concentrations (measured in mg/g were observed in samples obtained from petrol stations (I..l) burial grounds (2.1), soak away (1.1), and refuse dump sites (1.9). Samples from mechanic workshops indicate high average value of chloride content of 655.5 mg/1. Anomalously high average value of total coliform numbers (measured in MPN/ 100ml) observed in samples obtained from farming area (232), soak way area (142), motor parks (555) and market places (22), indicate wide spread contamination.

Generally, activities which include, farming, hospital cottage industries, residential and market places have minimal effects on groundwater resources. However, activities such as petrol stations, burial ground, car wash, mechanic workshops, soak -away, refuse dump sites and motor parks show grievous impacts on the quality of groundwater and therefore need to be zoned out of the area that have been demarcated for future groundwater resources development.

KEYWORDS: Groundwater, Landuse, Environment, Activity, Representative

INTRODUCTION

Generally, the use of land embraces all the various ways in which land serves to provide man with his needs and want. Depending on the geographical location, social status and cultural heritage of a particular community, land can be used for the purposes of recreation, agriculture, transportation, mineral resources and water resources development.

The importance of water to the sustenance of living things on the planet each cannot be over-emphasized. For instance, Buchanan (1983) described water to be the next major support to life after air. Factors such as emancipation from pathogenic organisms

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constant temperature, absence of turbidity and color, greater storage (which often not affected by short term drought), requirement of little or no treatment before consumption, constant chemical composition and availability (among others) have however, placed groundwater at an advantage

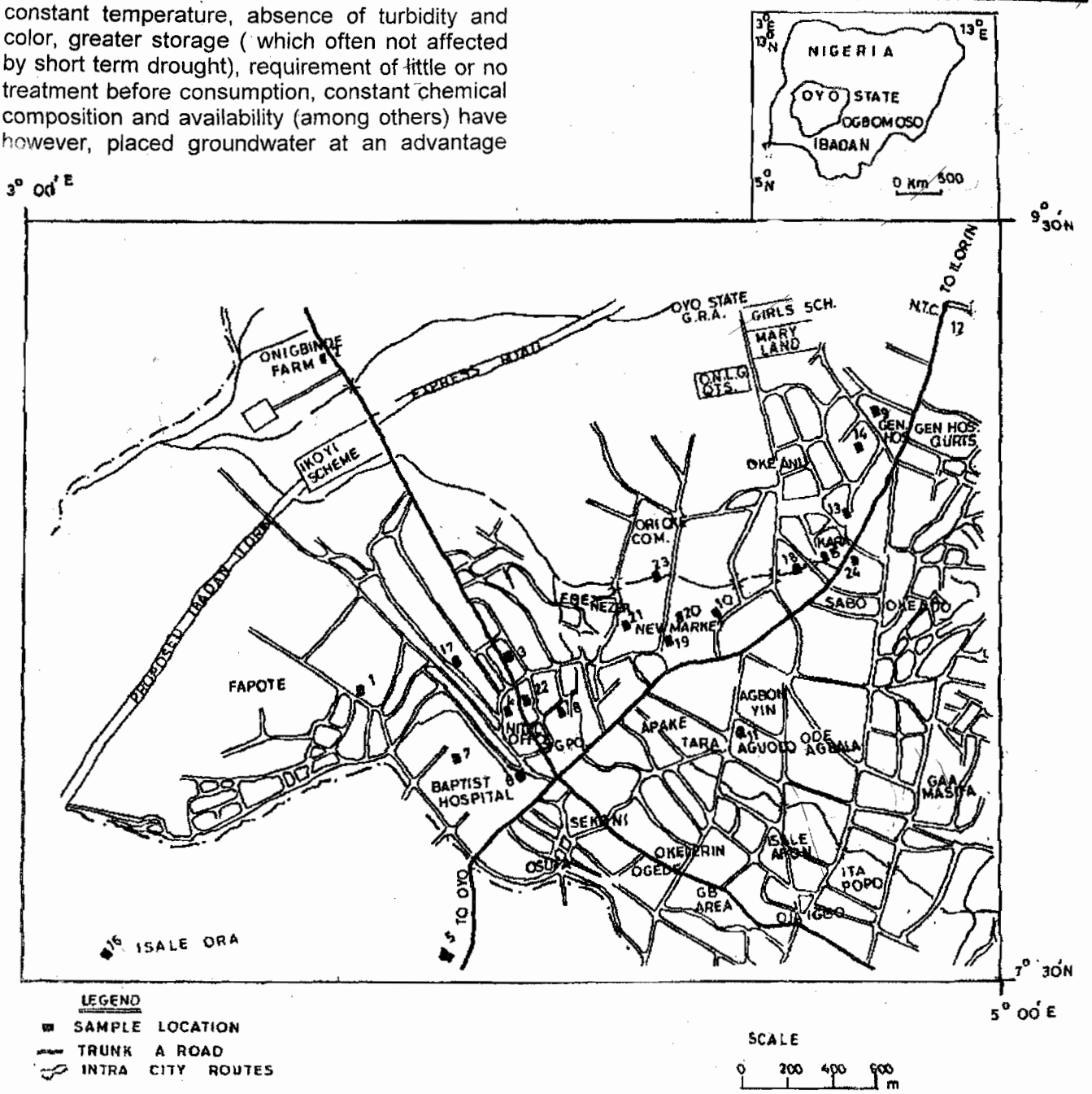


Fig. 1: Map of Ogbomoso township showing sites where samples were obtained

over the surface water counterpart. This notwithstanding, the increasing growth in urban development has begun to put under serious threats, the treasured physico-chemical and biological qualities of groundwater resources.

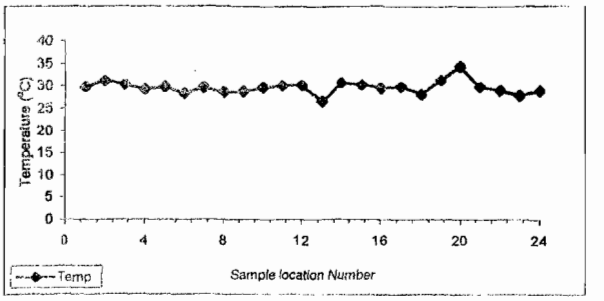
Landuse patterns have varied impacts on both the quality and quantity of groundwater resources system. For instance, insecticides and pesticides used in agriculture infiltrate into the soil to contaminate groundwater resources system. Also, rapid deterioration of soil may occur with continued use of saline water for irrigation purposes. Furthermore, infiltration rate is higher in thick forest than in light forest or bared land. Hence, contaminants from decay plants and animals are easily infiltrated in these forested water works, Ibadan, within the period of 72 hours of sampling.

The chemical and biological parameters analyzed for, in this work, include Ca^{2+} Mg^{2+}, Mn^{2+}, total iron, HCO_3^-, SO_4^{2-}, $C1^-$, NO_3^- and total coliform. The cations were determined using a Perkin-Elmer 305B atomic absorption spectrophostometer model while the anions were determined by titration and turbidemetric methods. The detection of coliform organisms was carried out multiple test method.

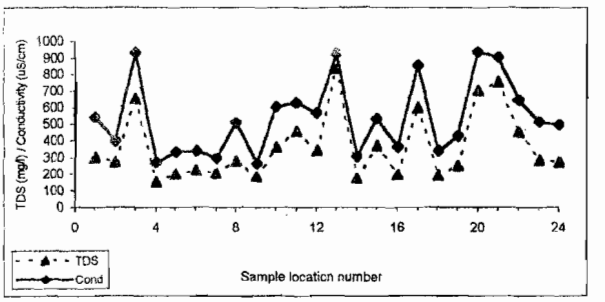
The results of chemical analysis were interpreted using graphical method and compared with W.H.O. (1984) international standard for drinking water. The evaluation of impacts of the various activities on the environment was done by determining the deviations between the laboratory results and the international standards.

RESULTS AND DISCUSSION

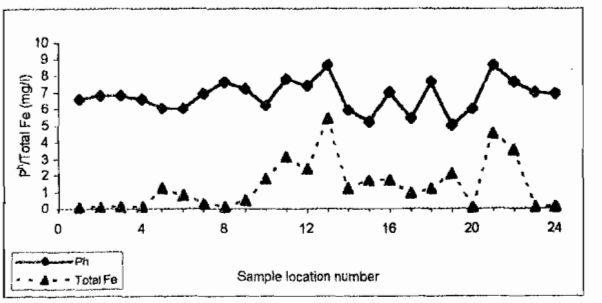
The results of the laboratory analyses are presented in Table 1. . The field temperature varied between a narrow range of 26.6°C to 34.4° (Fig. 2a). The ranges of values for TDS and electrical conductivities are 149.38 – 833.03 mg/1 and 271.60 – 939.55 µS/cm, respectively.



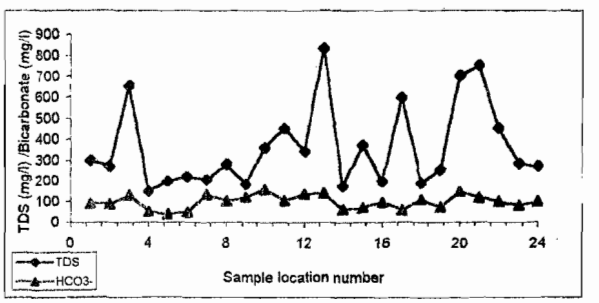
a : Variation of field temperature with sample location



b : Plot of TDS versus conductivity



c : Plot of P^h versus Total Fe concentration



d : Plot of TDS versus Bicarbonate concentration

Fig 2: Graphical relationships between various parameters obtained from the study area

Table 1: Results of physical, chemical and biological analyses

Sample No	Temp (°C)	pH	TDS (mg/l)	Conductivity (uS/cm)	Ca^{2+} (mg/l)	Mg^{2+} (mg/l)	Mn^{2+} (mg/l)	Total Fe (mg/l)	HCO_3^- (mg/l)	SO_4 (mg/l)	Cl (mg/l)	NO (mg/l)	Total Hardness (mg/l)	Ca Hardness (mg/l)	Mg Hardness (mg/l)	Total coliform MPN/100ml	Remarks	Appearance	Odour
1	29.7	6.6	298.44	542.62	32.8	2.24	0.1	0.1	92	0.1	150	50	86	72	14	1100	Farming	Clear	Odourless
2	31.1	6.8	273.36	395.6	24	2.56	0.1	0.1	88	0.1	128	23	70	60	10	23	Farming	Clear	Odourless
3	30.2	6.8	651.9	931.29	77.6	15	0.1	0.1	130	95	328	24	368	194	174	43	Ind Area	Clear	Odourless
4	29.2	6.6	149.38	271.6	15.2	5.96	0.1	0.1	52	10	48	27	160	138	22	460	Res Area	Clear	Odourless
5	29.8	6	199.44	332.4	10.4	11.14	0.1	1.2	40	0.1	136	15	178	154	24	4	Petrol Stn	Oily	Oily
6	28.3	6	220.81	339.71	9.6	7.43	0.1	0.8	43	0.1	150	18	190	164	26	4	Petrol Stn	Oily	Oily
7	29.5	6.9	205.7	294.24	49.6	4.2	0.01	0.3	134	8	46	11.8	140.4	123.6	16.8	9	Hospital	Clear	Odourless
8	28.5	7.6	279.4	508	61.6	11.44	0.1	0.12	104	45	55	18	142	102	40	43	Res Area	Clear	Odourless
9	28.7	7.2	184.41	263.44	45.2	3.1	0.01	0.5	120	6	42	11	145.1	130.2	14.9	93	Hospital	Clear	Odourless
10	29.5	6.2	361.32	602.2	[illegible]	4.31	0.01	1.8	160	2	176	46	108	72	36	23	Burial Grd	Brownish	H2S
11	30.1	7.8	454.09	631.51	74.8	24.3	0.01	3.1	106	69	183	30	256	172	84	460	Car Wash	Brownish	Odourless
12	30.1	7.4	340.63	568.25	7.8	8.28	0.03	2.4	138	2	195	51.7	104	72	32	15	Burial Grd	Brownish	H2S
13	26.6	8.6	833.03	925.071	38.4	14	0.09	5.4	140	4	686	13	150	96	54	460	Mech wsp	Oily	Rusty
14	30.7	5.9	176.18	303.76	20.4	6.66	0.01	1.2	62	8	3.43	95	144	116	28	43	Soak away	Brownish	Odourless
15	30.2	5.2	369.2	533.1	10.4	5.2	0.1	1.7	70	2	175	71	46	26	20	4	Refuse Dp	Brownish	Odourless
16	29.4	7	198.14	360.29	32.8	13.7	0.1	1.7	98	4	71.7	17.4	158	112	46	9	Motor Pk	Brownish	Odourless
17	29.9	5.4	598.15	854.5	24	7.76	0.01	0.9	58	6	447	80	190	160	30	240	Soak-away	Brownish	Odourless
18	28.1	7.6	192.31	337.39	34.4	12.4	0.01	1.2	110	2	67.2	12	164	86	48	1100	Motor Pk	Clear	Odourless
19	31.6	5	252.72	428.34	13.6	4.66	0.1	2.1	74	1	127	60	52	34	18	0	Refuse Dp	Brownish	Odourless
20	34.4	6	704.67	939.56	78.8	44.66	0.1	0.1	150	89	365	24	340	159	181	7	Ind Area	Clear	Odourless
21	29.8	8.6	753.2	904.27	34.4	11.38	0.12	4.5	120	2	625	10	130	86	44	4	Mech wsp	Oily	Rusty
22	29	7.6	453.21	647.44	76	22.3	0.01	3.5	100	70	185	28.4	276	190	86	210	Car Wash	Brownish	Odourless
23	27.8	7	282.88	514.33	16	5.17	0.01	0.1	80	20	175	19.4	60	40	20	43	Market	Clear	Odourless
24	28.9	6.9	273.33	496.96	16.8	3.62	0.01	0.1	100	18	165	17.8	65	51	14	0	Market	Clear	Odourless

Similarities exist between the patterns of trend of data obtained for TDS and electrical conductivities values (Fig. 2b).

The pH values range between 5.0 and 8.6 while total iron concentration range between 0.1 and 5.4 mg/1. Fig. 2c shows that, values of pH greater than 7, coexisted with high total iron concentrations in several places (samples sites coded 11, 13, 21). This implies that the observed high level of alkalinity in areas such as mechanic workshops (sampled sites coded 13.21) and motor parks (sample sites coded 16, 18) may have been influenced by various iron compounds present. These may have originated as a result of the activities going on in these areas.

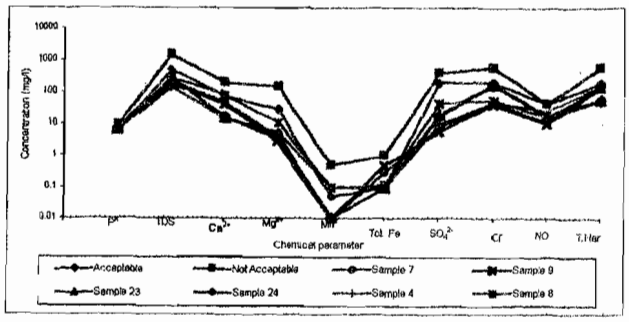
Furthermore, Table 1 shows that, the observed brownish colour (sample sites coded 10, 11, 12, 14, 15, 16, 17, 19, and, 22) may have been wholly impacted by the high iron concentrations present. This is because samples with brownish colours is associated with high iron content. When oxygen is present, Fe^{2+} is converted to Fe^{3+}, which may precipitate as ferric hydroxide. Also, the similarities in the patterns of trend of data between HCO_3^- irons and total hardness, (Fig. 2d) indicate that, the bicarbonate concentrations present in the waters constituted a larger portion of the dissolved solids.

The semi-logarithmic scholler diagrams for all the samples are presented in Fig. 3. Major ionic concentrations viz: Ca^{2+}, Mg^{2+}, Mn^{2}, SO_4^{2+}, $C1^-$, NO_3^-, fall below the highest desirable standard (W.H.O ., 1984) in several sampling locations. However, in few places, the concentration values of chemical and physical parameters occur above the maximum permissible level of W.H.O (1984). Worthy of mentioning are petrol stations with average pH and total iron values of 6.0 and 1.0 mg/1, respectively. Both the appearance and odour of water samples from this sub-area are oily. Other areas include burial ground, car wash, mechanic workshop, soak-away, refuse dump site and motor park with anomalously high average

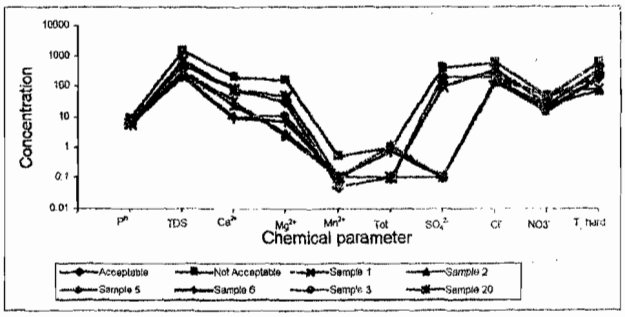
concentrations of total iron of 2.1, 3.3, 4.95, 1.05, 1.9 and 1.5 mg/1, respectively. The average NO_3^- ion concentrations for burial ground, soak-away and refuse dump site are 50.0, 87.5 and 65.5 mg/1 respectively. The average $C1^-$ ion concentration of 655.5 mg/1 occurred in samples obtained from mechanic workshop. All, samples with anomalously chemical concentration mentioned above appear brownish in colour and with rusty to hydrogen sulphide odour.

Various reasons may account for the presence of the observed chemical concentrations. The high total iron concentrations observed in wells around burial ground, car wash, mechanic workshop, refuse dump and motor park sub-areas are likely to be due to corrosion of metallic frameworks that are in direct contact with these areas. Metals have tendency to revert to a more natural and stable thermodynamic form if a suitable oxidation environment is available, thus, passing into solution to enrich subsurface waters anomalously. Factors that may cause spatial variation in iron contents include variations in the following parameters: run-off velocity, pH, dissolved oxygen present, TDS, temperature and bacterial presence. Although, iron is an essential element in both and animal metabolism, as well as an important constituent of hemoglobin in blood. its excessive concentration may promote bacterial activity in pipes and cause objectionable odour in water. It can discolour clothes and plumbing fixtures as well as causes scaling, which may encrust pipes.

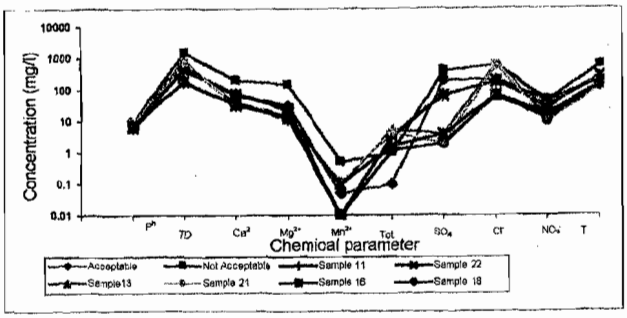
Wells around burial ground, soak-away and refuse dump sites indicate high nitrate concentrations. The origin is primarily anthropogenic. Uncontrollable disposal of human and animal wastes at dumping sites, decay materials at burial grounds and leakages from soak-away may have constituted possible sources of nitrogen, which when oxidized and leached by inflitratiing surface waters, pollute the groundwater. Excessive nitrate concentration possesses significant health hazards. It causes



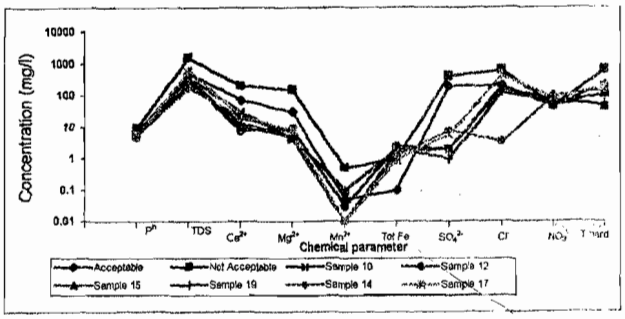
a :Hospital, Market & Residential areas



b :Farming, Petrol station & Industrial areas



c : Car wash, Mechanic workshop & Motor park areas



d : Burial ground, Refuse site & soak away areas

Fig. 3 : Semi-logarithmic Scholler diagrams

environment. The land used for parks and play grounds are continually exposed to recreational activities and hence compacted, thus allowing for little infiltration, large surface run-off and consequently, low groundwater recharge rate. Water used in mineral recovery during processing are discharged directly into the environment as effluents, thus carrying poisonous elements in solution which eventually infiltrate to pollute subsurface waters. Groundwater near oil fields get contaminated through oil spillages.

In addition, disposal of waste waters produced from generation of hydro-electric power and other various geothermal resources utilization, present serious threat to groundwater quality. Construction of roads exposes large surface area to atmospheric action where oxygen is released into the atmosphere and carbon dioxide added. Also, the uncontrolled waste disposal habits by individuals, homes and communities lead to groundwater pollution, and consequently make the water to become toxic to plants and for human consumption.

The sources of anomalous concentration of chemical parameters within different geological and geographical environment and their health implications have been studied (Ohagi and Akujieze, 1989; Smedley, 1996 and Gizaw, 1996). Also, works on the impact of urban development on the environment have been published by Boukari et al., 1996 (among others). In this work, however, the chemistry of groundwater samples obtained from Ogbomosho has been studied with a view of evaluating the variational impacts of various landuse patterns on groundwater quality within the study area, and also, other areas with similar socio-geological conditions.

DESCRIPTION OF STUDY AREA

The study area is located within Ogbomosho township, Nigeria, and geographically bounded by longitudes 3°00' – 5 °00' E and latitudes 7 °30'-9 °30'N (Fig. 1).

Ogbomosho is encompassed by the western upland portions of the Nigerian highland plateau, with average attitudes of between 1000m and 1500m above mean sea level. Major rivers that flow across the town include Oba, Moro, Asa and Ora. Oba and Ora rivers flow southward while Moro and Asa rivers flow towards the north-east.

The study area is covered by guinea savannah, with scattered matured trees, shrubs and bamboo. However, in many places, the natural vegetation patterns have been interrupted by agricultural practices and other human activities.

Two distinct seasons are identified. These include a dry season from November to March, and a wet season, from April to October. Mean annual rainfall is 1247mm, while the arithmetic mean of annual temperature for a period of 15 years (1940 – 1955) gives a value of 26.2°C (EPC, 1996).

The rock sequence in the study area consists mainly of fine-grained biotic-gneiss, quartzite and quartz-schist complexes all of Pre-Cambrian age. The gneiss complex underlies the northern and southern parts of the area and constitute a considerable larger portions, with good rock exposures. The gneiss body is cross-cut by numerous bands and lenses of pegmatite at several locations. A hog-back ridge of quartzite forms the most distinctive topographical feature in the central part of the study area. The quartzite however is seldom exposed, but the ridges are smothered with quartzite rubbles. In addition, large burrow pits where iron ores have been extensively extracted exist within the quartzite region. The occurrence of iron ore and transformation of quartzite to quartz-schist, suggest that the quartzite has a sedimentary origin (Jones and Hockey, 1964).

MATERIALS AND METHODS

Reconnaissance survey was carried out to identify locations where water samples were

collected in line with project design and objectives. Two water samples were collected from shallow wells located around places, where the underlisted activities were taking place. The activities include hospital, car wash, refuse dumping , soak-away, farming, petrol station and cottage industries (block making and saw-mill). Others are motor park, market, burial ground, mechanic workshop and residential areas. A total of twenty four (24) water samples were obtained. These activities constitute the most dominant ones being practiced in Ogbomosho township.

The sampling procedure, physical, chemical and bacteriological analysis of the representative water samples obtained from the study area, were carried out in accordance with W.H.O. (1984) specifications. Parameters which include temperature pH and total dissolved solids/electrical conductivity were measured in the field using mercury thermometer, HANNA pH meter and mettler – Toledo E.C./TDS meter respectively while the appearance was determined by visual observation.

Chemically clean 2 – litre, plastic bottles, equipped with plastic stoppers were used to collect water samples at each well location. The samples were labelled, and subsequently analyzed at the chemical laboratory of Asejire cyanosis in children and stomach cancer (Onugha et. al. 1992).

Furthermore, water samples from refuse dump site and soak-away have been noted (Table 1) to possesses low pH values. This makes these waters to be more corrosive to iron bearing materials.

The widespread presence of total coliform within the study area indicates possible contamination by sewage, human excrement or animal pollution. Sub-areas most hit include farming, residential area, hospital, car wash, mechanic workshop, soak-away, motor park and market places. The principal source may be the unhygienic attitudes of the individuals and host communities. Presence of coliform in drinking water may cause large spread epidemics of enteric fever, dysentery and cholera, among others.

CONCLUSION

The groundwater quality of some areas in Ogbomosho has been analyzed for major ionic concentrations and bacterialogical contaminants in relation to landuse patterns in the ancient town. Based on the physico-chemical and biological results, it can be concluded that activities such as farming, cottage industries, hospital, residential and market have minimal impact on the groundwater quality of the town and may therefore, be tolerated within the legal framework of their operations. However, activities which include petrol stations, burial ground, car wash, mechanic workshop, soak-away, refuse dump and motor park may have grievous effect on ground water quality and therefore care should be taken in using these areas for future groundwater resources development. Finally, the observed high iron and nitrate concentrations and wide spread presence of total coliform may pose high degree of health hazards and therefore it is urgent that an extensive study be carried out in which more representative samples would be used in order to go beyond the preliminary assessment as reported in this study with a view to corroborating our research results and thereby making appropriate recommendations.

REFERENCES

Buchanan, T.J., 1983. International Water Technology Conference and Exposition. Acapulco, Mexico.

Boukari,M., Gaye, C.B Faye, A. and Faye, S., 1996. The Impact of Urban Development On coastal aquifers near Cotonou, Benin. Journal of African Earth Sciences 22(4): 358-389.

Environscape Planning Consultants (EPC), 1996. Physical Development (Master Plan) for Ladoke Akintola University of Technology (LAUTECH), Campus

Site, Ogbomosho. Unpubl. Preliminary Report, 36p.

Gizaw, B., 1996. The origin of high bicarbonate and fluoride concentration In waters of the main Ethiopioan rift valley, East African rift system. Journal of African Earth Sciences. 22 (4): 391-402.

nes, H.A and Hockey, R.D., 1964. The geology of parts of south-western Nigeria Geological survey of Nigeria bulletin, No 31, 18pp.

Ohagi, S.M.O and Akujieze, C.N., 1989. Iron in borehole water sources in Bendel state, Nigeria. Water Resources. 1(2): 192-196.

Onugba, A., Blavoux, B., Guirud, R. and Travi, Y., 1992. Nitrate Pollution Of groundwaters in Gongola state, Nigeria. Journal of Mining and Geology. 28(2): 317-323. .

Smedley, P.L., 1996. Arsenic in rural groundwater in Ghana. Journal of African Earth Sciences. 22(4): 459-470.

World Health Organization (W.H.O.), 1984. Interntional standards for drinking Water. Third edition. Geneva, Pp38-40.