GROUND WATER QUALITY IN EJIGBO TOWN AND ENVIRONS, SOUTHWESTERN NIGERIA

A.O. Olorunfemi, K.S. Salahudeen and T.A. Adesiyan
Department of Geology, Obafemi Awolowo University, Ile-Ife, Nigeria.

(Received: September, 2010; Accepted: April, 2011)

ABSTRACT

This study assessed the physico-chemical parameters and quality of ground water in Ejigbo and environs, southwestern Nigeria with a view to determining its suitability for human consumption.

The concentrations of cations which included Ca^{2+}, Na^{+}, Mg^{2+}, K^{+}, Zn^{2+}, Cd^{2+}, Pb^{2+}, Fe^{2+} and Mn^{2+}; those of anions such as SO_4^{2-}, NO_3^{-} and PO_4^{2-} ; the pH and the total dissolved solids (TDS) in twenty-six (26) ground water samples from fourteen boreholes and twelve hand-dug wells (HDW) were determined.

The results showed that Na^{+} and K^{+} were the most abundant dissolved cations in the groundwater. The concentrations of K^{+} exceeded the WHO recommended level of (10 12) mg/L in all the samples. The concentrations of Cd^{2+} exceeded the WHO standard of 0.003 mg/L in 19 wells while that of Pb^{2+} exceeded the WHO standard of 0.01 mg/L in 9 wells. These are probably attributable to anthropogenic activities. Concentrations of the other ions and parameters like pH and TDS are within the recommended WHO maximum allowable limits for drinking water.

The exceptionally high values of cadmium and lead in waters from some wells in the study area showed that the ground water in most of the boreholes and hand-dug wells sampled is not suitable for human consumption. This gives course for concern, since the majority of people living in this area depend on water supply from the hand-dug wells and boreholes for various domestic purposes. There is, therefore the need to alert the local authority in the area of this dangerous trend, so that an alternative arrangement can be made to provide domestic water for residents of the area.

Key words: Ground water, Physico-chemical Parameters, Cations, Anions and Ejigbo.

INTRODUCTION

Water is an indispensable requirement by all organisms (plants and animals). The sustenance of man is largely dependent on water availability and quality. Water is a requirement that sustains life: without it life will be impossible (Fetter, 1980). Water is the next to air as a major support substance to life.

Water therefore is important in that it is essential for growing food, for household water uses, as a critical input into industry, for tourism and cultural purposes, and for its role in sustaining the earth's ecosystem (Mark *et.al*, 2002).

Groundwater, which is the focus of this study accounts for about one percent of the Earth's water worldwide, or about 100 times more than total volume of all lakes and rivers (USGS, 2005). Groundwater is the water that is found below the ground surface in the rock interstices. It accumulates by infiltration of rain water into the soil and bedrocks and re-appears at the surface (Press and Siever, 1978). The infiltrating water chemically alters rocks and soil, and becomes adulterated with dissolved ions (mainly from rocks) and other components contributed by plants and animals that live on and in soil (Press and Siever, 1978). Though chemical impurities may also originate from air, soil or rocks of the area in which the groundwater occurs, human activities such as improper disposal of untreated sewage, introduction of domestic and industrial wastes into the underground water and the use of pesticides and chemical fertilizers in farming contribute immensely to the groundwater contamination.

However, access to safe drinking water and sanitation is critical in terms of health, especially for children. For instance, unsafe drinking water contributed to numerous health problems in developing countries such as the one billion or more incidents of diarrhea that occur annually (Mark *et al.*, 2002).

Various authors have carried out studies on the relationship between ground water quality and rock types in many parts of the world (Kawamura, 1942; Davis and De West, 1966; Azeez, 1971; Handa, 1975; Johnson, 1975., Freeze and Cherry, 1979; Okufarasin, 1984, Ako, *et.al.*, 1990, Adediji and Ajibade, 2005), but very little work has been done on the suitability of ground water for human consumption in the study area. Pipe-borne water in the towns and cities in Nigeria are not evenly distributed and regularly supplied and so, many people have depended on ground water from boreholes and hand dug wells for all their daily water needs. Thus, the main objective of this study was to determine the quality and suitability of ground water from boreholes and hand-dug wells in Ejigbo and environs, southwestern Nigeria for human consumption, by comparing the results obtained from its chemical analysis with WHO drinking water standards.

MATERIALS AND METHODS

Geology of the Study Area and Sampling Points

The study area is situated in Osun state, Nigeria and it lies between latitudes 7°52' and 7°55'N and longitudes 4°18' and 4°21' East of Greenwich Meridian. It is underlain by one of the rocks of the crystalline Precambrian Basement

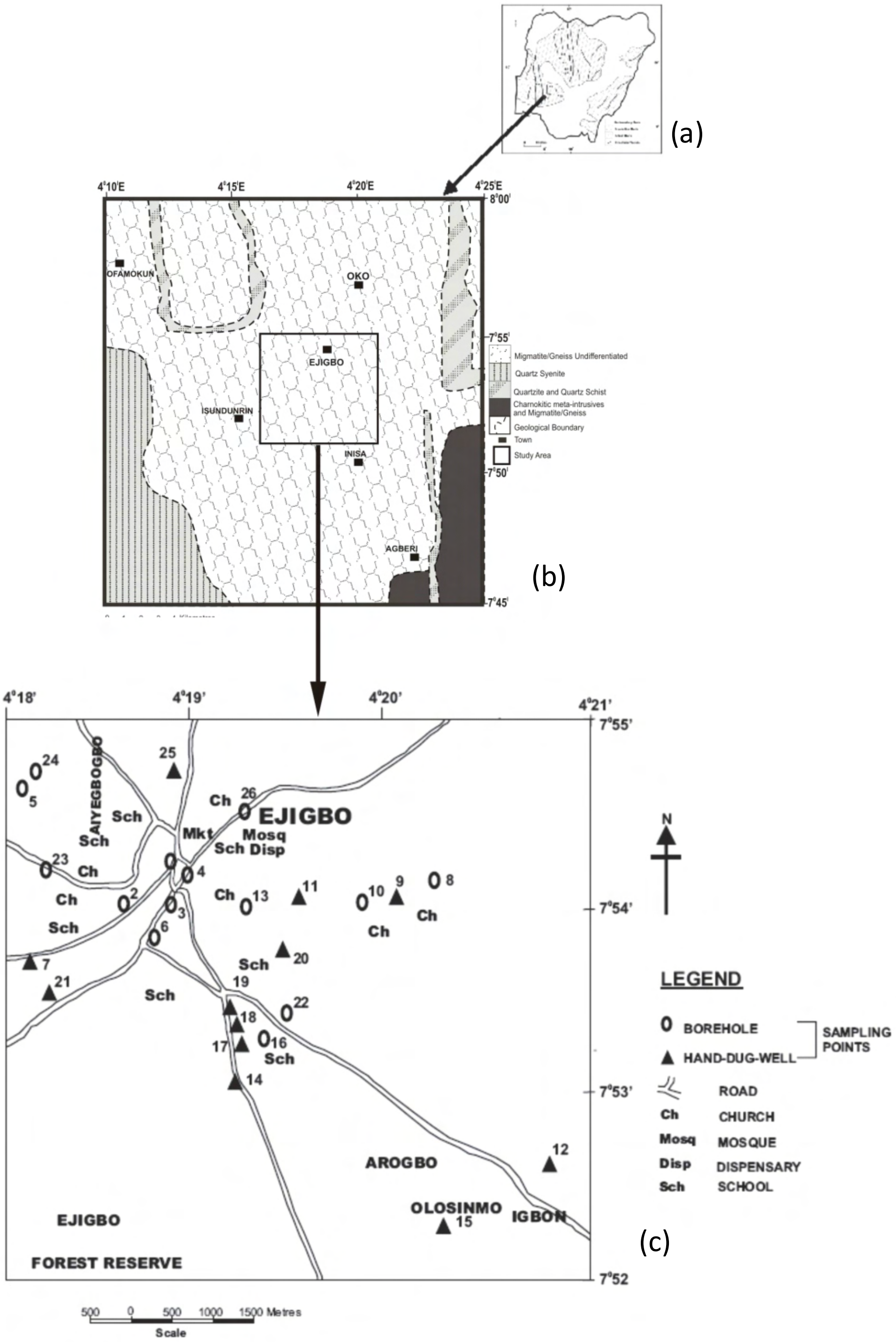

Fig.1: Map of Nigeria Showing the Study Area (a), the Geological Map (b), and the Sampling Points (c).

Complex of Nigeria which is migmatitic gneiss of the migmatite-gneiss-quartzite complex (Fig. 1(b)). The migmatite-gneiss-quartzite complex is the most abundant rock group of the basement complex of Nigeria (Rahaman, 1976, 1988). The migmatitic gneisses are composed of three main components which may be observed in a single outcrop. These three components are early gneiss, mafic-ultramafic bands and granitic or felsic components.

A total of twenty-six groundwater samples from fourteen (14) boreholes and twelve (12) hand-dug wells were selected for this study. Fig. 1(c) shows the sampling points in the study area. The choice of the wells used for the study partly depends on the wish of the owners to make them available for sampling, the sanitary system in the immediate surrounding and the environmental conditions around the wells, which are likely to affect the composition and quality of the water. The samples were taken randomly from the center to the outskirt of the town in the study area. The sampling was done in October 2007 and the Global Positioning Systems (GPS) readings of all the sampled boreholes and hand-dug wells were taken for accurate location (Table 1). The wells studied were of varying depths which depends to an extent on the topography of the site. Most of the boreholes were in a clean environment and had covers. Most of the hand-

Table 1: Description of Sampling Locations (Ejigbo, Southwestern Nigeria)

(BH/HDW) S/N	LOCATION (COORDINATES)	TYPE OF WELL	REMARK/OBSERVATION
1 (BH)	NO7^{O} 54.122` EOO4$^{O}$ 18.839`	Borehole	About 75m away from a vulcanizer
2(BH)	N 07^{O} 54.028` EOO4$^{O}$ 18.708`	Borehole	Residential area with clean environment
3 (BH)	N 07^{O} 54.299` EOO4$^{O}$ 18.856`	Borehole	Residential area with clean environment
4 (BH)	N 07^{O} 54.307` EOO4$^{O}$ 18.950`	Borehole	Residential area with clean environment
5(BH)	N 07^{O} 54.669` EOO4$^{O}$ 19.075`	Borehole	Residential area with clean environment
6 (BH)	N 07^{O} 53.810` EOO4$^{O}$ 18.784`	Borehole	Residential area with clean environment
7(HDW)	N 07^{O} 53.679` EOO4$^{O}$ 19.086`	Hand dug well	Well is covered and cased with concrete rings and located about 20m away from a poultry
8 (BH)	N 07^{O} 54.159` EOO4$^{O}$ 20.277`	Borehole	Residential area with clean environment
9(HDW)	N 07^{O} 54.029` EOO4$^{O}$ 20.049`	Hand dug well	Well is uncovered but cased. It is located about 10m away from a cassava processing site
10(BH)	N 07^{O} 53.998` EOO4$^{O}$ 19.905`	Borehole	Residential area with clean environment
11(HDW)	N 07^{O} 53.997` EOO4$^{O}$ 19.561`	Hand dug well	Well is covered and cased. It is about 8m away from a surface running water
12(HDW)	N 07^{O} 54.089` EOO4$^{O}$ 19.364`	Hand dug well	Well is covered and cased. Located in a clean environment.
13(BH)	N 07^{O} 53.971` EOO4$^{O}$ 19.401`	Borehole	Residential area with clean environment
14(HDW)	N 07^{O} 53.044` EOO4$^{O}$ 19.180`	Hand dug well	Well is covered and cased in a clean environment
15(HDW)	N 07^{O} 53.102` EOO4$^{O}$ 19.163`	Hand dug well	Well in uncovered and cased in a dirty environment
16(BH)	N 07^{O} 534.306` EOO4$^{O}$ 19.340`	Borehole	School premises with clean environment
17(HDW)	N 07^{O} 53.239` EOO4$^{O}$ 19.165`	Hand dug well	Well is covered and cased
18(HDW)	N 07^{O} 53.429` EOO4$^{O}$ 19.157`	Hand dug well	Well is covered and cased
19(HDW)	N 07^{O} 53.365` EOO4$^{O}$ 19.167`	Hand dug well	Well is uncovered but cased. It is located in a dirty environment
20(HDW)	N 07^{O} 53.469` EOO4$^{O}$ 19.206`	Hand dug well	Well is covered and cased in neat environment
21(HDW)	N 07^{O} 53.502` EOO4$^{O}$ 18.163`	Hand dug well	Well is covered and cased
22(BH)	N 07^{O} 53.416` EOO4$^{O}$ 19.489`	Borehole	Residential area with clean environment
23(BH)	N 07^{O} 54.184` EOO4$^{O}$ 18.161`	Borehole	Residential area with clean environment
24(BH)	N 07^{O} 54.706` EOO4$^{O}$ 18.146`	Borehole	Residential area located about 55m near a refuse dumping site
25(HDW)	N 07^{O} 54.741` EOO4$^{O}$ 18.902`	Hand dug well	Residential area with covered and cased well
26(BH)	N 07^{O} 54.521` EOO4$^{O}$ 19.316`	Borehole	Residential area with clean environment

LEGEND
HB -Borehole
HDW – Hand dug well

dug wells were also covered and had concrete ring lining, but a few were left open. The environmental conditions around the wells varied slightly (Table 1).

PHYSICO-CHEMICAL ANALYSES

The chemical parameters examined are pH, Total Dissolved Solids (TDS), cations concentration which included those of calcium (Ca^{2+}), sodium (Na^{+}), magnesium (Mg^{2+}), potassium (K^{+}), zinc (Zn^{2+}), cadmium (Cd^{2+}), lead (Pb^{2+}), iron (Fe^{2+}) and manganese (Mn^{2+}) and anions concentration which included those of sulphate (SO_4^{2-}), nitrate (NO_3) and phosphate (PO_4^{3-}).

The pH of the water samples was measured immediately after sample collection by using a checker pocket-sized pH meter with a replaceable electrode. The meter is a product of WOONSOCKET, RI 02895 HANNA. In order to obtain accurate results, the meter was first standardized with buffers of pH 7.00 and 4.00. The electrode of the meter was inserted into the water samples and the pH value was read directly on the meter.

The total dissolved solids (TDS) of the water samples were determined with the use of METTLER TOLEDO MC 126 TDS/conductivity meter. This instrument which is of average size with two sensitive probes was similarly used for measuring the electrical conductivity (EC) of the samples. To measure the TDS, the instrument was put on TDS mode while the probes were inserted into each sample and the displayed TDS value was read. Conversely, to measure the electrical conductivity of the samples the meter was changed to EC mode and first standardized with a solution of electrical conductivity of 12.88us/cm at 25°C in order to obtain accurate results. For each analysis of EC, the probes of the meter were inserted into the water sample such that the water level was above the probes. The instrument measures TDS in either milligram per litre (mg/L) or gram per litre (g/L) while the EC is measured in siemens (S) or microsiemens (uS).

The cations concentrations were determined using Atomic Absorption Spectrophotometer (AAS) (Perkin ELMAR 463) at the Centre for Energy Research and Development (CERD), Obafemi Awolowo University (OAU) Ile-Ife. The working procedure of the machine is such that a small sample solution is aspirated into a flame where atomic vapour is formed. Since uncharged atoms in a vapour state are capable of absorbing photons of light having energy appropriate for exciting the outer electrons, a sharp spectral line of the element to be analysed is generated in a source lamp and passed through the vapourised sample. The wavelength absorbed allow specific identification of the element, and the proportion of light absorbed is a measure of the concentration of the element in the light path (Price, 1972).

The anions concentrations which included those of phosphate (PO_4^{3-}), sulphate (SO_4^{2-}) and nitrate (NO_3) were determined at the Central Science Laboratory (CSL), Obafemi Awolowo University (OAU) Ile-Ife. The concentration of phosphate (PO_4^{3-}) in the water samples was determined with the use of VANADO-MOLYBDO-PHOSPHORIC ACID COLORIMETRIC METHOD. This method is based on the ability of ammonium molybdate in dilute orthophosphate solution to react under acidic conditions to form a heteropoly acid-molybdo-phosphoric acid. In the method, yellow coloured vanado-molybdo-phosphoric acid was formed and the intensity of the yellow colour which is proportional to the phosphate concentration in the solution was then measured with a UV visible spectrophotometer.

Concentrations of sulphate (SO_4^{2-}) in the water samples were determined using TURBIDIMETRIC METHOD. This method is based on the principle of formation of barium sulphate in the colloidal form by a sulphate in the presence of (acidified HCl) barium chloride. The process is enhanced in the presence of glycerol or other organic compound. The absorbance of the colloidal solution can be measured against a standard on UV visible spectrophotometer.

The concentrations of nitrate (NO_3) in the water samples were determined by using the ULTRA VISIBLE SCREENING METHOD. 0.7218g of KNO_3 salt dried at 105°C for 24hrs was dissolved in distilled water and diluted to mark in a 1000 mL standard flask. This was preserved with 2 mL chloroform and then used to prepare calibration standards of 1 mg/L to 40 mg/L by dilution. 0.2mL of HCl was added to 10 mL of each of the standard solutions and mixed thoroughly. Absorbances of the standards were then read against distilled water of zero absorbance at 220nm and 275nm. Differences in the readings were plotted against the concentrations to obtain calibration curve for the analysis. To 10mL of each sample, 0.2 mL HCl was added and mixed thoroughly before reading the absorbance at 220nm and 275nm. The differences in absorbances were used in determining the concentration of nitrate in the samples from the calibration curve obtained.

RESULTS AND DISCUSSION

The pH and total dissolved solids (TDS) of the ground water (boreholes and hand-dug wells) sampled are shown in Table 2. On the basis of the general classification of water according to pH as recommended by WHO International Standard for drinking water in 2006 (Table 3), about 81% of all the samples tested are within the recommended range of between 6.5 and 9.5, which is the allowable concentrations for drinking water while the remaining 19% are slightly acidic.

Table 2: pH and Total Dissolved Solids (TDS) of the Sampled Wells

(BH/HDW) S/N	TDS (mg/L)	pH
1 (BH)	192.0	6.61
2(BH)	533.0	6.48
3 (BH)	315.0	7.29
4 (BH)	128.0	7.42
5(BH)	53.6	7.68
6 (BH)	272.0	7.18
7(HDW)	50.5	6.76
8 (BH)	114.0	6.87
9(HDW)	112.0	6.66
10(BH)	323.0	6.63
11(HDW)	116.0	7.34
12(HDW)	129.0	6.87
13(BH)	80.7	6.58
14(HDW)	44.3	7.50
15(HDW)	108.0	7.47
16(BH)	168.0	8.17
17(HDW)	41.3	6.94
18(HDW)	183.0	8.14
19(HDW)	123.0	7.04
20(HDW)	102.0	7.35
21(HDW)	39.0	7.60
22(BH)	118.0	7.57
23(BH)	48.5	6.93
24(BH)	227.0	7.26
25(HDW)	111.0	7.54
26(BH)	49.37	7.68

LEGEND
BH- Borehole
HDW- Hand dug well

Based on the Total Dissolved Solids (TDS), which is used as an indicator to determine the general chemical quality of water, all the water samples falls in the class of freshwater using Gorrel (1958)'s classification of ground water (Table 4), as reported by Davis and De West (1966). In this regards, none of the water samples is classified saline or brine. The values obtained are within the WHO (2006) maximum allowable concentrations.

Table 3: The WHO (2006) Standards for Drinking Water

Parameters	Maximum Allowable Limits
pH	6.5-9.5
Total Dissolved Solids (mg/L)	<600
Sodium (mg/L)	200
Potassium (mg/L)	-
Calcium (mg/L)	200
Magnesium (mg/L)	100
Iron (mg/L)	<0.3
Manganese (mg/L)	0.1
Cadmium (mg/L)	0.003
Lead (mg/L)	0.01
Zinc (mg/L)	3.0
Nitrate (mg/L)	50
Sulphate (mg/L)	250

The concentrations of the cations are shown in Table 5. The table shows that the concentration of calcium (Ca^{2+}) ranged from 1.43 to 44.20 mg/L. This range is within the concentration for potable water, as it is below the maximum permissible level of 75.00 mg/L stipulated by the WHO (1971) (Table 3). Calcium, within this concentration range has no known adverse health implications.

The magnesium (Mg^{2+}) concentrations of the ground water samples ranged from 6.32 to 54.09 mg/L. These values falls within the highest desirable and maximum permissible levels (50-150 mg/L) for potable ground water recommended by WHO (1971). These very low values of magnesium in the water samples may indicate that water in these wells have undergone natural softening by cation exchange.

Sodium (Na^{+}), unlike other alkali metals such as potassium, is the only metal found in significant quantities in natural waters. The primary source of most of the sodium ions in natural water is from the release of soluble sodium products during the weathering of plagioclase feldspars (Akinola, 1994). As shown in Table 5, the concentration of sodium (Na^{+}) in the

Table 4: Total Dissolve Solid (TDS) Classification of Water After Gorrel (1958) in Davis and De Wiest (1966)

Name	Concentration of TDS (ppm)	Number of boreholes and hand dug wells	%
Fresh water	0 – 1000	26	100
Brackish water	1000 – 10,000	-	-
Salty water	10,000 – 100,000	-	-
Brine	> 100,000	-	-

samples ranged from 0.00 to 69.29 mg/L. These values falls within the highest desirable and maximum permissible levels (20-150 mg/L) for portable ground water recommended by WHO (1971).

All natural waters contain measurable amount of potassium (K^+). Although, the abundance of potassium in the earth crust is about the same as sodium, yet, potassium is commonly less than one-tenth of the sodium concentration in natural water. For most potable groundwater, potassium (K^+) concentration should be less than 10 ppm. The concentrations of potassium (K^+) in all the samples analyzed ranged from 0.00-68.72 mg/L. The values exceeded the highest desirable and maximum permissible levels (10-12 mg/L) for potable ground water recommended by WHO (1971). From Table 5, it can be seen that only five samples with concentration values of 0.00 mg/L (sample 1), 0.63 mg/L (sample 11), 4.04 mg/L (sample 13), 6.06 mg/L (sample 16) and 2.07 mg/L (sample 20), fall within the desirable and permissible range for portable water. The abundance of K^+ in the ground water samples studied can be related to the high concentration of the Total Dissolved Solids (TDS) in these samples.

Iron (Fe^{2+}) concentrations in the ground water samples ranged from 0.00-0.41 mg/L and thus exceed the maximum allowable limits (0.3 mg/L) for potable ground water according to WHO (2006) recommendation. This high concentration of iron in some of the samples can be attributed to the type of bed rock in the area of study.

The concentrations of cadmium (Cd^{2+}) in the water samples from the study area ranged from 0.00-0.10 mg/L. The Cd values in some samples are higher than the maximum allowable limits of 0.003 mg/L for cadmium as recommended by WHO (2006). Sample numbers 6, 10, 13, 14, 20, 24, and 26 has Cd concentrations well below the detection limit of the AAS. All the other samples had concentrations that are very high compared to the WHO drinking water standards. Sample numbers 11 (HDW) and 22 (BH) have concentrations of 0.1 mg/L which is extremely high compared to the rest of the samples and WHO standards (Table 3). Cadmium is not known to have any beneficial effects in human body and can cause a number of adverse health effects. Its source of high concentration could probably be the environmental pollution effect of used storage batteries dumped indiscriminately into the environment as observed in parts of the study area.

According to Rose *et al.* (1979), cadmium shows an almost universal association with zinc with a Zn/Cd ratio that does not deviate by more than a factor of 2 from an average of 500 of Zn to 1 of Cd in many geological occurrences. This relationship indicates that zinc should have a higher concentration than cadmium in natural deposits. But, from our study, zinc and cadmium had more or less the same concentrations. This strongly suggests some anthropogenic source for Cd in the study area.

The concentration of zinc (Zn^{2+}) ranged from 0.00 to 0.14mg/L. This range of values falls below the maximum allowable limits (3.0mg/L) for zinc as recommended by WHO (2006). Sample numbers 11 (HDW) and 22 (BH) had concentrations of 0.13 mg/L and 0.14 mg/L which are relatively high compared to the rest of the samples (Table 5). These high values of zinc

Table 5: Concentration of Cations and Anions of the Ground Water Sampled in Milligramme Per Litter (mg/L)

(BH/HDW) S/N	Na^+ (mg/L)	K^+ (mg/L)	Mg^{2+} (mg/L)	Cd^{2+} (mg/L)	Pb^{2+} (mg/L)	Zn^{2+} (mg/L)	Ca^{2+} (mg/L)	Fe^{2+} (mg/L)	Mn^{2+} (mg/L)	NO_3^- (mg/L)	SO_4^{2-} (mg/L)	PO_4^{3-} (mg/L)
1 (BH)	0.00	0.00	12.38	0.03	0.06	0.04	9.94	0.16	0.00	4.87	43.42	0.54
2(BH)	33.27	14.50	34.39	0.01	0.00	0.02	37.80	0.03	0.00	3.24	39.06	0.38
3 (BH)	45.51	22.22	8.99	0.01	0.00	0.01	2.96	0.00	0.00	6.01	48.11	0.67
4 (BH)	46.19	15.39	20.31	0.01	0.00	0.08	2.58	0.01	0.03	8.55	65.84	1.28
5(BH)	24.17	20.18	29.61	0.01	0.03	0.02	25.42	0.09	0.00	6.23	58.86	0.81
6 (BH)	26.96	12.63	19.40	0.00	0.00	0.02	1.43	0.01	0.02	3.11	34.56	0.32
7(HDW)	22.51	19.18	16.31	0.01	0.00	0.01	24.05	0.00	0.02	23.82	98.92	4.27
8 (BH)	23.01	37.33	26.75	0.01	0.00	0.02	5.48	0.13	0.03	27.01	121.25	4.88
9(HDW)	16.38	25.78	54.09	0.04	0.02	0.00	44.00	0.10	0.00	4.21	12.16	0.43
10(BH)	19.46	39.26	42.72	0.00	0.00	0.01	44.20	0.02	0.03	8.06	8.07	1.08
11(HDW)	7.70	0.63	24.88	0.10	0.02	0.13	8.30	0.19	0.04	2.10	20.96	0.19
12(HDW)	15.24	14.44	19.38	0.01	0.01	0.02	13.60	0.01	0.02	19.25	48.99	3.07
13(BH)	0.00	4.04	18.43	0.00	0.00	0.01	2.50	0.00	0.01	7.82	46.87	0.91
14(HDW)	17.59	40.24	23.13	0.00	0.02	0.03	17.80	0.03	0.01	6.1	45.44	0.75
15(HDW)	30.34	47.65	13.22	0.06	0.09	0.07	18.40	0.15	0.06	5.92	23.93	0.68
16(BH)	17.27	6.06	11.91	0.02	0.01	0.00	1.50	0.00	0.00	12.53	37.83	2.96
17(HDW)	28.38	35.43	10.54	0.01	0.00	0.00	11.50	0.06	0.00	10.73	83.56	2.01
18(HDW)	69.29	21.31	6.32	0.01	0.01	0.01	30.60	0.02	0.01	8.95	74.88	1.47
19(HDW)	14.18	68.72	7.92	0.01	0.01	0.03	23.90	0.04	0.00	6.75	60.02	0.89
20(HDW)	57.92	2.07	12.32	0.00	0.01	0.01	12.20	0.07	0.00	3.16	39.11	0.39
21(HDW)	26.78	58.50	10.84	0.02	0.02	0.02	2.20	0.05	0.00	4.72	12.22	0.47
22(BH)	18.88	23.94	14.71	0.10	0.00	0.14	19.40	0.35	0.00	12.63	18.91	3.05
23(BH)	32.99	34.38	9.70	0.06	0.01	0.10	9.70	0.22	0.07	9.26	25.85	1.52
24(BH)	42.61	11.57	11.86	0.00	0.06	0.02	3.00	0.41	0.00	7.71	18.94	0.86
25(HDW)	34.50	16.15	11.57	0.01	0.04	0.01	9.50	0.01	0.02	8.13	8.28	1.19
26(BH)	13.11	26.54	14.80	0.00	0.00	0.00	19.00	0.03	0.03	6.15	45.51	0.79

BH- Borehole
HDW- Hand dug well

correspond to the high cadmium concentration in the same samples. Zinc is an essential nutrient for almost all plants. However, the element is toxic to most forms of plants and aquatic life if it occurs in amounts exceeding certain limit. The degree of toxicity varies with pH, alkalinity and hardness of the water (Fetter, 1980). The zinc toxicity in water can cause gastro intestinal distress if ingested in large quantities.

The concentrations of lead (Pb^{2+}) ranged from 0.00-0.09 mg/L (Table 5) and about 65% of the samples falls within the maximum allowable limits of 0.01 mg/L for lead recommended by WHO (2006). Thus, lead content in the water sample is generally low. However, in samples number 1 (BH), 15 (HDW) and 24 (BH), the concentrations of lead (Pb^{2+}) are 0.06, 0.09 and 0.06 mg/L respectively, and these are fairly high compared with the maximum allowable limits of 0.01 mg/L stipulated by the WHO standard. Levinson (1974) stated that it is sometimes possible to check on the likelihood of contamination by considering element association. In natural deposits, lead and zinc do associate together. From our study, the concentrations of lead and zinc vary slightly except in wells 11HDW, 22BH and 23BH in which there are wide variations. This suggests a possible contamination by one of these elements possibly Pb in the ground water of the study area.

Manganese (Mn^{2+}) concentration in the water samples ranges from 0.00 to 0.07mg/L. This range of values falls within the maximum allowable limits of 0.5 mg/L of the WHO standard for manganese in normal portable water.

The concentration of nitrate (NO_3) in the water samples ranges from 2.10 to 27.01 mg/L. These values of NO_3^- in the samples are below the maximum allowable limits of 50 mg/L recommended WHO Standards for drinking water (2006).

Most sulphate compounds are readily soluble in water. The sulphate (SO_4^{2-}) concentration of the groundwater samples from the study area ranges between 8.07 and 121.25 mg/L. Hence, these concentration ranges is lower than the maximum allowable limits of 400 mg/L recommended by WHO International Standards for drinking water (2006).

Analysis of the water samples showed that the concentration of phosphate (PO_4^{3-}) ranges from 0.19 to 4.88 mg/L. Unlike as we have in the case of other ions, there was no value(s) stipulated in the WHO standards and most other available drinking water standards for comparison as maximum or minimum allowable limits for phosphate. However, since phosphorus is usually present in natural water as phosphate, the desirable criteria for phosphorus in the Federal Environmental Protection Agency of Nigeria (FEPA) water quality criteria is used for comparison in this case. The maximum desirable criterion set for phosphorus by FEPA is 10 mg/L and this is far higher than the concentration range of phosphate in the water samples studied. The presence of phosphate in the groundwater studied may therefore not give cause for concern now based on the results got in this study. The phosphate levels in the samples may likely be from the applied agricultural fertilizer on the farms in the vicinity of the study area.

CONCLUSION AND RECOMMENDATIONS

The groundwater in Ejigbo and its environs, southwestern Nigeria is free of acids as indicated by the pH values of all the samples analyzed. Sodium and potassium ions are the most abundant dissolved cations in the groundwater and have contributed immensely to the Total Dissolved Solids (TDS) of the ground water samples.

The levels of some of the cations such as sodium, magnesium, calcium, zinc, iron and manganese in the studied groundwater samples conformed to the WHO recommended limits for drinking water. However, the concentrations of cadmium and lead generally exceeded the WHO standards. An anthropogenic source of lead and cadmium has been suggested for the water samples in this study area. The concentration of anions such as nitrate, sulphate and phosphate are also within the safe WHO recommended limits and gives no cause for concern now but biomagnification of these ions may lead to deleterious health effects in human in the nearest future, if indiscriminate usage of agricultural fertilizers continues in the study area.

Hence, it can be concluded that most of the groundwater samples from Ejigbo area, are not potable and good for human consumption on the basis of the high concentrations of cadmium and lead that exceed WHO standards in most of the samples studied.

However, since the majority of people living in this area depend on water supply from the hand-dug wells and boreholes for domestic purposes, there is the need to alert the local authority in the area of this dangerous trend, so that an alternative arrangement can be made to provide potable domestic water for the residents of the area. We also recommend that waste disposal facilities should be located at the outskirt of the town by the local authority and thorough study of the topography of the location of new boreholes and hand dug wells should be considered to avoid contamination of ground water from sources such as surface erosion of fertilizers and septic tanks.

REFERENCES

Adediji, A., and Ajibade, L. T. 2005. Quality of groundwater in Ede Area, southwestern Nigeria. A *Journal published by the Department of Geography*, Obafemi Awolowo University, Ile-Ife, Nigeria.

Akinola A.A. 1994. Hydrogeochemistry of groundwater samples from hand-dug wells in Ede area of southwestern Nigeria. *Unpublished B.Sc dissertation*. Department of Geology, Obafemi Awolowo University, Ile-Ife.

Ako, B. D., Adeniyi. F. I. and Adepoju. J. F. 1990. Statistical tests and chemical quality of shallow groundwater from metamorphic terrain, Ile-Ife/Modakeke, southwestern Nigeria. *Journal of African Earth Sciences,* 10(4).

Assez, 1971. Hydrogeology of southwestern Nigeria: The Nigeria Engineers. *Journal of the Nigeria Society of Engineers*. 7(1): 22-44.

Davis, S.N. and West, De 1966. Hydrogeology. John Wiley, New York.

FEPA 1991. Guidelines and standards for drinking water, industrial effluent, gaseous emissions and hazardous waste management in Nigeria.

Fetter, C. W. 1980. Applied Hydrogeology. Charles E. Merrill Publishing Company; A Bell and Howell Company Columbus, Ohio.

Freeze, R. A. and Cherry, J.A. 1979. Groundwater, Prentice-Hall, Englewood Cliffs, New Jersey.

Gorrel, H.A. 1958. Classification of formation waters based on sodium chloride content. *American Association of Petroleum Geology Bulletin,* 42, 2513.

Handa, B.K. 1975. Occurrences and distribution of potassium ions in natural waters in India. *Journal of Hydrogeology,* 26: 267-276.

Johnson, E.J. 1975. Groundwater and wells. Johnson Division, VCP inc; St. Paul, Minnesota.

Kawamura, R. 1942. Abstract: Groundwater quality in Nairobi, Kenya. *Bulletin of Hygiene,* 17: 260.

Levinson, A.A. 1974. *Introduction to exploration geochemistry.* Applied Publishing Limited, U.S.A. 614p.

Mark, W.R., Ximing Cai and Sarah A.C. 2002. World water and wood to 2025: dealing with scarcity. International Food Policy Research Institute, NW, Washington, DC, USA.

Okufarasin, A. 1984. Influence of weathering of rocks types on chemical composition of ground-water in Ilesa Area. Unpublished M.sc. Thesis, Department of Geology, Obafemi Awolowo University, Ile-Ife, Nigeria.

Press E. and Siever W. R. 1978. Outline of methods for estimating groundwater supplies. *US geological survey supply paper 638,* Washington D. C.

Price, W.J. 1972. *Analytical atomic absorption spectrometry.* Heyden and Son, London, 239p.

Rahaman, M. A. 1976. Review of the basement geology of southwestern Nigeria. In: C. A. Kogbe (ed.), *Geology of Nigeria.* Elizabethan Publishing Company, Lagos. p 41-56.

Rahaman, M. A. 1988. Recent advances in the study of the Basement Complex of Nigeria. In *Precambrian Geology of Nigeria* (Edited by Oluyide *et al.*,) p. 241-256.

Rose, A.W., Hawkes, H.E. and Webb, J.S. 1979. *Geochemistry in mineral exploration.* Academic Press, London, 657p.

Salahudeen, K.S. 2007. *Assesment of groundwater quality of Ejigbo town and environs, southwestern Nigeria.* Unpublished B.Sc. dissertation, Department of Geology, Obafemi Awolowo University, Ile-Ife, Nigeria, 99p.

United States Geological Survey 2005. Water levels and artesian pressures in observation wells in the United States. *Water-supply papers.* Washington D. C. Published annually.

World Health Organization 1971. *International drinking water standards.* Third edition, Geneva, Switzerland, WHO.

World Health Organization 2006. I*nternational drinking water standards.* Third edition, Geneva, Switzerland, WHO.

Ife Journal of Science

Tables of Contents: June Edition 2011; Vol. 13, No. 1