Assessment of Physico-Chemical Properties of Water from Oyo Dumpsites Vicinities, Southwestern Nigeria

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***Abstract*- Inadequate and improper management of municipal solid waste disposal sites pose serious environmental threats to their surrounding and nearby resident due to groundwater contamination, causing various health problems. This investigation was carried out to assess the groundwater contamination of well water around dumpsites in Oyo, South Western Nigeria. Fourteen water samples were collected from active wells and analyzed for physicochemical parameters. The fourteen water samples were observed to have pH values ranging from 6.57 to 7.83, with an average of 7.30 , the TDS ranges from 107 to 960 with an average of 499 mg/l and hardness ranges from 42 to 344(mg/l CaCO3. The Turbidity from 0.08 to 0.34 (FTU) with average of 0.169 (FTU). The analytical results obtained showed high level of pH, and very high level of electrical conductivity compared to World Health Organization, WHO standards of 417.00 permissible limits. Total Dissolved Solids is above the recommended value of 500 which may affect the taste adversely and deteriorate water pipes and other piping appliances. Calcium is within the recommended value of 100. Bicarbonate and Magnesium values are above the WHO standard. High value of magnesium can lead to hardness of water with frequent intake resulting to cardiovascular disease, cancer, diabetes and childhood atopic dermatitis, while high value of bicarbonate causes diarrhea, constipation in the human body and also causes a deformation in plant growth. Sodium and potassium values are within the recommended WHO permissible limits. Nitrates and sulphates are below the recommended WHO values.**

***Index terms*- Turbidity, Biotoxins, Contamination, Anthropogenic, Aquifer, Water borne disease.**

INTRODUCTION

Fresh water is a valuable resource for human needs and of fundamental importance to human life, animals and plants. It is of equal importance with the air we breathe in maintaining the virtual process of life and it makes up about 60% of body weight in human beings. Among the various sources of water, groundwater is known to be more appropriate for human consumption and often meets the criteria of quality of water. Groundwater is the most widely used sources of water in most African countries, Nigeria inclusive. Untreated groundwater could pose serious health threat to people drinking it. Likewise, treated water if not properly monitored could be further contaminated especially during distribution. In Nigeria, greater percentage of groundwater is used for domestic purposes and it requires certain degree of purity to prevent outbreak of diseases. Such diseases may result in acute illness caused by pathogens, chemicals or toxins. Groundwater contamination may be caused by certain anthropogenic activities which introduce foreign agents into the aquifer, thereby shifting the natural equilibrium to the detriment of the end users. Such activities include mainly poor waste disposal methods as well as increased industrial activities such as mining arising from industrialization and urbanization.

Water quality refers to the chemical, physical and biological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose. It is most frequently used by reference to a set standard against which compliance can be assessed. The most common standards used to assess water quality relate to health of ecosystems, safety of human contact and drinking water [1].

Increasing industrialization, population density, and high urbanization of modern societies and improper management of wastes arising from these sources, results in pollution of water bodies [2]. Water pollution is a potential source of waterborne diseases caused by pathogenic micro-organisms, biotoxins and toxic contaminants transmitted in water. Common water borne diseases include Cholera, Dysentery, Hepatitis ‘A’ which is a liver infection caused by consuming contaminated food and water or by coming in close contact with someone who has the infection. Common symptoms are fatigue, jaundice, nausea and vomiting, abdominal pain, especially near the liver, loss of appetite, and sudden fever and Salmonella coming from ingestion of food or water contaminated with feces. Undercooked meat, egg products, fruits, and vegetables can also carry this disease. Peculiar symptoms are blood in stool, chills, headache and diarrhea.

Water pollution is basically a condition whereby the level of chemicals, nitrates or heavy metals in water has attained the level not suitable for human consumption [3]. Contaminated water is a host to bacteria, viruses and parasitic organisms capable of causing diseases. Water borne disease can be contacted by humans from bathing, washing, drinking water, or eating food exposed to contaminated water.

Contamination of natural water bodies is a major challenge in Nigeria as in developing and densely populated countries of the world [4]. When untreated wastes have access into water body, water quality is compromised and the dangers of water contamination to human lives and other aquatic organisms increases [5]. Contaminants to groundwater from waste dumpsites and land disposal sites could be from infiltration and percolation, solid waste decomposition process, leaching, gas production and movement, groundwater travel and direct runoffs. The process of ground water contamination could be by horizontal leaching of refuse by ground water, vertical leaching by percolating water, transfer by diffusion and convection of gases produced during decomposition

Water as a valuable resource to man, making up about 60% of body weight, is also of fundamental importance to animals and plants. Groundwater through motorized boreholes and hand dug well is the most widely source of water for industrial and domestic purpose in Nigeria as in most African countries.

Naturally, groundwater has the potential of being purer and safer than surface waters but with uncontrolled waste disposal system and other anthropogenic activities, groundwater could pose serious health threat to people if left untreated before consumption. Groundwater contamination may be caused by certain anthropogenic activities which introduce foreign agents into the aquifer, thereby shifting the natural equilibrium to the detriment of the end users. In Nigeria, groundwater is a major source of water for domestic purposes.

GEOLOGY OF STUDY AREA

Oyo town lies within the Basement Complex of southwestern Nigeria. The study area is generally underlain by quartzite, garnet schist, banded gneiss and migmatite rocks. The gneissic rocks are the most dominant rock type occurring as granite gneiss and banded gneisses with coarse to medium grained texture. Pegmatites are common as intrusive rocks occurring as joints and vein fillings (Figure 1).

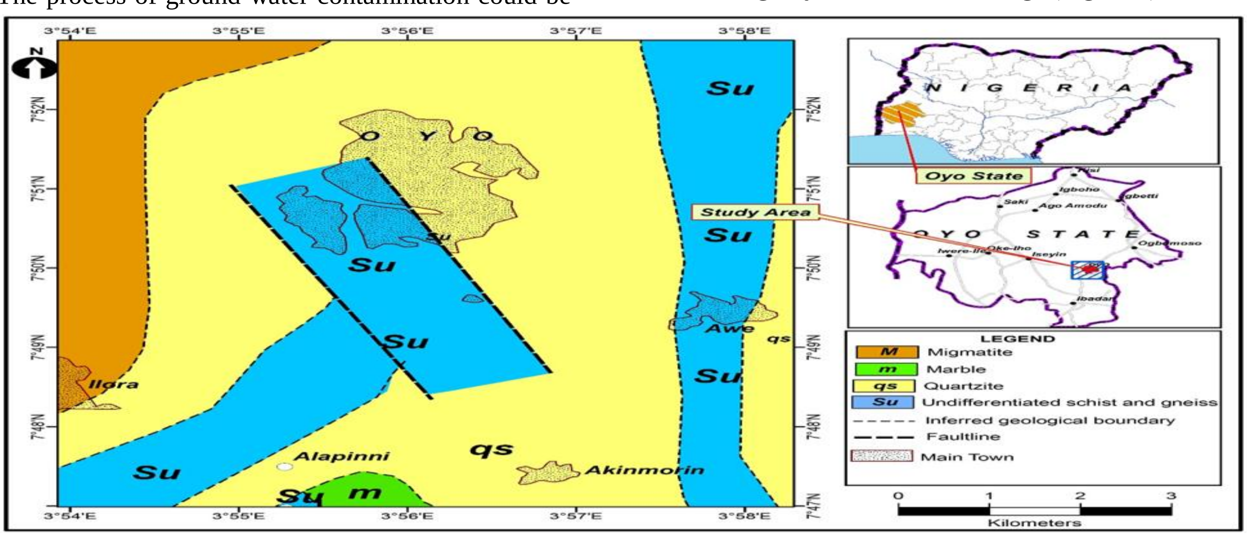

Figure 1: Geological map of the study area.

MATERIALS AND METHODOLOGY

Field Sampling

A total of fourteen water samples were taken from caged wells at different depths and average distances of 56m from dumpsites within the study area (Table 1). Standard procedures for field sampling of drinking water for quality assessment were carefully applied [6, 7]. The materials used for water sampling on the field include sterilized 2½ litres plastic containers, hand gloves, the GPS (Geographical Positioning System) for location identification, pH meter, thermometer, field notebook, masking tape and permanent marker. The gloves are cleaned at every sample point to avoid contamination and the sample containers were not opened until they are ready to be filled. The pH meter is well calibrated before being used.

Table 1: Well Locations and Distance From Dumpsites In The Study Area

LOCATIONS	COORDINATES	DISTANCE OF WELL TO DUMPSITES	NATURE OF SAMPLE
1.	N07^{O}51$'$ 02.4$''$, E003^{0}57$'$21.7$''$	62m	Well water
2.	N07^{0}51$'$ 17.6$''$, E003^{0}56$'$14.6$''$	68m	Well water
3.	N07^{0}50$'$ 55.7$''$, E003^{0}56$'$10.2$''$	25m	Well water
4.	N07^{0}51$'$ 50.2$''$, E003^{0}56$'$10.2$''$	55m	Well water
5.	N07^{0}51$'$ 50.2$''$, E003^{0}55$'$29.9$''$	72m	Well water
6.	N07^{0}50$'$ 50.4$''$, E003^{0}55$'$29.9$''$	75m	Well water
7.	N07^{0}49$'$ 38.7$''$, E003^{0}54$'$32.5$''$	65m	Well water
8.	N07^{0}49$'$ 51.8$''$, E003^{0}54$'$07.4$''$	51m	Well water
9.	N07^{0}49$'$ 37.9 $''$, E003^{0}58$'$05.5$''$	65m	Well water
10.	N07^{0}49$'$ 54.0$''$, E003^{0}56$'$53.8$''$	No dumpsite nearby	Well water
11.	N07^{0}48$'$ 01.4$''$, E003^{0}55$'$21.8$''$	84m	Well water
12.	N07^{0}49$'$ 46.5 $''$, E003^{0}56$'$06.4$''$	72m	Well water
13.	N07^{0}50$'$ 36.4 $''$, E003^{0}56$'$39.5$''$	45m	Well water
14.	N07^{0}49$'$ 29.5 $''$E003^{0}57$'$38.2$''$	53m	Well water

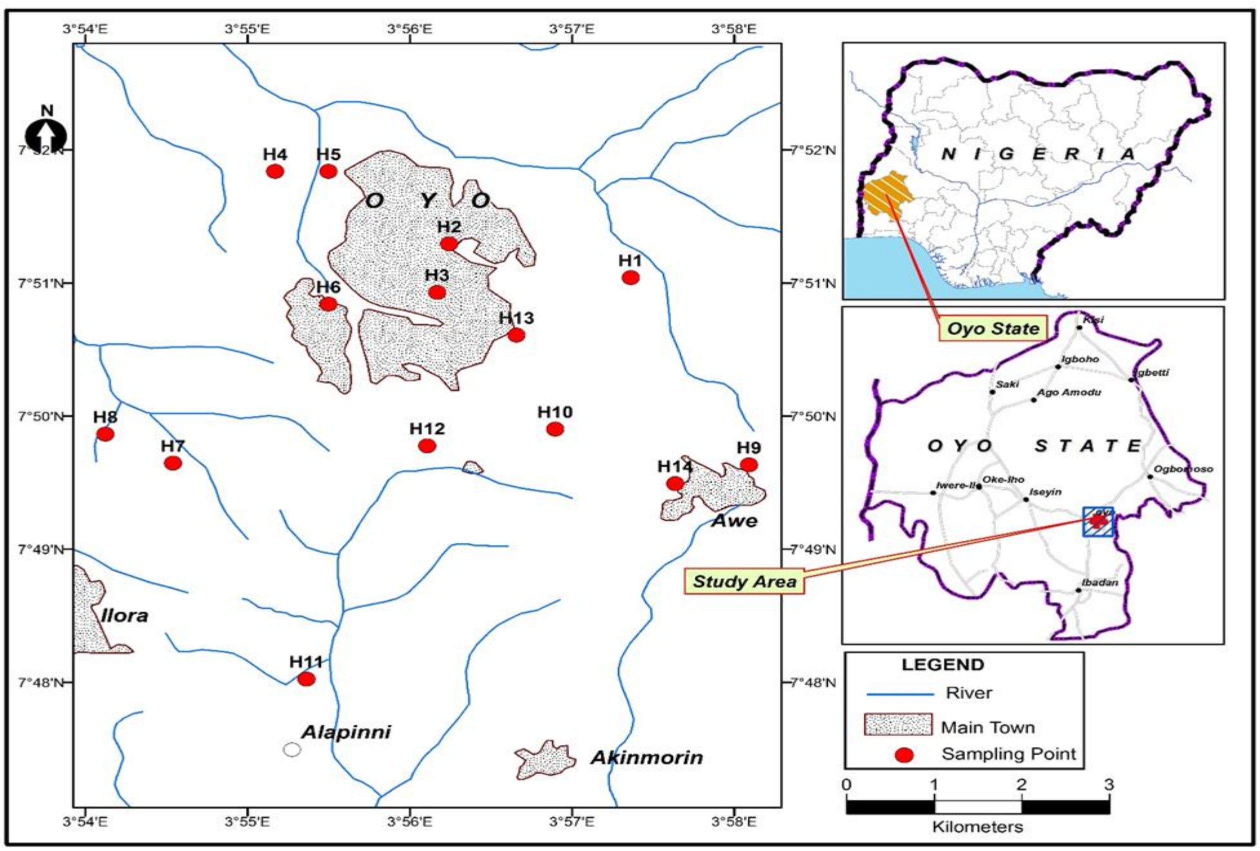

Fig. 2: Drainage Map Showing Sample Locations

Foutreen servicing wells are located in Oyo, Awe Akinmorin and Ilora as shown in figure 2. Because water is susceptible to undergo some physical and chemical reactions which would undermine the quality of the water if analysis was not done immediately the samples are collected, the samples were acidified to a lower pH value by adding 2 M hydrochloric acid and kept in refrigerator to preserve it at a temperature of between 2 and 8°C.

Water temperature, Odour, Taste and TDS were analyzed on the spot after collection while other parameters like Alkalinity, Chloride, Calcium, Magnesium, Total Hardness, Dissolved oxygen, Dissolved carbon dioxide, Barium, Copper, Sulphate were determined by standard procedures in the laboratory.

LABORATORY ANALYSIS

Titrimetric Analysis

For alkalinity, standard hydrochloric acid 0.02N as titrant, phenolphthalein indicator, methyl orange indicators were the reagents used. 2 drops of phenolphthalein indicator was added to a 50.0ml water sample in a conical flask. Titrate over a white surface with 0.02N standard acid to the coloration of corresponding to the proper equivalent point of pH 8.3, that is, pink to colourless.

Total alkalinity was determined by adding 3 drops of methyl orange indicator to the solution in which the phenolphthalein alkalinity has been determined. Titrate with 0.02N standard acid to the proper equivalent point. The indicator changes to orange at pH 4.6 and to pink at 4.0.

Calculation

Phenolphthalein alkalinity as mg/l $CaCO_3$ = AxNx50,000 / ml sample and Total alkalinity as mg/l $CaCO_3$ = BxNx50,000 / ml sample. Where A= ml titration for sample to reach phenolphthalein end point, B = total ml titration for sample to reach the second end point and N = normality of acid.

HARDNESS

The reagents include buffer solution, Standard EDTA titrant (0.01N), Solochrome black T indicator. 1-2 ml of buffer solution was added to 50.0 ml sample in the conical flask to increase the pH of the sample to 10.0 to 10.1. Then, add 2 drops of indicator solution and titrate with standard EDTA titrant slowly, stirring continuously until the last reddish tinge disappears from the solution. The colour at the end point is blue.

Calculation

Hardness (EDTA) as mg/l $CaCO_3$ = A x B x 1,000 / ml sample where A= ml titration for sample, and B = mg $CaCO_3$ equivalent to 1.00 ml EDTA titrant.

pH

The pH of a solution is basically a measure of the acidity or alkalinity of an aqueous solution. Solutions having pH less than 7 is considered as acidic and solutions having pH greater than 7 is alkaline. It is mathematically defined as the negative logarithm of the activity of hydrogen ion.

The pH meter electrodes were immersed in the water sample such that the bulb at the tip of the electrode is completely covered by the sample and the reading was obtained from the meter screen. The pH is important in determining the solubility and biological availability of chemical constituents such as nutrients (phosphorus, nitrogen, and carbon) and heavy metals (lead, copper, cadmium.) .Extremely high pH causes bitter tastes with water pipes and water-using appliances becoming encrusted with deposits resulting in a reduced effectiveness chlorine as a disinfectant. Low pH of water might corrode or dissolve metals and other substances. Pollution has the potential to change the pH of water which might in effect harm animals and plants living in water.

ANIONS

Anions are Nitrate, Chloride, Sulphate, Phosphate, Flouride and Nitrite. Anions in water were analyzed by Spectrophotometer method (HACH DR-2000 Spectrophotometer). Two 10ml sample cells were filled with the sample to be tested, 1 pillow of test parameter was added to one of the sample in the sample cell and was shaken, it was then allowed to stay for reaction time depending on the test parameter (for example 0, 5, 10 minutes). The blank was then placed in the sample chamber to calibrate or zero, then the second sample cell was placed in the chamber, the concentration of the test parameter in mg/l was displayed on the spectrophotometer screen.

Carbonate is determined from Phenolphthalein alkalinity. Bicarbonate is gotten from the difference between the Total Alkalinity and Carbonate alkalinity.

TURBIDITY

Turbidity (TDS) describes the haziness or cloudiness of a fluid due to suspended particles of various sizes. Some of these particles can be seen with the naked eyes while some are microscopic in character and cannot be seen with the nicked eyes. Turbidity has relevance in glass and plastic production where it is known as haze when percentage deflected light greater than 2.5°. It is also a measure of a liquid's relative clarity.

Turbidity is an optical characteristic of water and an expression of the amount of light scattered by material in water when a light shines through water sample. The higher the intensity of scattered light, the higher the turbidity. Silts, clay, finely divided inorganic and organic matter, soluble colored organic compounds, algae, plankton and various other microscopic organisms characteristically results in turbidity of water.

Turbidity makes water cloudy or opaque and is measured by putting water in glass bottle and shine light through the water in the bottle. It is measured in nephelometric turbidity units (NTU).

High concentrations of particulate matter affect light penetration in water and inhibits quality of water. Increased sedimentation and siltation in streams as a result of anomalous concentration of particulate matters can result in harming fish and other aquatic life in water. Particles also provide attachment places for some other pollutants, especially bacteria and metals and therefore turbidity serves as indicator of potential pollution in a water body.

TOTAL DISSOLVED SOLIDS

A measure of the combined content of all inorganic and organic substances contained in a liquid in molecular, ionized or micro-granular suspended form is called Total Dissolved Solids (TDS). Characteristically, solids small enough to survive filtration through filters with smaller pores spaces fits into the definition of TDS. The most important application of TDS is in the study of water quality for streams, rivers and lakes even though TDS is not a primary pollutant in these systems but TDS serves as indicators of aesthetic characteristics of drinking water and the presence of a broad array of chemical contaminants.

Agricultural and residential runoff are primary sources of TDS in receiving waters, and so are leaching of soil contamination and point source water pollution discharge from industrial plants. Calcium, phosphates, nitrates, sodium, potassium, sulphates and chloride comprise few of the important chemical constituents which might be cations, anions, molecules or agglomerations in the order of one thousand or fewer molecules as long as soluble micro-granule is formed. Pesticides arising from surface runoff are more toxic and harmful elements of TDS. Certain naturally occurring total dissolved solids arise from the weathering and dissolution of rocks and soils.

Concentration of dissolved ionized solids in water is directly related to the electrical conductivity of water. Ions in dissolved solids state has the potential to conduct electricity in water and this can be measured by TDS meter or conductivity meter. Conductivity generally provides an approximate value for TDS concentration in water to within ten-percent accuracy. The total dissolved solids concentration of acceptable drinking water should not be more than 500 mg/L [8] although higher concentrations might be consumed without harmful physiological effects. The limit is set on the basis of taste thresholds. Wildlife and livestock might get injured by drinking water that contains total dissolved solids exceeding the 500mg/l mark and a continuous use of such water might cause weakness, scouring, reduced production, bone degeneration and death. However, temporarily, animals can drink high saline waters, but that will be harmful if used continuously.

CONDUCTIVITY

This is the ability of an electrolyte solution to conduct electricity. Conductivity is also referred to as specific conductance. The SI unit of conductivity is Siemens per meter (S/m). In many industrial and environmental applications, conductivity measurements are used as an inexpensive, reliable and fast way of getting the measure of the ionic content in a solution. For example, a typical way to monitor continuously, the trend or performance of water purification systems is by measuring the conductivity.

Conductivity is directly linked to the total dissolved solids (TDS) in various cases. Conductivity is found out by measuring the AC resistance of the solution between two electrodes. Dilute solutions follow Kohlrausch's Laws of concentration dependance and additivity of ionic contributions.

SULPHATE CONTENT

Naturally, sulphates are found in various minerals, such as epsomite ($MgSO_4 \cdot 7H_2O$), gypsum ($CaSO_4 \cdot 2H_2O$) and barite ($BaSO_4$). Such dissolved minerals constitute the mineral content in drinking water. Sulfates find their way into water through smelters and mines and also from kraft pulp and paper mills, tanneries and textile mills. Sulphates of potassium, magnesium and sodium are highly soluble in water, while barium and calcium sulfates and various other heavy metal sulfates are little less soluble. Suphur dioxide and Sulphur trioxide also contribute to the sulphate content of water to some extent.

CHLORIDE CONTENT

Naturally, chlorides are found as salts such as sodium chloride (NaCl), potassium chloride (KCl), and calcium chloride ($CaCl_2$). Chlorides are leached from different rocks into soil and water due to weathering. The chloride ion is generally mobile and is shifted to oceans or closed basins. Chloride levels in unpolluted waters are generally below 10 mg/litre and sometimes even below 1 mg/litre. Chloride in water may be significantly increased by treatment processes in which chlorine or chloride is used.

IRON CONTENT IN WATER

Iron accounts for almost 5% in the earth's crust and is consequently the second most abundant metal in the earth's crust. The ions of iron form sulphates, nitrates, carbonates, hydroxides and elemental iron is rarely found in nature. The most common form of iron found in nature is that of oxides.

Bacterial growth is generally promoted by iron and aeration of iron-containing layers in soil can affect the quality of both ground and surface water, if the groundwater table is lowered or nitrate leaching takes place. Dissolution of iron might take place as a result of oxidation and decrease in pH.

The concentration of iron is about 0.7 mg/l in rivers and ranges between 0.5-10 mg/l in anaerobic groundwater where iron is generally in form of Fe (II). Concentration of iron in drinking water should be less than 0.3 mg/l.

MANGANESE CONTENT IN WATER

Manganese is one of the most abundant metal on earth. Though it is not found in its natural form, it is actually a component of more than hundred (100) minerals. Manganese can exist in eleven (11) oxidative states. It can occur naturally in many surface and groundwater and in soils where it is erodible into these waters. However, human activities are also potential sources of manganese contamination in water in some areas. Ambient manganese concentrations in seawater have been reported to range from 0.4 to 10 μg/l averaging about 2 μg/l. Levels in fresh water typically range from 1 to 200 μg/l. Manganese has a median level of 16 μg/l in surface waters. Higher levels in aerobic waters are usually associated with industrial pollution (Table 2).

RESULTS AND INTERPRETATION

PHYSICOCHEMICAL PARAMETERS

The pH and Temperature of the Well Waters

Temperature plays a significant role on pH measurements. As the temperature rises, molecular vibrations increase which results in the ability of water to ionize and form more hydrogen ions. As a result, the pH will drop. The dissociation of water into hydrogen and hydroxide ion can be represented as: $H_2O\ (l) \rightleftharpoons H^+\ (aq) + OH^-\ (aq)$.

Every solution will undergo a change in their pH value through changes in temperature. A difference in pH measurements at different temperatures is not to be considered an error since the new pH level is simply indicating the true pH value for that solution at that specific temperature. A fall in pH as temperature increases is not an indication that the water is now more acidic at that higher temperature. The acidity of a solution is a measure of how much hydrogen ion is present over hydroxide ions in the water, that is, pH < pOH. When the solution is pure water, the hydrogen ions and hydroxide ions concentrations are the same, therefore, the water is neutral (pH = pOH) .In the study area, pH values range from 6.57 to 8.16 and temperature ranges from 27.1oC to 31.0oC with an average of 28.9oC. Figure 3 indicates the marginal variation of the temperature and pH of water samples from study area

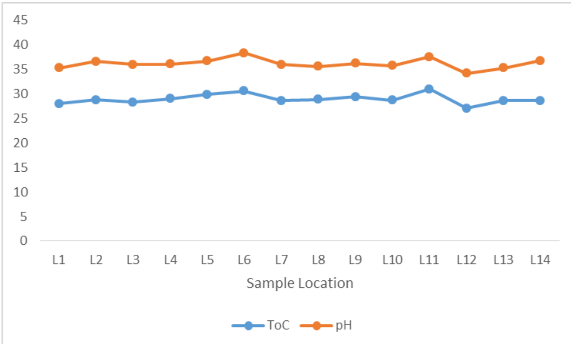

Fig 3: Temperature and pH Values of Well Water Samples from Study Area

CONDUCTIVITY

In the study area, conductivity ranges from 160 to 1440 in the water sample, its lowest value is in sample L11 with the highest in sample L2.

ALKALINITY

In the study area, the alkalinity ranges from 40-370 (mg/l CaCO3) in the well sample. The lowest value is recorded in L11, while the highest is observed in sample L13. The mean alkalinity value in the waters is 190.3(mg/l CaCO3).

TOTAL DISSOLVED SOLID (TDS)

In the well samples, TDS ranges from 107 – 960(mg/l) with lowest value in L11 (107) and the highest in L2 (960). The average TDS value is 455mg/l. The EPA recommends that water containing more than 500 mg/l of dissolved solids should not be used if other less mineralized supplies are available.

TOTAL HARDNESS

The hardness of high-quality water should not exceed 270 mg/l (15.5 grains per gallon) measured as calcium carbonate. Water softer than 30 to 50 mg/l may be corrosive to piping, depending on pH, alkalinity and dissolved oxygen. Water softeners will correct hard water of more than 270 mg/l. In the study area, the hardness ranges from 42 - 372(mg/l CaCO3) in the well samples, the lowest in L11 and the highest in L13. The average value is 188.14 (mg/l CaCO3).

TABLE 2: RESULTS OF PHYSICAL PARAMETERS OF WELL WATER FROM STUDY AREA

LOCATIONS/WATER	Temp. (^{o}C)	pH	Conductivity (µs/cm)	Turbidity (FTU)	Total Dissolved Solid (mg/l)	Total Hardness (mg/l CaCO3)	Total Alkalinity (mg/l CaCO3) (Methyl Orange)	Chloride (mg/l)	Bicarbonate(mg/l)	Nitrate (mg/l)	Sulphate (mg/l)	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Potassium (mg/l)
1	28	7.28	280	0.08	187	112	110	5.98	110	0.05	12	20.79	17.16	7.82	4.42
2	28.8	7.83	1440	0.1	960	336	338	183.29	330	0.04	40	94.38	28,61	25.81	13.88
3	28.3	7.73	920	0.18	615	276	280	97.62	280	0.07	36	75.21	25.17	18.15	12.11
4	29	7.05	1210	0.2	806	220	218	107.58	218	0.05	38	51.19	26.31	21.23	14.17
5	29.9	6.83	1080	0.32	720	344	346	99.62	336	0.21	40	100.8	26.31	21.75	15.53
6	30.6	7.79	1400	0.18	930	260	264	167.35	252	0.07	30	60.81	30.89	26.14	11.06
7	28.6	7.38	390	0.34	260	116	112	15.94	112	0.1	16	14.39	22.88	7.15	3.45
8	28.9	6.71	290	0.09	193	76	76	19.92	76	0.04	18	9.61	14.87	5.88	2.14
9	29.4	7.11	400	0.11	266	120	120	15.94	120	0.08	22	24	17.16	6.64	2.24
10	28.7	6.57	160	0.19	107	42	40	9.96	40	0.03	2	12.8	2.86	2.23	1.09
11	31	7.11	260	0.22	173	76	80	15.74	80	0.09	6	12.78	12.58	7.18	3.62
12	28	7.28	280	0.08	187	112	110	5.98	110	0.05	12	20.79	17.16	7.82	4.42
13	28.8	7.83	1440	0.1	960	336	338	183.29	330	0.04	40	94.38	28,61	25.81	13.88
14	28.3	7.73	920	0.18	615	276	280	97.62	280	0.07	36	75.21	25.17	18.15	12.11

TABLE 3: RESULTS OF PHYSICAL PARAMETERS OF WELL WATER INDICATING MAXIMUM, MINIMUM AND AVERAGE VALUES

WATER PARAMETERS	MAX	MIN	AVER
Temp. (^{o}C)	31	28	29.02
pH	7.83	6.57	7.30
Conductivity (µs/cm)	1440	160	747.86
Turbidity (FTU)	0.34	0.08	0.169

Total Dissolved Solid (mg/l)	960	107	498.5
Total Hardness (mg/l CaCO3)	344	42	193
Total Alkalinity (mg/l CaCO3)	346	40	193.71
Chloride (mg/l)	183.29	5.98	73.27
Bicarbonate(mg/l)	336	40	191
Nitrate (mg/l)	0.21	0.03	0.07
Sulphate (mg/l)	40	2	24.86
Calcium (mg/l)	100.8	9.61	47.65
Magnesium (mg/l)	30.89	2.86	19.88
Sodium (mg/l)	26.14	2.23	14.41
Potassium (mg/l)	15.53	1.09	8.15

Table 4: W.H.O. DRINKING WATER STANDARDS

PARAMETER	UNIT	LIMIT
Aluminium	mg Al/l	0.2
Arsenic	mg As/l	0.05
Barium	mg Ba/l	0.05
Berylium	ug Be/l	0.2
Cadmium	ug Cd/l	5.0
Calcium	mg Ca/l	200.0
Chromium	mg Cr/l	0.05
Copper	mg Cu/l	1.0
Iron Total	mg Fe/l	0.3
Lead	mg Pb/l	0.01
Magnesium	mg Mg/l	150.0
Manganese	mg Mn/l	0.1
Mercury	ug Hg/l	1.0
Selenium	mg Se/l	0.01
Sodium	mg Na/l	200.0
Zinc	mg Zn/l	5.0
Chlorides	mg Cl/l	250.0
Cyanide	mg Cn/l	0.1
Fluorides	mg F/l	1.5
Nitrates	mg NO_3/l	10.0
Nitrites	mg NO_2/l	-
Sulphates	mg SO_4/l	400.0
Suphides	mg H_2S/l	0
TOTAL "drins"	ug/l	0.03
TOTAL "ddt"	ug/l	1.0
Hydrocarbons	mg/l	0.1
Anionic Detergents	mg/l	0
pH		9.2
Total dissolved solids	mg/l	1500
Total hardness	mg/l	500
Alkalinity	mg/l	500

Turbidity

In the well waters, turbidity ranges from 0.1 to 0.45 (FTU) with average of 2.686(FTU).The lowest value is recorded in L2 while the highest value is recorded in L13. The well waters have an average value of 0.18FTU.

Calcium and Magnesium

In the study area, calcium and magnesium ranges from 9.61 – 100.78 (mg/l) and 2.86 -51.61 (mg/l) respectively in the well samples. The lowest value for calcium is observed in L8 while the highest values was observed in L5. The mean value for Ca is 43.53(mg/l). For magnesium, the lowest values in the well samples are observed in sample L11 while the highest values is in sample L13. The average values for magnesium in both well waters is 22.68. The magnesium values are within limits for consumption.

Chloride

Chloride is an anion found in variable amounts in natural waters and waste water. The chloride content normally increases as the mineral content increases. High concentrations of chloride ions can cause water to have an objectionable salty taste and corrode hot-water plumbing systems. High-chloride waters have a laxative effect for some people. An upper limit of 250 mg/l has been set for chloride ions, although noticing the taste at this level is difficult, and even higher concentrations do not appear to cause adverse health effects. An increase in the normal chloride content of water may indicate possible pollution from human sewage, animal manure or industrial wastes. In the well samples, chlorine values range from 5.98 to 183.29 (mg/l), with the lowest value at L1 and the highest value in sample L2. The average value is 62.88 (mg/l).

Nitrate

Nitrate can be reported as nitrogen (N) or nitrate-nitrogen or as nitrate (NO3). The following are the maximum levels for each: Nitrogen (N) or nitrate-nitrogen (NO3-N) should not be higher than 10mg/L. Nitrate (NO3) should not be higher than 45mg/L.

In the study area, Nitrate ranges from 0.1 to 0.09 (mg/l) in the well samples with the lowest value recorded in L7 and the highest value recorded in L12. The average value of nitrates content in the well samples is 0.07(mg/l).

Sodium

In the study area, sodium content in well samples ranges from 2.23 to 26.14 mg/l, with sample L11 having the lowest and sample L6 having the highest values. The well waters have an average of 13.81 mg/l.

Potassium

In the study area potassium ranges from 1.09 – 15.53 (mg/l) in the well samples. The average of potassium contents in the well samples is 7.51mg/l.

Sulphate

The sulphate contents in the well waters ranges from 2 – 40(mg/l) with the lowest in L11 and the highest in L2 and L5 having the same values. The average value samples is 21.42(mg/l).

Bicarbonate

The bicarbonate content in the well samples ranges from 21.8 – 370(mg/l) with the lowest on L4 and the highest in L13. The average content is 174(mg/l).

CONCLUSION

The analytical results obtained showed High level of pH which causes a bitter taste making water pipes and water-using appliances become encrusted with deposits, and it also depresses the effectiveness of the disinfection of chlorine, thereby generating the need for additional chlorine when pH is a bit high. Pollution has the potential to change the pH of water, which might harm animals and plants living in the water. Electrical conductivity is very high in the study area compared to World Health Organization, WHO (2003) standards of 417.00 permissible limits with a recommended value of 1000, treatments with reverse osmosis is effective for consumable water purposes.

Total Dissolved Solids is above the recommended value of 500 which may affect the taste adversely and deteriorate water pipes and other piping appliances, it might not be dangerous to drink but it is advisable to treat with reverse osmosis. Calcium is within the WHO recommended value of 100. However, bicarbonate and magnesium is above the WHO standard. High value of magnesium can lead to hardness of water with frequent intake resulting to cardiovascular disease, cancer, diabetes and childhood atopic dermatitis, while high value of bicarbonate causes diarrhea, constipation in the human body and also causes a deformation in plant growth. Sodium and potassium are within the recommended WHO limits for drinking water. Nitrate and sulphate are below the recommended WHO limits.

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