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Aspect of the Environmental impact Assessment of Limestone Quarry Site, Shagamu, South Western Nigeria

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Abstract

A total of twelve water samples which include those from two hand dug wells, five bore holes and five streams as well as twenty soil samples were collected around the West African Portland Cement (WAPCO) factory in Shagamu, Southwestern Nigeria. The water samples were analysed for physical, chemical and biological parameters while the concentrations of cations and anions in soil samples were also determined. There is a general trend of dominance of Ca^{2+} over Na^{+} over Mg^{2+} over K^{+} and HCO_3 over SO_4^{2-} over Cl^- over NO_3 among cations and anions respectively in water samples while that of soil samples show trend of dominance of Ca^{2+} over Mg^{2+} over Na^{+} over K^{+} and HCO_3 over SO_4^{2-} over Cl^- over NO_3^- among cations and anions respectively. The underlying rocks have a significant effect on the geochemistry of water and soil as indicated by the dominant ions and the boomerang diagram. The study has shown that the soil samples especially within 500m radius of the limestone activities are contaminated as revealed by the concentrations of Ca^{2+} and Mg^{2+} that exceed normal background values for soil, while the composition of water samples are within the maximum permissible levels of World Health Organization (WHO) standard for drinking water. However, some water samples have concentration of ions in excess of the highest desirable levels.

Introduction

Limestone (Industrial mineral) production has been on the increase since its inception in 1957 because of the high demand for cement in the Nigerian market. This activity after a long time may cause environmental damage, widespread pollution and disruption of ecosystem.

In Shagamu, where the underlying geology is of uncompacted and high permeability alluvial sands, the polluting effluent as a result of limestone mining are capable of escaping into the subsurface to contaminate the surface and groundwater in the aquifer as well as the soil. This can form a pollution plume that can extend for several hundreds of meters (Keswick et al, 1982, Okufarasin, 1991 and Asiwaju- Bello et al, 2001). The aim of this study is thus to access the effect of limestone mining activities in Shagamu on soil, surface and groundwater.

The study area, Shagamu, lies within longitude 3° 3'E and 3° 45'E and 6° 30'N and 7° North (fig 2). It occupies a low lying marshy depression about 200m above the sea level (Ewekoro depression) within the Dahomey basin (Jones and Hockey, 1964) bounded by highland to the north and south.

The area falls within the tropical rainforest zone of Nigeria with annual rainfall ranging between 1500mm and mean annual temperature distribution of 27° C with two distinct seasons, the dry and wet seasons (Iloeje, 1981).

Geology and Hydrogeology

Shagamu lies within the Dahomey basin, which is one of the sedimentary basins on the continental margin of the Gulf of Guinea extending from southwestern Ghana in the West to Western flank of the Niger Delta (Jones and Hockey, 1964). The stratigraphic units include; Ise, Afowo, Araromi, Ewekoro, Akinbo, Oshosun and Ilaro formations (fig 1) as studied by various authors like Jones and Hockey, (1964), Adegoke and Omatsola, (1981), Agagu, (1985). The sediments exposed at the Shagamu quarry belong to the paleocene-Eocene age. In contrast to the homogeneous Ewekoro exposure, the formation in this area is heterogeneous varying appreciably in color, texture and fossil contents. The local stratigraphy comprises sequence of sediments (in order of increasing age).

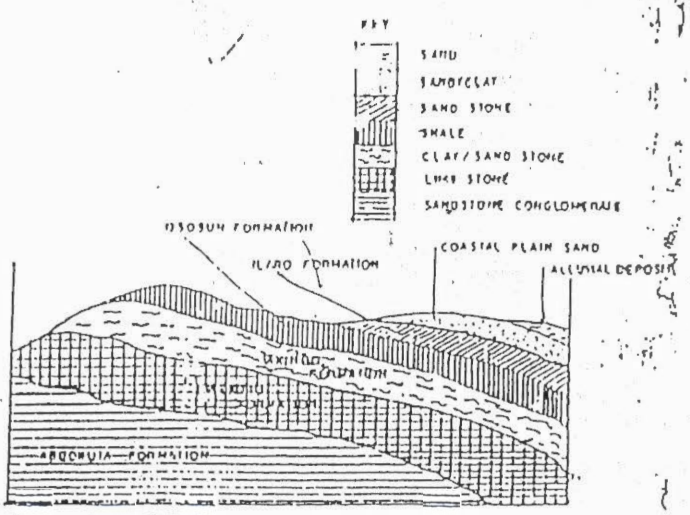

Fig. 1: Stratigraphy of Dahomey Basin after Omatsola and Adegoke (1981)

Brown alluvium (top soil)
Red alluvium (laterite)

Shale (Akinbo formation)
Limestone (Ewekoro formation)

The drainage is dendritic and the major rivers include Odari and Bere (fig 2). The area is water logged for most part of the year due to low relief, high water table and impervious nature of underlying rocks.

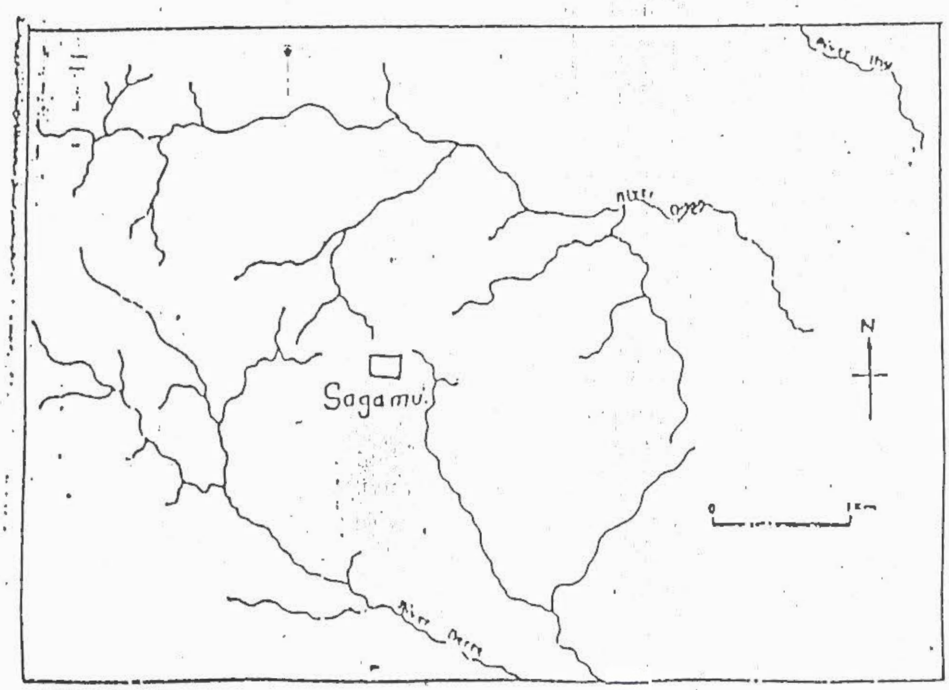

Fig. 2: Map showing the Dendritic drainage pattern of the study area, (Sagamu)

...odology

...of twelve water samples which include two from hand dug wells, five from bore holes and five ...streams as well as twenty soil samples were collected around the premises of the West African ...and Cement Company (WAPCO) in Sagamu, Southwestern Nigeria.

...samples were collected with 1 litre white kegs and spread across the study area for the purpose ...determining water quality. Physical properties of water such as color, oder, taste and pH were ...mined on the field by visual inspection and the use of pH meter.

...parameters such as Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, HNO_3^-, NO_3^-, SO_4^{2-}, total hardness, TDS, were ...lysed in the laboratory using atomic Absorption Spectrophotometer and titration methods. ...liform counts were also determined.

...top soil samples were collected at depth of 0-5cm and at interval of 50m into clean polythene ...air dried for 24 hours before they were taken to the laboratory where pH, major cations and ...ions were analysed using Atomic absorption Spectrophotometer after the soil samples have been ...ested appropriately.

...lts and Discussion

...results of physical, chemical and bacteriological analyses of water samples are presented in ...1 to 5 and illustrated in Figs 3-20. There is general trend of dominance among cations of Ca^{2+} ...Mg^{2+} over Na^{2+} over K^+(Figs 5) in the water samples while soil samples show general trend of ...minance of Ca^{2+} over Mg^{2+} over Na^+ over K^+ among cations (Fig 3).

...le 1: Result of chemical analysis of various water sources from different locations within the study area.

	LOCATION											
	BOREHOLES					STREAMS				HAND DUG WELLS		
...RS	1	2	3	4	5	6	7	8	9	10	11	12
[illegible]	9.4	8.6	8.5	7.1	8.9	8.1	8.3	8.9	9.6	8.3	8.5	8.6
[illegible]	115.22	54.32	32.09	72.68	21.26	11.69	11.69	57.09	82.49	18.25	60.83	15.14
[illegible]	18.00	19.00	14.00	16.00	9.00	16.00	16.00	16.00	20.00	8.00	20.00	17.00
[illegible]	6.00	8.00	4.00	8.00	10.00	5.00	5.00	6.00	10.00	6.00	18.00	2.00
[illegible]	0.03	0.64	0.40	0.86	0.84	0.97	1.02	0.28	0.95	2.19	0.21	0.68
[illegible]	90.00	94.00	28.00	80.00	31.00	9.00	8.00	48.00	120.00	10.00	96.00	18.00
[illegible]	40.00	34.00	10.00	23.00	8.00	4.00	3.00	12.00	60.00	6.00	5.00	7.00
[illegible]	40.07	42.04	40.00	40.49	32.39	32.58	22.01	43.47	36.98	32.86	32.26	44.03
[illegible]	9.98	10.50	12.01	15.87	11.01	6.04	10.74	11.01	21.03	5.09	11.01	20.02
...ess	207.00	156.00	40.00	158.00	35.00	16.00	12.00	61.00	145.00	23.00	122.00	21.00
...lved (...DS)	260	250	100	220	70	40	30	120	250	20	220	20
...ount	0	0	0	0	2	0	0	0	0	180	0	0

Table 2: Chemical analysis results of soil samples (ionic concentration in ppm)

p^H	Na^{2+}	K^+	Ca^{2+}	Mg^{2+}	SO_4^{2-}	NO_3^-	CO_3^-	HCO_3^-	Cl^-
8.20	24,000	14,700	26,240	15,400	26,100	10,200	24,240	201,500	14,100
7.50	30,200	4,800	23,020	13,400	14,200	12,800	21,020	195,500	15,800
8.14	23,300	8,400	21,380	12,800	15,300	11,800	19,880	191,800	15,200
8.12	22,900	7,900	21,250	15,800	16,800	10,400	20,440	84,100	16,200
8.16	20,200	8,100	21,040	13,200	29,200	11,600	26,180	178,800	17,400
8.72	16,900	14,200	20,040	8,800	18,200	13,400	22,040	17,800	12,200
8.50	15,800	14,800	19,720	21,500	30,400	12,200	21.870	172,200	24,900
8.40	18,200	20,200	19.270	22,900	28,600	9,200	29,360	166,600	22,700
8.34	20,400	16,200	18,890	47,700	14,900	10,300	18,830	160,200	23,200
8.45	25,100	19,200	18,120	21,700	17,200	9,400	17,600	151,700	28,300
8.04	20,300	8,000	17,720	84,800	19,200	8,500	17,240	150,300	20,400
7.62	13,200	20,800	17,5[illegible]0	37,700	23,200	12,200	22,280	144,500	11,700
8.41	15,800	21,200	17,0[illegible]	45,200	31,200	15,300	19,920	140,300	10,900
8.18	15,200	22,800	16,9[illegible]0	13,800	25,200	14,100	28,750	133,200	13,800
7.94	31,200	23,400	16,870	39,700	32,800	15,200	25,760	130,400	25,500
8.62	27,500	17,500	16,850	20,200	29,800	13,400	24,600	127,600	21,400
8.21	24,700	18,800	16,550	12,100	21,800	7,200	22,700	121,700	26,600
8.24	14,800	8,700	16,040	11,900	20,400	6,500	20,590	12,300	27,100
8.15	19,2200	5,400	15,680	14,200	22,600	5,700	21,250	181,900	19,800
7.21	13,600	6,900	14,040	7,200	27,200	19,900	10,073	181,500	9,400

Table 3: Summary of Water Chemistry (Mg/l) AND (PPM)

PARAMETERS	RANGE	MEAN	SD
p^H	7.1-9.6	9.0	0.74
HCO_3^- (Mg/L)	11.69-115.22	46.43	31.38
Cl^- (ppm)	8-20	15.5	3.76
SO_4^{2-} (ppm)	2-18	7.3	3.92
NO_3^- (Mg/L)	0.03-2.19	0.75	0.53
Ca^{2+} (ppm)	8-120	52.67	39
Mg^{2+} (ppm)	3-60	17.69	17.27
Na^+ (ppm)	22.01-44.03	37.13	6.02
K^+ (Mg/L)	6.04-21.03	12.03	4.15
Total Hardness (CaC03)	12-207	82.2	64.31
Total Dissolved solid (TDS) (Mg/L)	20-260	133.33	11.85

SD = Standard Deviation = $\frac{(Ef(x-x)^2)}{N}$

f = the frequency of each value observed

n = number of observation of the variable x.

No. of sample: N = ef.

Mean: (x) = $\frac{efx}{N}$

Table 4: Summary of Soil Chemical Analysis Results

Parameters	Range (ppm)	Average
pH	7.21-8.72	8.42
Na^+	13200-31200	23447
K^+	6900-23400	15480
Ca^{2+}	14040-262400	196940
Mg^{2+}	7200-84800	25480
SO_4^{2-}	14200-28600	25920
NO_3^-	5700-19900	14673
CO_3^-	10073-29360	19810
HCO_3^-	12300-201500	151967
Cl^-	9400-27,100	19533

Table 5: Bacteriological Analysis Result

SAMPLE	COLIFORM COUNT (CFU)
L1	0
L2	0
L3	0
L4	0
L5	2
L6	0
L7	0
L8	0
L9	0
L10	180
L11	0
L12	0

The concentrations of anions on the other hand show that $HCO_3^- > Cl^- > SO_4^{2-} > Cl^- > NO_3^-$ in soil (Fig 4) and $HCO_3 > Cl > SO_4 > NO_3$ (Fig 6). Elevated values of all the ions are recorded within 500m radius for water samples while control samples were taken as far as 15,000m away from the quarry. However, it is noted that Ca^{2+}, Mg^{2+} and HCO_3^- constitute the major contaminant in both soils and water. Their mean values are 52.67 mg/l, 17.67ppm, and 46.43mg/l respectively in water and 196.94ppm, 25.48ppm and 198.10ppm in soil (Tables 3 and 4).

Na	K	Ca	Mg
23447	15480	196940	25480

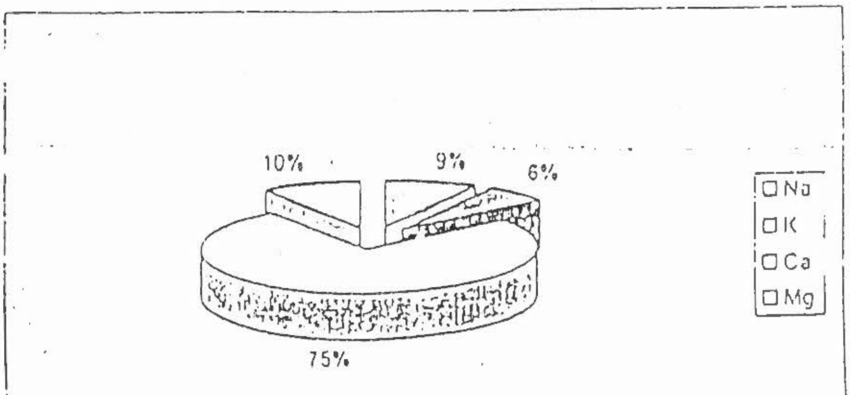

Fig. 3: Concentrations of Cations in soil Samples

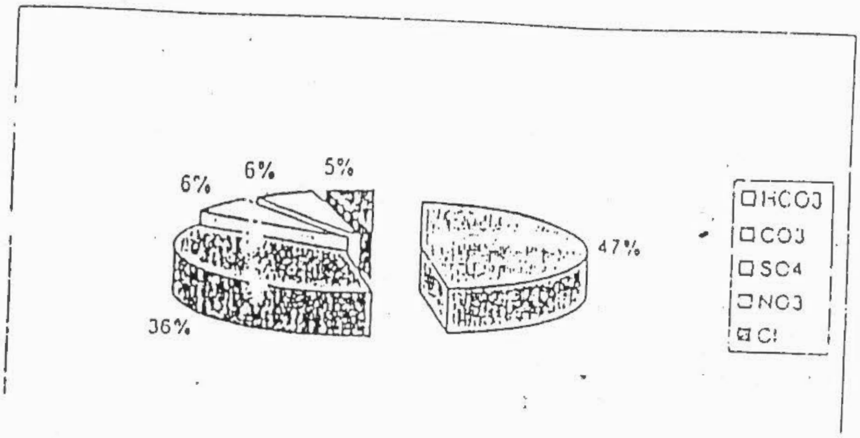

Fig. 4: Concentrations of Anions In Soil

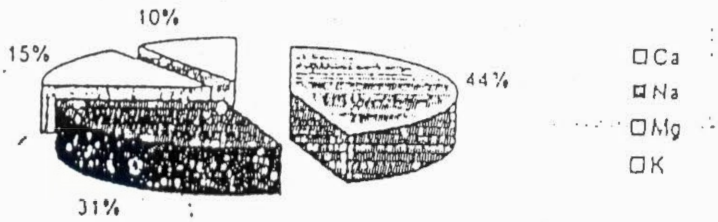

Fig. 5: Concentrations of Cations In Water Samples

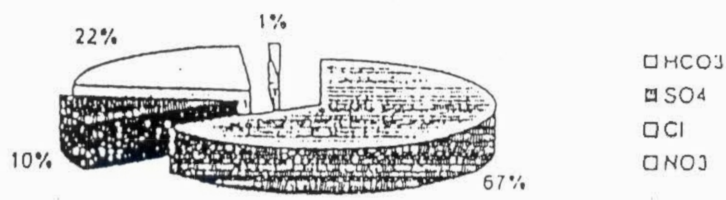

Fig. 6: Concentrations of Anions in Water Samples

Also, the concentration of some major ions like Ca^{2+}, Mg^{2+} and Hco_3^- as well as pH were seen to be higher for samples taken very close to the quarry site than those far away from it (Fig 7-14).

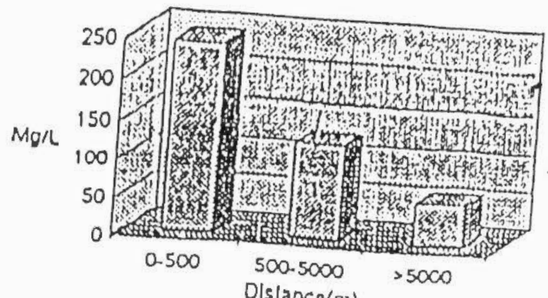

fIG 10 Bicarbonate in soil samples against distance

Fig. 10: Bicarbonate in soil samples against distance

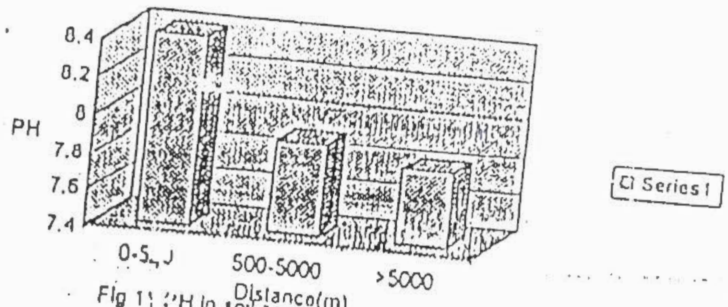

Fig 11 PH in soil against distance

Fig. 11: pH in soil samples against distance

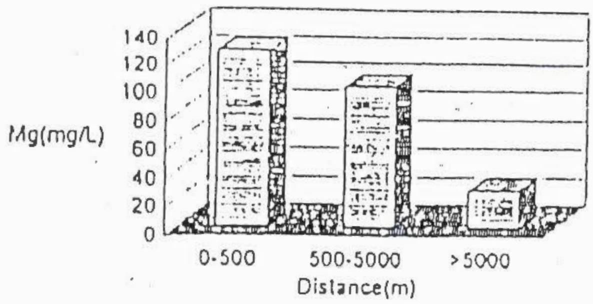

FIG 12 Magnesium in water sample against distance

Fig. 12: Magnesium in Water samples against distance

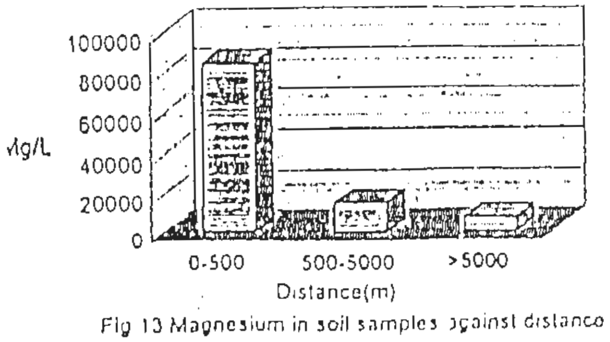

Fig. 13: Magnesium in soil samples against distance

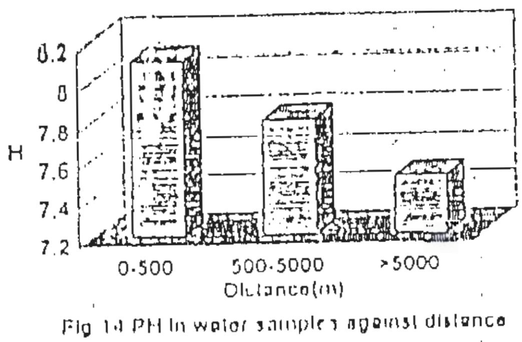

Fig. 14: pH In Water samples against distance

Various rock types, their weathered products and precipitation from rainfall contributed greatly to the chemical composition of water and soil in the study area. This has gone a long way to impair their quality. This is confirmed in fig 15, where log TDS against $Na^{+}/Na^{+} + Ca^{+}$ ratio were used to plot boomer

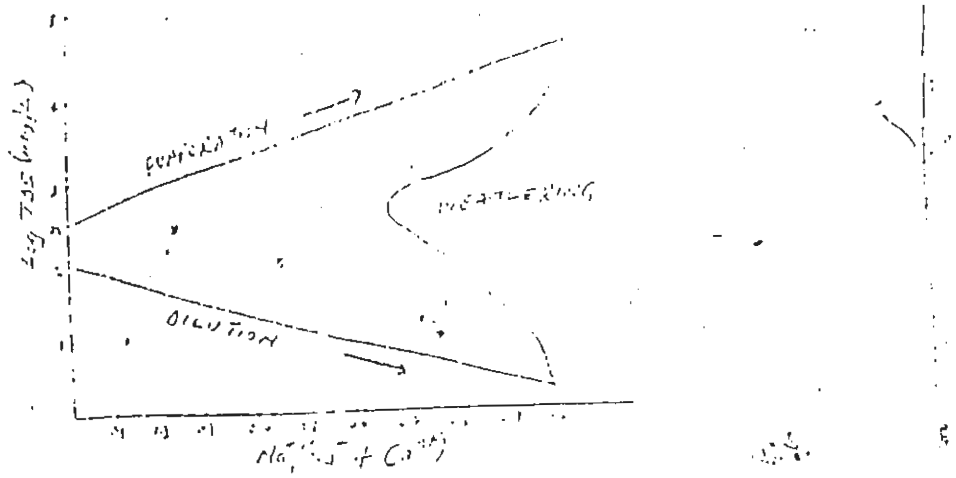

Fig. 15: Classification of surface water according to GIBBS (1970)

diagram shows that water samples in the study area are influenced by the chemical weathering of underlying bedrock which is limestone ($CaCO3$) in this case. Also, the high concentration of cium as the dominant cation and HCO_3 as the dominant anion in both soil and water confirms this jani, 1994). The high concentration of Mg^{2+} also indicates alteration of some limestone ($CaCO_3$ – Mg (CO_3) while SO_4^{2-} is produced primarily from the oxidation of sulphate minerals and dissolution of gypsum or other sulphate minerals. Most of the water samples very close to the quarry have their chemical parameters especially Ca^{2+} and Mg^{2+} above the highest desirable level (Table 5).

correlation coefficient established between Ca^{2+} and Mg^{2+} is + 0.80 (direct and very good) which shows that the water samples are generally related while that between NO_3^- and Cl – is 0.64 (Indirect and good) and shows that there is no trace of faecal pollution in the water samples. This is also confirmed by the absence of coliform bacteria as revealed by the bacterioloical analysis of water samples (Table 6).

was also observed that the water sampled close to the quarry site are very hard according to Todd, 1980) and alkaline in nature. This can be linked with high concentration of Ca^{2+}, Mg^{2+} and pH in water.

results of chemical analysis of soil samples were compared with the normal background values soil (Table 6) and it was noticed that the concentrations of all the cations except that of Na and pH exceeded the normal background values for soil (Figs 10-20). Hence, the soil is contaminated especially those within 500m radius of the quarry site.

mperature of water is between 27°C and 28.5°C with average of 27.8°C. TDS values range between 50ppm and 329.96ppm with an average value of 104.95ppm and this confirms the fresh nature of ater while total Alkalinity ranges between 33.3 mg/l and 132.2mg/ l with an average of 65.49mg/l. water samples are classified as Excellent based on the Sodium Absorption Ratio (SAR = Na^+ / + Mg^{2+} /2) which means that they are perfect for irrigation purposes. The values of total hardness ich range from 20mg/l to 152mg/l with average of 65.49mg/l show that the water fall between soft oderately hard category.

dium has a concentration of 7.82ppm to 60.00ppm with an average of 16.72 ppm while the ncentration of magnesium ranges from 2.50ppm to 10.75ppm with an average of 5.38ppm. The ncentrations of potassium and sulphate are 10.56ppm and 4.56ppm respectively. Bicarbonate has erage of 0.87ppm. Fe^{2+} was present in only one sample with value of 0.02ppm. Chemical analysis that all the water samples have properties that fall within the WHO standard for drinking water ble 5).

cteriological Analysis

was used to detect the presence and density of organisms in the water as indices of faecal and teria pollution. The results (Table 1) show that the coliform count ranges from 0cfu/m to 18cfu/ml one of these values is above WHO standard recommended value for potable water. Appropriate ment measure must be applied before its suitability for domestic purposes.

nclusions

study focused on the effects of limestone ($CaCO_3$) on the geochemistry of water and soil in mu, Southwestern Nigeria. The sources of the water include surface and groundwater which eloped through the weathering and fracture of the rocks. This water percolates through fractures pore spaces between the underlying bedrock which is limestone. Also, the soil in the study area high permeability and porosity which comprises brown alluvial sands as top soil and this enables access of ions into the soil.

was observed that the closer the soil and water samples are to the quarry site, the higher are the centrations of ions such as HCO_3^-, SO_4^{2-}, Ca^{2+} and Mg^{2+} while TDS and Total hardness are cullar to water samples only.

wever, Proximity to the quarry site does not show any significant effect on the concentration of K^+, , Cl^- NO_3^- and coliform count but has a pronounced effect on the pH as indicated in the alkaline ture of water and soil in the study area.

us, it can be concluded that the underlying rocks which are predominantly Limestone have a nificant effect on the geochemistry of water and soil in the study area as indicated by the omerang diagram after Gibbs (1970). Although the concentration of water samples for now are still hin the maximum permissible level c WHO standard, some parameters already have values higher n highest desirable level in the WHO standard which means that with time there is possibility that ter within the study area will be contaminated.

study has also shown that soil samples especially within 500m radius of the limestone quarry site contaminated as revealed by the concentrations of Ca^{2+}, Mg^{2+} and HCO_3^-, which exceeded the mal background value for soil.

recommended that Government should put in place stiff environmental protection laws that will e industries to operate a standard waste disposal method that is free of Environmental hazards

erences

egoke, O. and Omatsola, E. (1981): Stratigraphy and Paleontology of formation of Southwestern Nigeria. Bulletin of American Paleontology Vol.71, No. 295-379.

agu, O.K (1985): A geological guide to Bituminous sediments in Southwestern Nigeria, Dept. of Geology. Univ. of Ibadan. Pp2-16.

waju-Bello, Y.A and O.O. Akande (2001): Urban groundwater pollution. Case study of disposal site in Lagos metropolis. (Water Resources)Journal of the Nigerian Association of Hydro-geologists, Vol.12 pp22-26.

yose, E.A. (1970): Stratigraphy and paleontology of the Afowo 1 well Jour. Of Nig. Min. Geol. Metal. Soc. Vol.5, pp1-99

bbs, R.J. (1970): Mechanism controlling world water chemistry science Vol. 170, pp1085-1090.

oje, N.P. (1981): A new Geography of Nigeria Longman, Nigeria 201p.

nes, H.A and Hockey, R.D (1964): The Geology of parts of Southwestern Nigeria. Geol. Surv. Nig. Bull. Vol.31 pp1-101.

swick, B.H., Wang, D. and Gerba, C.P. (1982): The use of microorganisms as groundwater tracers. A review of groundwater 20(2): 142-149.

ufarasin, Y.A. (1991): A multi-phase model for the transport of Pollutants in groundwater Ph.D dissertation. The University of Leeds, Dept. of Civil Engineering, England. 255p.

ani, M.N.(1994): Hydrogeochemical assessment of groundwater in Moro area, Kwara, Nig. Environ. Geol. 24 pp194-200.

dd, D.K (1980): Groundwater hydrology. John Wiley and Sons inc. New York second Edition. Pp535.

orld Health Organization (1996): Guidelines for drinking water quality. 2nd ed. Vol.2.pp.940-949 and Addendum to vol. 2 1998 pp. 281-283. Geneva, World Health Organization.