 doi:10.20944/preprints201801.0076.v1

Physico- Chemical and Microbial Properties of Surface and Groundwater Resources: Case Study of Kogi State, Central Nigeria

Seyi, Mepaiyeda[1*] and Kakaba, Madi [1]

[1] Department of Geology, University of Fort Hare, Private Bag X1314, Alice 5700, South Africa.

[*] Correspondence; 201714260@ufh.ac.za, geospiritonline@yahoo.com, Tel; +27 632129422

ABSTRACT

Analysis of water resources of this area was carried out in order to assessing the water quality by determining the concentrations of cations, Anions, Heavy metals, Trace elements, PH, Alkalinity, Total Dissolved Solids and microbial loads in water samples. Ten (10) water samples were collected from the study area - samples each of rain water, two pond waters - 1 and 2, stream water, four (4) hand-dug wells, hand pump water and a motorized borehole. The results obtained were compared with WHO standards and it showed that all the cations in water samples are within the limits. The water samples at locations B, E, F, G, H, I, and J have high alkalinity and $HC0^-_3$ content. The heavy metals (Pb, Ni and Cd) and trace elements (Fe and Cu) are dominantly high in the surface waters. Microbiological substances in the water samples from the study area revealed indicator organisms higher than the WHO standard for drinking water. Samples obtained from location G, I and J recorded an absence of E. coli and are fit for human consumptions but needed to be treated due to high MPN (Most Probable Number) index of viable microorganisms as against WHO standard. This research showed that the water resources of the study area are gradually polluted and in the near future may not be good for drinking.

Keywords; cations; groundwater; heavy metals; pollution; anions; surface water; microbes

 doi:10.20944/preprints201801.0076.v1

1.0 INTRODUCTION

A large number of communities in Nigeria, especially those in the Eastern highland, Western highland and central parts of Nigeria depend largely on ground water supply from Basement complex rocks from boreholes. The development of ground water resources in these parts of Nigeria are carried out under severe budgetary constraints, with little opportunity for fundamental hydro geological studies. Hard rock masses such as the basement-rock masses covering about two third (2/3) of the land surface of Nigeria in their under -formed state possess little or no primary inter-granular porosity or permeability and the hydro-geological properties are thus mainly determined by secondary storability and transmissivity.

It is not possible to find absolutely pure water in nature even rain water, when it drops just emitting from the clouds, may be considered pure, but as the drops fall down, certain gasses get dissolved in it and make impure (1). Depending largely upon the sources from which they are derived, surface and groundwater so obtained may differ greatly in purity and suitability for the purposes for which they are required (2). Ground water is the water which is stored by nature, underground in the water bearing formation of earth's crust. This could be natural springs, well and boreholes, infiltration galleria and radial collector wells (2).

Communicable diseases which may be transmitted by water include bacterial, viral and protozoan infections. These diseases include typhoid, salmonesis, shigellosis, bacillary, dysentery, cholera, hepatitis e.t.c. (3). These organisms are spread through the fecal discharges (excrement) of sick or carrier persons. The inorganic materials for which maximum contaminant levels have been established are generally toxic in one manner or the other. Lead, Mercury, Arsenic, Barium, Cadmium and Chromium are well known poison and can exhibit chronic or acute toxicity depending on the concentration (3).

 doi:10.20944/preprints201801.0076.v1

This research examined the quality of drinking water around Agbadu- Bunu in Kabba Local Government Area of Kogi State, central Nigeria. The area has a fast growing population and increasing level of diverse socio-economic activities. Factors responsible for water contamination and the type of contaminants in water to determine its deviance from the normal were examined.

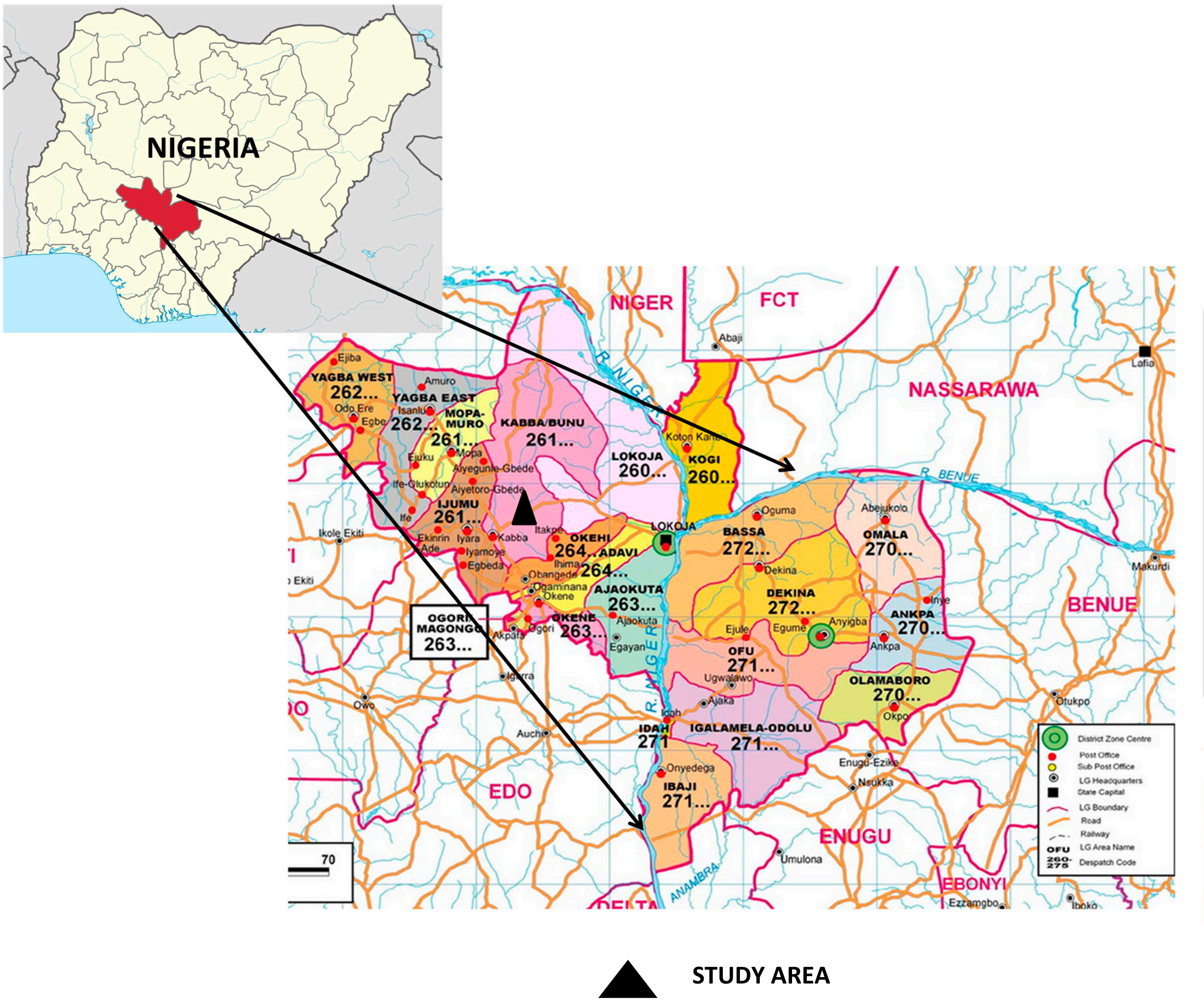
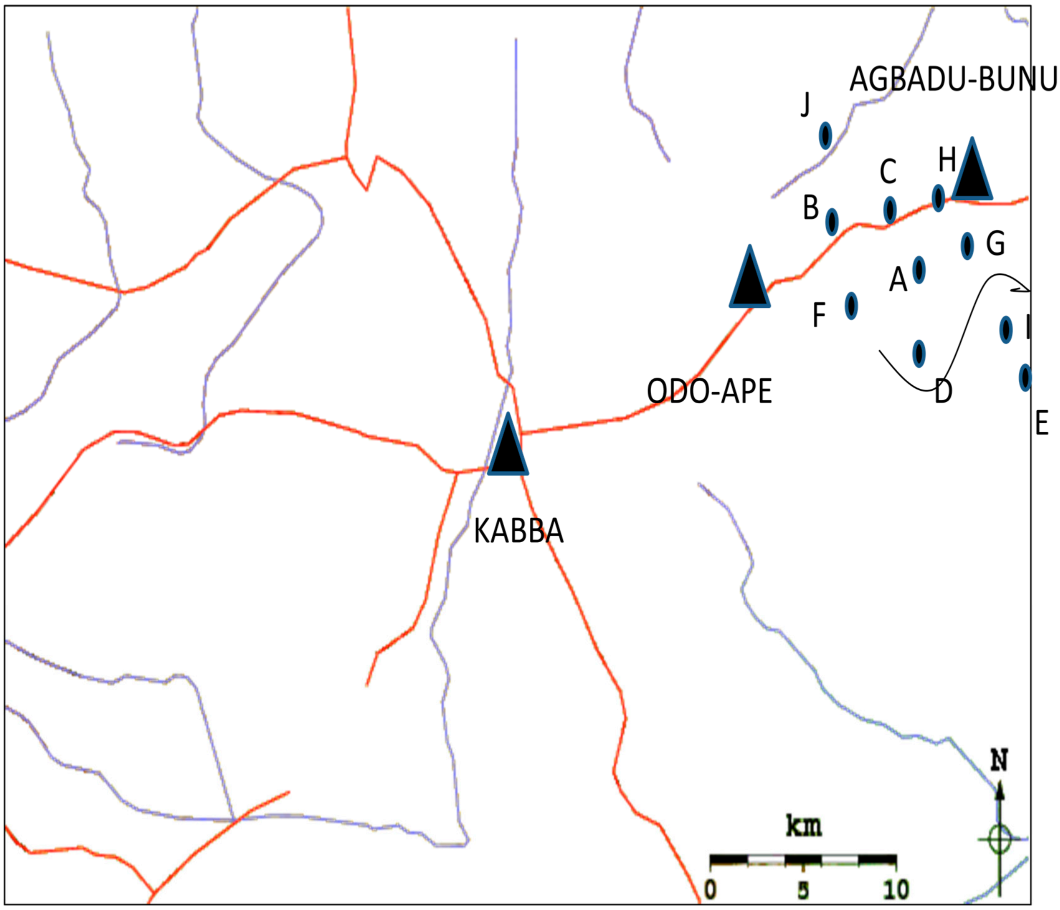


Figure 1; Map of Nigeria showing the study area

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 9 January 2018 doi:10.20944/preprints201801.0076.v1



KEY

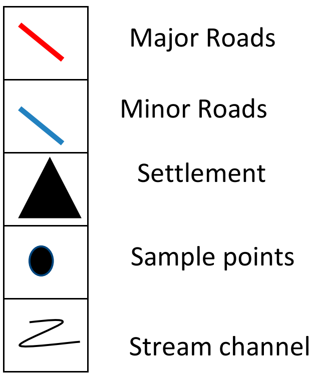


Figure 2; Location map of the study area showing the sample points

Agbadu - Bunu Community lies between latitude 7.91786^0 and longitude 6.26911^0. The Community is located within Kogi state, central Nigeria and it is accessible by motorable road along Obajana - Kabba road. Agbadu - Bunu Community experiences distinct dry and wet seasons. There is a fairly high amount of rainfall in the wet season and water is readily available during the wet season but may be come dried the dry season. This is particularly so in areas underlain by crystalline rocks of the basement complex where many rivers are intermittent and the underlain lithology does not favor large accumulation of ground water (4). Therefore the major task in such area is to locate ground water while the issue of ground water qualities receives little attention. The study area lies within the tropical savannah climate with distinct dry and wet seasons with an average maximum temperature of 33.2^o and an average minimum temperature of 22.8$^o{}_c$ having distinct dry and wet seasons. The dry season occurs between November and February while the rainy season is between March and October (7-8 months). Mean annual evaporation for the study area ranges between 750mm-1200mm. The mean annual rainfall in the area is 2000mm-2500mm. There is usually severe harmattan in December and January; this is the period when the north-east trade wind begins to blow towards the country from the Sahara belts.

Vegetation in the study area is characterized by sparse shrubs and interrupted by isolated medium sized trees which are typical of Sudan Savannah. There is usually a more continuous cover of grasses especially during the dry season. The study area rises from about 300 meters along the Niger/Benue Confluence, to the heights of between 300 and 600 meters above sea level in the uplands. The locations of the study area are shown in Figure 1-2. All the (10) ten sample were taking from Agbadu Bunu Community Area of Kogi State, North Central Nigeria.

Table 1; Sample points and their coordinates

SAMPLE POINTS	A RW	B PW1	C PW2	D SW	E HDW1	F HDW2	G HDW3	H HDW4	I HPW	J MBW
Location/ (N) Coordinate (E)	N 00785.69	N 07·55.655	N 07·55.655	N $07^0$55.477	N 0755.025	N 0755.051	N 0755.055	N 0755.087	N 0755.27	N 0755.03
	E 00625.65	E $006^0$15.75	E $006^0$15.75	E $066^0$16.032	E 0061.6138	E 00616.160	E 00615.7552	E 06615.757	E 0061.614	E 0061.613

KEY: RW: Rain Water, PO: Pond Water, HDW: Hand Dug Well, HPW: Hand Pump Water, MPW: Motorized Pump Water

Previous work on the physico-chemical characteristics of surface and ground water in central Nigeria has been carried out (5). It was reported that the concentration of cations and Anions in the water resource of certain parts of central Nigeria conformed to the World Health Organization (WHO) for potable water (5). 55 water samples collected for both Cations and Anions analysis using inductively coupled plasma-optical emission spectrometry (ICP-DES) and inductively coupled plasma-mass spectrometry (ICP-MS) were done in the area (6). It was discovered that the area consist of two water types; earth-alkaline water and earth-alkaline waters with alkaline compounds with cations and anions concentrations below WHO limit in one part while some parts had their concentrations above WHO limits.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 9 January 2018 doi:10.20944/preprints201801.0076.v1

2.0 MATERIALS AND METHODS

2.1 FIELD WORK

A preliminary (reconnaissance) survey of the study area was carried out in order to study the various sources and kind of drinking water available in Agbadu - Bunu community in Kogi state, central Nigeria. This survey helped in the locations of various water sources and was marked out for random sample collection. Global Positioning System (GPS) was used to measure the longitude and the latitude of the respective sample locations as well as the distance above sea level. The source of data for this research work is divided into two, the Primary Source and the Secondary Source of data. Primary data were water samples rain water, two pond water sources, stream water, 4 Hand dug wells and 2 borehole water samples. Two samples each of the above water sources were collected. One set of samples were analyzed for physico-chemical properties while the other set of samples were analyzed to determine the microbial components. Secondary data source was the review of published research works, journals, textbooks, scientific discussion and first hand information and other relevant works on water quality.

2.2 SAMPLING TECHNIQUES

Two different types of containers were used for collection of sample for analysis in the laboratory. Bottles for microbiological samples were first washed with detergent, rinsed with distilled water, dried and sterilized at 150^{0}c for 2hours while other plastic bottles were washed with detergent, rinsed with distilled water before used for sampling water. In the process of sampling, care was taken that the container used in fetching the water (fetcher) was thoroughly washed to making sure that level of contamination is minimized. For the rain water sources, early morning water from the rain was collected into a sample bottle. Boreholes water samples, (Hand Pump Water and Motorized Borehole) were collected after the mouth of the tap was first swabbed with cotton wool soaked with alcohol (ethanol) for sterilization. Some quantities of the water were first pumped out to create room for fresh water from the source and also help in flushing out bacteria or other possible contaminants along the lining of the pipe.

After collection, the samples were protected from reacting with air by tightening the cork properly, packed into a small cooler and transported to the laboratory for analysis. There it was kept in the refrigerator awaiting analysis. The water samples taken from both surface (Stream, Rain, Pound) and ground (Hand Dug Wells/Boreholes) water were collected at random and labeled accordingly as A, B, C, D, E, F, G, H, I and J respectively.

2.3 LABORATORY ANALYSIS

The chemical analytical procedures employed the use of Atomic Absorption Spectrophotometer (AAS). The concentrations of cations, Anions, Heavy Metals and Trace elements were analyzed. Physico-chemical parameters were analyzed based on the physical changes associated with chemical reactions. The different methods used were in accordance with Hydrological Project Technical Assistance (HPTA) method for standard analytical procedure for water. The PH of the samples was determined using a PH meter (Mode: HP 2211 PWORP meter). 10ml of each of the sample was poured in to a sterile beaker and the anode of the PH meter was inserted into it, allowed to stay till for some time before the readings were taken and recorded one after the other. The stainless sensor was rinsed with distilled water after each reading.

2.3.1 DETERMINATION OF CATIONS IN WATER

APPARATUS/EQUIPMENT**;** Atomic Absorption Spectrophotometer (Model 201 VGP), Standard Flasks and filtering set-up.

PROCEDURE; Reagents used for cations concentration in water sample are basically 1000ppm of each of the elements to be determined. In this case, 1000ppm of Ca, Mg, K, Na, Pb, Mn, Fe and Cu were prepared and used accordingly. From the stock solution, i.e. 1000ppm of each of the element, 1000ppm was prepared by diluting 10ppm stock solution to 100ml, then 2, 4, 6, 8 and 10ppm working standard of each element to be used for AAS calibration. Then concentration (in PPM) determination for the water samples using the respective Cathode lamp of the element in question were carried out.

2.3.2 DETERMINATION OF ANIONS IN WATER

A. NITRATE ($N0_3$) (7)

APPARATUS AND REAGENTS**;** Spectrophotometer (Model Genesys 20), Analytical balance and Standard flasks

- 4ml of sodium hydroxide 160g (NaOH) in 1000ml of distilled water.
- 5% Salicylic acid in concentrated H_2SO_4 made to 100ml, prepared a day before use and allowed to be stable for seven (7) days.
- Standard Nitrate: 7.223g dry $KN0_3$ was dissolved and made up to one litre with distilled water. This solution gave 1000ppm of $N0_3$.
- The stock solution was distilled to 50ppm and then 1, 2, 4 and 8ppm were prepared as working standard.

PROCEDURE; 5ml of each sample was pipette into the test tubes, 1ml of 5% salicylic acid solution was added to each test tube and mixed thoroughly. This was allowed to stand for 30minutes after which 10ml of 4ml Na0H solution was added. It was then allowed to stand for one (1) hour for color development and twelve hours for stabilization. The absorptions were read from spectrophotometer at 410nm

B. DETERMINATION OF SULPHATE ($S0_4$) (TURBID METRIC METHOD)

APPARATUS**;** Spectrophotometer (Model Genesys 20)**,** Analytical balance and standard flask

REAGENTS AND THEIR PREPARATION

- $Bacl_2$ reagent: 0.6g gelatin in 200ml of hot ($70^0{}_c$) distilled water was allowed to cool and kept on the refrigerator at about $4^0{}_c$ for sixteen (16) hours. The semi-gelatinous fluid was brought to room temperature and 2g of analytical grade of $Bacl_2$ was dissolved in the fluid.

- 0.543g of H_2S0_4 was dissolved in 100ml distilled water which gave 50ppm of $S0_4$. Then 1, 2, 3 and 4ppm standards were further prepared.

PROCEDURE; 25ml of each water samples were pipetted in to different 50ml standard flask followed by 20ml of distilled water, then 2ml of gelatinous $Bacl_2$ solution was also added and made up to 50ml mark of the standard flask. The mixture was allowed to stand for about 30minutes. The absorbance of standard solutions were read from the spectrophotometer at 420mm

C. DETERMINATION OF CHLORIDE (Mohr's Method)

APPARATUS AND REAGENTS; Titration Apparatus, Analytical Balance, 0.025m silver nitrate solution, 5% potassium chromate indicator

PROCEDURE; 50ml of water sample was pipetted into 250ml conical flask. 1ml of the indicator (Phenolphthalein) was added and titrated with silver nitrate solution until a permanent brick red

 doi:10.20944/preprints201801.0076.v1

precipitate persisted. The titre value was recorded as V_I. The titration was repeated twice and the average volume used was determined for each sample of water.

$$Cl\ (ppm) = V_I \times \frac{0.025}{1000} \times 35.5 \times \frac{1000}{50}$$

 doi:10.20944/preprints201801.0076.v1

3.0 RESULTS

The results of the concentrations of cations, Anions, Heavy Metal, Trace Elements, PH, Alkalinity and Total Dissolved Solids in the water resources (Surface and Ground water) are shown in the tables 3.1, 3.2, 3.3, 3.4 and 3.5 respectively. While the average concentrations in the study area are shown in tables 3.6, 3.7, 3.8, 3.9, 3.10, 3.11, 3.12, 3.13, 3.14, and 3.15 respectively. Tables 3.16, 3.17, 3.18, 3.19, and 3.20 shows the comparisons of the average concentrations of Cations, Anions, Heavy Metals, Trace Elements and PH, Alkalinity and Total Dissolved Solids of the water resources of the study area with the World Health Organization (WHO) standard for drinking water. Figure 3 to 6 shows the plots of the respective concentration parameters against the sample locations

Table 3.1: Concentrations of cations in the Water Resources of the Study Area (mg/L)

Samples Location/ Parameter	**A (RW)**	**B (PW1)**	**C (PW2)**	**D (SW)**	**E (HDW1)**	**F (HDW2)**	**G (HDW3)**	**H (HDW4)**	**I (HPW)**	**J (MBH)**
Ca^{2+}	4.38	4.22	4.21	3.64	4.12	4.101	2.90	2.64	2.11	1.48
Mg^{2+}	2.64	2.50	2.49	2.103	1.94	1.90	1.81	1.92	2.53	1.21
K^{+}	3.51	4.11	3.04	3.61	2.11	2.38	2.04	2.87	3.31	3.73
Na^{+}	0.13	0.782	0.63	0.67	0.37	0.13	0.48	0.38	3.41	4.76

Sample A = Rain Water (RW), sample B and C = Pond Water (PW1 & PW2),

Sample D = Stream Water (SW), samples E, F, G, and H= Hand Dug Well (HDW1 – 4),

Sample I and J = Boreholes (Hand Pump Well and Motorized Borehole) respectively

 doi:10.20944/preprints201801.0076.v1

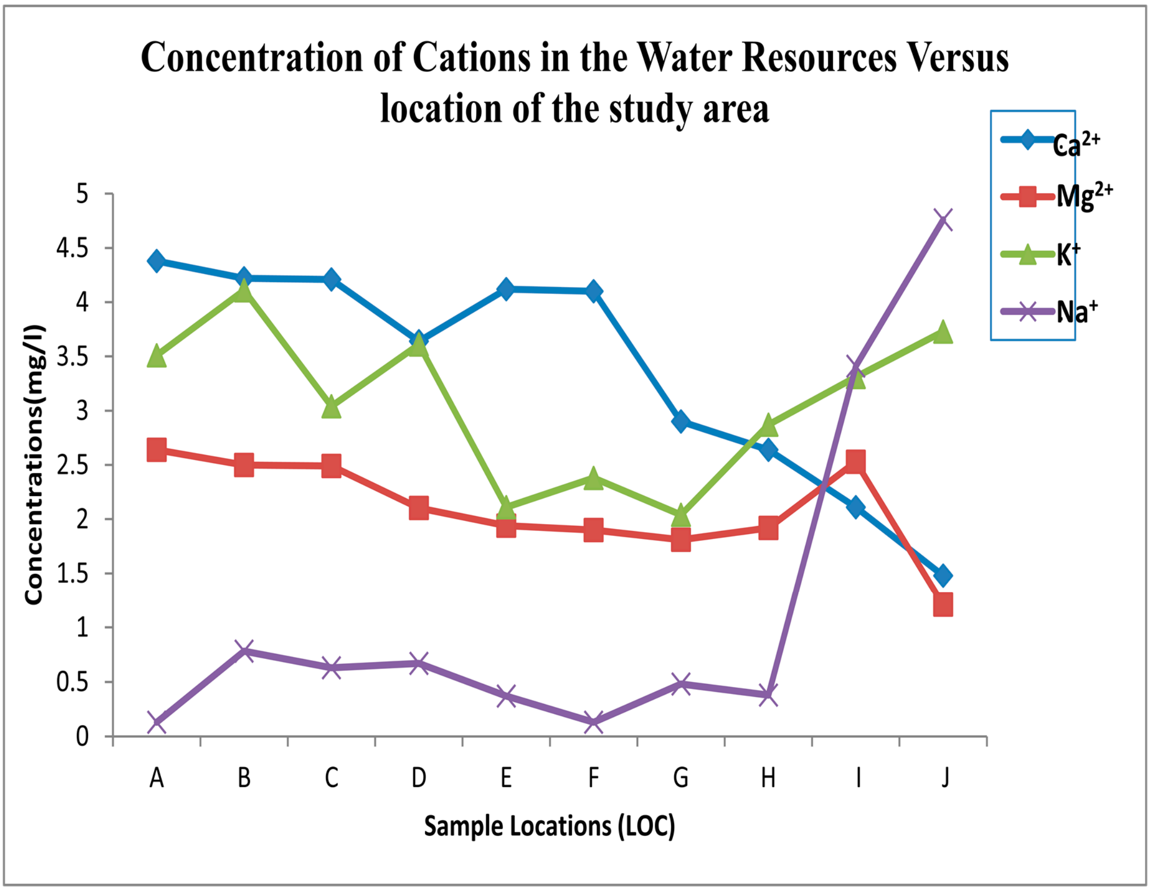


Figure 3: Plots of Concentrations cations in the Water Resources versus Location of the Study Area. A-Rain Water, B-Pond Water 1, C-PW2, D- SW, E-HDW1, F- HDW2, G- HDW3, H- HDW4, I- HPW and J- MBH

Table 3.2: Concentrations of Anions in the Water Resources of the Study Area (mg/l)

Samples Location/ Parameter	A (RW)	B (PW1)	C (PW2)	D (SW)	E (HDW1)	F (HDW2)	G (HDW3)	H (HDW4)	I (HPW)	J (MBH)
$N0^-_3$	4.53	0.27	0.019	15.943	0.019	0.016	0.024	0.016	0.142	0.39
$HC0^-_3$	19.76	66.15	48.97	38.67	103.95	126.30	59.30	64.43	251.72	97.08
CL^-	29.78	6.62	8.51	17.02	16.54	17.02	25.53	25.52	19.85	23.16
$S0^-_4$	5.32	3.801	3.803	0.25	0.38	0.36	0.38	0.39	0.25	0.66

Sample A = Rain Water (RW), sample B and C = Pond Water (PW1 & PW2),

Sample D = Stream Water (SW), samples E, F, G, and H= Hand Dug Well (HDW1 – 4),

Sample I and J = Boreholes (Hand Pump Well and Motorized Borehole) respectively

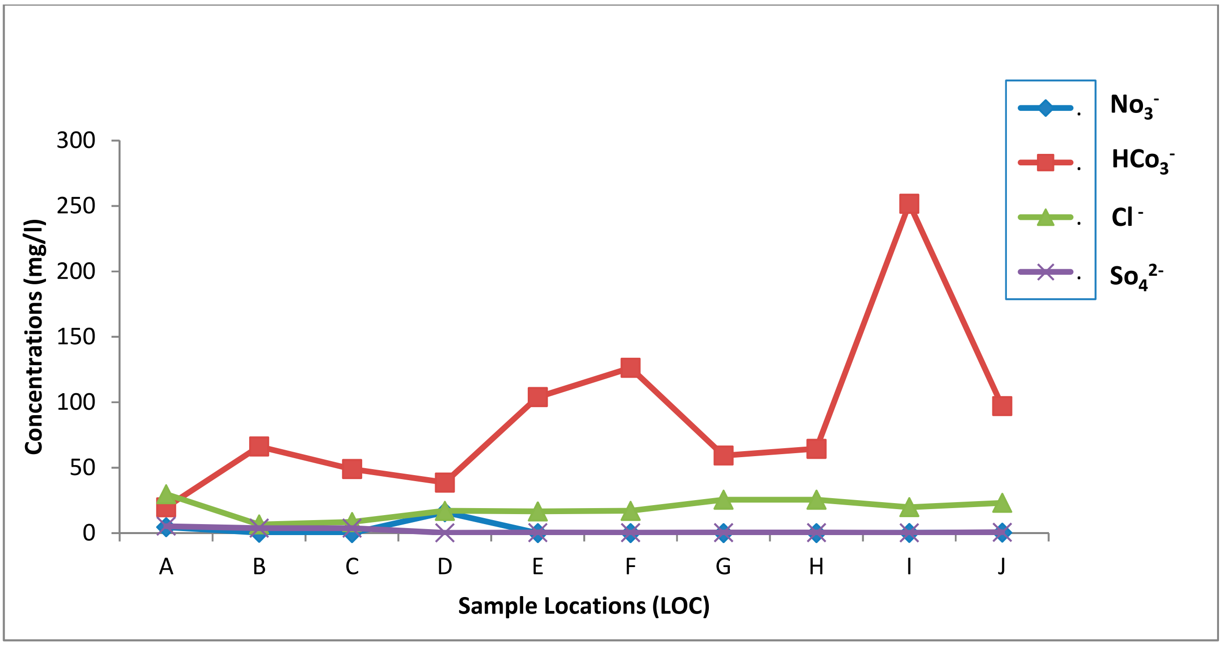


Figure 4:Plots of Concentrations of Anions in the Water Resources Versus Locations of the Study Area A- Rain Water, B- Pond Water 1, C- Pond Water 2, D- Stream Water, E- Hand dug Well 1, F- HDW 2, G- HDW 3, H- HDW 4, I- HPW and J- MBH

 doi:10.20944/preprints201801.0076.v1

Table 3.3: Concentrations of Heavy Metals in the Water Resources of the Study Area in (mg/L)

Samples Location/ Parameter	A (RW)	B (PW1)	C (PW2)	D (SW)	E (HDW1)	F (HDW2)	G (HDW3)	H (HDW4)	I (HPW)	J (MBH)
Pb^{2+}	0.031	0.071	0.07	0.30	0.044	0.043	0.046	0.05	0.034	0.031
Zn^{2+}	0.16	0.22	0.23	0.13	0.12	0.104	0.101	0.102	0.12	0.002
Ni^{2+}	0.071	0.06	0.051	0.35	0.03	0.03	0.039	0.03	0.045	0.02
Cd^{2+}	0.004	0.075	0.073	0.062	0.04	0.05	0.041	0.06	0.014	0.011

Sample A = Rain Water (RW), sample B and C = Pond Water (PW1 & PW2), sample D = Stream Water (SW), samples E, F, G, and H= Hand Dug Well (HDW1 – 4), sample I and J = Boreholes (Hand Pump Well and Motorized Borehole) respectively

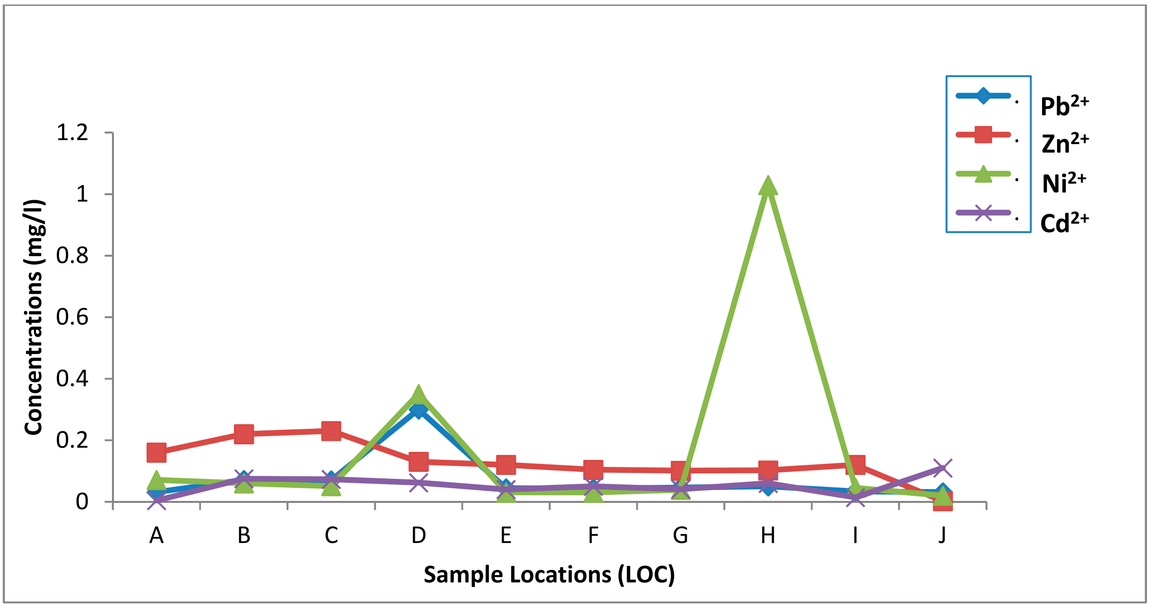


Figure 5: Plots of Concentration of Heavy Metals in the Water Resources Versus Locations of the Study Area

 doi:10.20944/preprints201801.0076.v1

Table 3.4: Concentrations of Trace Elements in the Water Resources of the Study Area (Mg/L)

Samples Location/ Parameter	A (RW)	B (PW1)	C (PW2)	D (SW)	E (HDW1)	F (HDW2)	G (HDW3)	H (HDW4)	I (HPW)	J (MBH)
Fe	0.74	0.241	0.25	0.42	0.13	0.12	0.14	0.12	0.33	0.19
Mn	0.01	BDL	BDL	BDL	0.00	0.00	0.00	0.00	0.00	0.00
Cu	2.01	3.46	3.61	2.88	2.19	2.18	2.18	2.19	2.41	0.70

Sample A = Rain Water (RW), sample B and C = Pond Water (PW1 & PW2),

Sample D = Stream Water (SW), samples E, F, G, and H= Hand Dug Well (HDW1 – 4),

Sample I and J = Boreholes (Hand Pump Well and Motorized Borehole) respectively

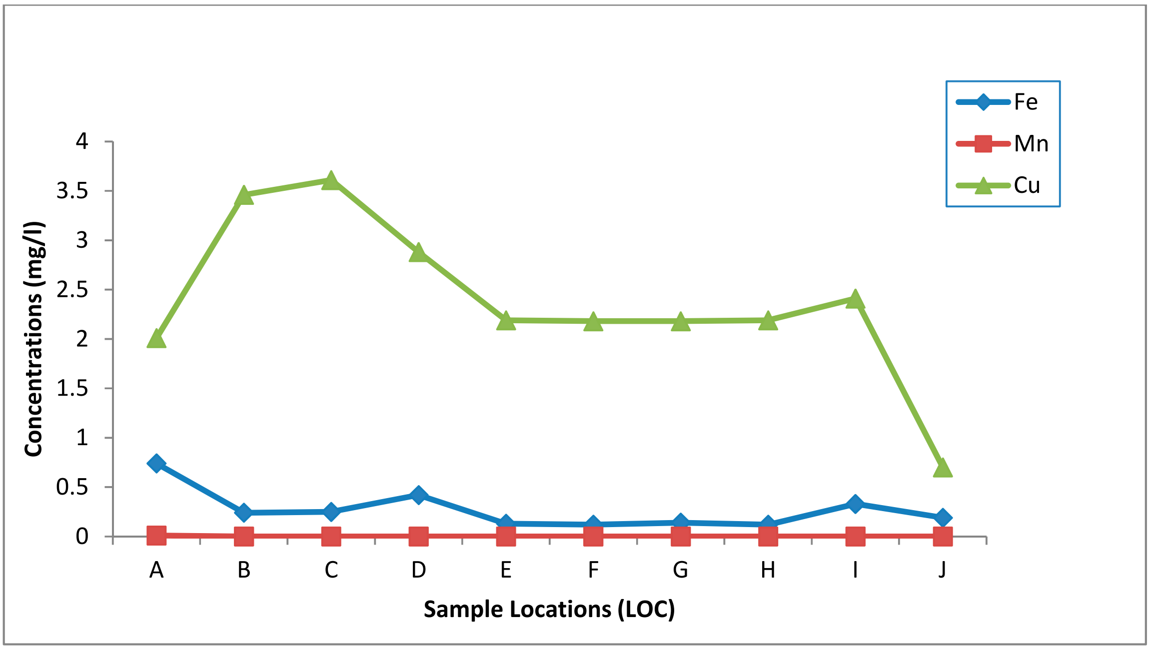


Figure 6: Plots of Concentrations of Trace Elements in the Water Resources versus Locations of the Study Area

Table 3.5: Value of PH, Alkalinity and Total Dissolved Solids (TDS) in the Water Resources of the Study Area

Samples Location/ Parameter	A (RW)	B (PW1)	C (PW2)	D (SW)	E (HDW1)	F (HDW2)	G (HDW3)	H (HDW4)	I (HPW)	J (MBH)
PH	6.95	7.18	6.96	7.06	7.22	7.01	6.82	6.76	7.21	7.66
Alkalinity	43.33	133.33	100.00	80.00	206.67	250.00	120.00	130.00	493.33	193.33
TDS	0.00	20.00	20.00	20.00	380.00	20.00	20.00	20.00	360.00	20.00

Sample A = Rain Water (RW), sample B and C = Pond Water (PW1 & PW2), Sample D = Stream Water (SW), samples E, F, G, and H= Hand Dug Well (HDW1 – 4), Sample I and J = Boreholes (Hand Pump Well and Motorized Borehole) respectively

Table 3.6: Average Concentrations of cations in the Surface Water Resources of the Study Area

PARAMETERS	AVERAGE CONCENTRATIONS(Mg/L)
Ca^{2+}	4.113
Mg^{2+}	2.433
K^{+}	3.568
Na^{+}	0.553

Table 3.7; Average Concentrations of cations in the Ground Water Resources of the Study Area

PARAMETERS	AVERAGE CONCENTRATIONS(Mg/L)
Ca^{2+}	2.892
Mg^{2+}	1.885
K^{+}	2.743
Na^{+}	1.588

Table 3.8: Average Concentrations of Anions in the Surface Water Resources of the Study Area

PARAMETERS	AVERAGE CONCENTRATIONS(Mg/L)
$N0_3^-$	5.188
$HC0_3^-$	43.388
Cl^-	15.483
$S0_4^{2-}$	3.293

Table 3.9: Average Concentrations of Anions in the Ground Water Resources of the Study area

PARAMETERS	AVERAGE CONCENTRATIONS(Mg/L)
$N0_3^-$	0.101
$HC0_3^-$	116.13
Cl^-	21.268
$S0_4^{2-}$	0.403

 doi:10.20944/preprints201801.0076.v1

Table 3.10: Average Concentrations of Heavy Metals in the Surface Water Resources of the Study Area

PARAMETERS	AVERAGE CONCENTRATIONS(Mg/L)
Pb^{2+}	0.118
Zn^{2+}	0.054
Ni^{2+}	0.185
Cd^{2+}	0.133

Table 3.11; Average Concentrations of Heavy Metals in the Ground Water Resources of the Study Area

PARAMETERS	AVERAGE CONCENTRATIONS(Mg/L)
Pb^{2+}	0.041
Zn^{2+}	0.036
Ni^{2+}	0.92
Cd^{2+}	0.398

Table 3.12: Average Concentrations of Trace Elements in the Surface Water Resources of the Study Area

PARAMETERS	AVERAGE CONCENTRATIONS(Mg/L)
Fe	0.213
Mn	0.003
Cu	2.99

Table 3.13; Average Concentrations of Trace Elements in the Ground Water Resources of the Study Area

PARAMETERS	AVERAGE CONCENTRATIONS(Mg/L)
Fe	0.172
Mn	0.00
Cu	1.975

Table 3.14; Average values of PH, Alkalinity and Total Dissolved Solids (TDS) in the Surface Water Resources of the Study Area.

PARAMETERS	AVERAGE CONCENTRATIONS(Mg/L)
PH	7.04
Alkalinity	89.165
TDS	15.00

Table 3.15; Average values of PH, Alkalinity and Total Dissolved Solids (TDS) in the Ground Water Resources of the Study Area

PARAMETERS	AVERAGE CONCENTRATIONS(Mg/L)
PH	7.113
Alkalinity	232.22
TDS	136.67

 doi:10.20944/preprints201801.0076.v1

Table 3.16: Showing the Comparison of Average Concentrations of Cations in the Water Resources of the Study Area with WHO standards

Cations	WHO,2011 Guideline Maximum Value Mg/L	Guideline Value Mg/L	Maximum Admissible Concentration Mg/L	Analyzed Average Value of Study Area Mg/L
Calcium (Ca^{2+})	-	100.00	-	3.503
Sodium (Na^{+})	200.00	20.000	150.000	1.071
Potassium (K^{+})	-	10.000	12.000	3.156
Magnesium (Mg^{2+})	-	30.000	50.000	2.159

Table 3.17: Comparison of Average Concentrations Anions in Water Resources of the Study Area with WHO standards

Anions	WHO,2011 Guideline Maximum Value Mg/L	Guideline Value Mg/L	Maximum Admissible Concentration Mg/L	Analyzed Average Value of Study Area Mg/L
Chloride ion (Cl^{-})	250	-	-	18.376
Sulphate ion	250	-	-	1.848

($S0_4^{2-}$)				
Nitrate ion ($N0_3^-$)	50	-	-	2.645
Hydrogen trioxocarbonate IV ion ($HC0_3^-$)	50	-	-	80.209

Table 3.18: Comparison of Average Concentrations of Heavy Metals in the Water Resources of the Study Area with WHO standards

Heavy Metals	**WHO,2011 Guideline Maximum Value Mg/L**	**Guideline Value Mg/L**	**Maximum Admissible Concentration Mg/L**	**Analyzed Average Value of Study Area Mg/L**
Lead (Pb^{2+})	0.010	-	0.005	0.080
Cadmium (Cd^{2+})	0.003	-	0.005	0.045
Zinc (Zn^{2+})	3.000	0.100	-	0.139
Nickel (Ni^{2+})	0.020	-	-	0.266

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 9 January 2018 doi:10.20944/preprints201801.0076.v1

Table 3.19: Comparison of Average Concentrations of Trace Elements in the Water Resources of the Study Area with WHO standards

Trace Elements	WHO,2011 Guideline Maximum Value Mg/L	Guideline Value Mg/L	Maximum Admissible Concentration Mg/L	Analyzed Average Value of Study Area Mg/L
Iron (Fe)	0.300	0.050	0.200	0.193
Manganese (Mn)	0.050	-	-	0.002
Copper (Cu)	0.05	-	-	2.483

Table 3.20: Comparison of Average values of PH, Alkalinity and Total Dissolved Solids (TDS) Resources of the Study Area with WHO standards

Other Parameters	WHO,2011 Guideline Maximum Value Mg/L	Guideline Value Mg/L	Maximum Admissible Concentration Mg/L	Analyzed Average Value of Study Area Mg/L
PH	8.500	6.5-8.5	6.5-8.5	7.082
Alkalinity	100.000	-	-	174.999
TDS	500.000	-	-	88.000

 doi:10.20944/preprints201801.0076.v1

Total Bacterial Count (TBC) value of the water samples analyzed has the mean value of 199.75 X 10^3cfu/100ml and 50 X 10^3cfu/100ml for surface and ground water of the area respectively. The highest values ranging from 2.35 X 10^2cfu/100ml to 1.38 X 10^2cfu/100ml for surface and ground water respectively against the 100cfu/ml for WHO standard for potable water. Total Coliform Count of the water samples has mean values of 2.0 X 10cfu/100ml and 0.717 X 10^1cfu/100ml for surface and ground water respectively. The highest values ranging from 0.23 X 10^2cfu/100ml to 0.30 X 10^2cfu/100ml for surface and ground water respectively against zero (0) cfu/100ml for WHO standard for potable water (Table 3.21). E. Coli Count for the water samples analyzed is absent in most of the samples and only present in very minute amount in some of the samples. Though no particular amount was recorded, this mostly conformed with the zero (0) cfu/100ml for WHO standard for potable water.

Table 3.21; Microbiological analysis of water samples in the study area

Microbiological/ Samples Factors	**A RW**	**B PW1**	**C PW2**	**D SW**	**E HDW1**	**F HDW2**	**G HDW3**	**H HDW4**	**I HPW**	**J MBW**
Location/ Coordinate (N)	N 00785.69	N 07·55.655	N 07·55.655	N $07^0$55.477	N 0755.025	N 0755.051	N 0755.055	N 0755.087	N 0755.27	N 0755.03
(E)	E 00625.65	E $006^0$15.75	E $006^0$15.75	E $066^0$16.032	E 0061.6138	E 00616.160	E 00615.7552	E 06615.757	E 0061.614	E 0061.613
Protozoan (Count/ml)	0	12	0	0	0	0	0	0	0	0
Total Plate Count(cfu/ml)	5	110	129	235	50	138	40	57	10	05
Total Coliforms(cfu/100ml)	10	30	17	23	30	03	0	10	0	0
Salmonella Typhi	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Shigella SP	Present	Absent	Absent	Absent	Absent	Present	Absent	Present	Absent	Absent

E.Coli	Absent	Present	Present	Present	Present	Present	Absent	Present	Absent	Absent
Streptococcus Faecalis	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
MPN Index<10/100ml	2400	2400	94	8	2400	920	11	2	2400	26
	Accept	Not accept	Not accept	Not accept	Not accept	Not accept	Accept	Not accept	Accept	accept

4.0 DISCUSSION

The quality of water is most often a function of the mineralogical and geochemical characteristics of the rocks underlying the area (8). Most minerals in rocks are soluble under appropriate geochemical condition. The quality of ground water therefore, in some parts of the country, particularly shallow ground changed as a result of human activities. Ground water is less susceptible to bacterial pollution than surface water because the soil and rocks through which ground water flows screens out most bacteria's (9). Bacteria however occasionally find their way into ground water sometimes in dangerously high concentrations. But, freedom from bacteria's pollution alone does not mean that the water is fit for drinking. Many unseen dissolved minerals and organic constituents are present in ground water in various concentrations. Most of which are harmless or even beneficial while others are harmful and a few may be highly toxic.

Water typically is not considered desirable for drinking if the quantity of dissolved minerals exceeds 1000mg/L (9). Water with a few thousand mg/L of dissolved minerals is classified as lightly saline, but is sometimes used in area where less mineralized water is available (9). Water from some wells and springs can contain very large concentrations of dissolved minerals and waste, which cannot be tolerated by humans, animals and plants. The quality of water resources (Surface/Ground) in the study area can be degraded by excessive waste disposal and dissolved minerals which can upsets the balance that exist between plants and animals with severe effects on all forms of life.

4.1 CONCENTRATIONS OF ANIONS IN THE SURFACE AND GROUND WATER RESOURCES OF THE STUDY AREA

Carbonate ($HC0_3^-$):

The World Health Organization standard has given the guideline maximum concentration of carbonate to be 50ml/L (10). The results of the analysis showed that the concentrations of carbonate in the surface water were 19.76mg/L, 66.15mg/L, 48.97mg/L and 38.67mg/L respectively. Their average is 43.388mg/L. However, the results of the ground water (Hand dug wells and boreholes) concentration ranged from 103.95mg/L, 126.30mg/L, 59.30mg/L, 64.43mg/L, 251.72mg/L to 97.08mg/L. their average concentration is 116.13mg/L. The analysis of surface water concentration shows that three (3) of the four (4) water samples analyzed were within the World Health Organization standard limit and is therefore safe, while the ground water concentration for $HC0_3^-$ is higher than the World Health Organization standard limit. This is hard water that is not safe for drinking, except by boiling.

Nitrate ($N0_3^-$) and Sulphates:

The World Health Organization standard has shown that the guideline maximum concentration for nitrate is 50mg/L (10). The result of the analysis shows that the concentration of nitrate in the surface water is 4.52mg/L, 0.27mg/L, 0.019mg/L and 15.943mg/L respectively. Their average concentration is 5.188mg/L. However the results of the ground water (Hand dug wells and boreholes) concentration ranges from 0.019mg/L, 0.016mg/L, 0.024mg/L, 0.016mg/L, 0.142mg/L to 0.39mg/L respectively. Their average concentration is 0.101mg/L. The surface and ground water concentrations fall below the World Health Organization standard limit and are therefore safe for drinking. A very low level of nitrate might be that the water contains less or no organic matter water as revealed by (2). The World Health Organization standard for the guideline maximum concentration of sulphate ion is 250mg/L (10). The results of the analysis show that the concentrations of sulphate in surface water are 5.32mg/L, 3.801mg/L, 3.803mg/L, 0.25mg/L respectively. Their average concentration is 3.293mg/L. However, the results of the ground water (Hand dug wells and boreholes) concentrations ranges from 0.38mg/L, 0.36mg/L, 0.38mg/L, 0.39mg/L, 0.25mg/L to 0.66mg/L. their average concentration is 0.403mg/L. The surface and ground water concentration fall below the World Health Organization standard limit and is therefore safe for drinking. The low level of sulphate is attributed to the geological profile of the soil and the mineral constituent of the source of water used.

Chloride (Cl^-):

The World Health Organization standard has shown the guideline maximum concentration for chloride (Cl^-) as 250mg/L (10). The results of the analysis show that the concentrations of chloride ion in the surface water are 29.78mg/L, 6.62mg/L, 8.51mg/L and 17.02mg/L respectively. Their average concentration is 15.483mg/L. However, the results of the ground water (Hand dug wells and boreholes) concentrations ranges from 16.54mg/L, 17.02mg/L, 25.52mg/L, 19.85mg/L to 23.16mg/L. Their average concentration is 21.268mg/L concentrations fall below the World Health Organization standard limit and are therefore safe for drinking. The level of chloride is due to the natural occurrence of chlorides in the geological strata of borehole and well and the entry of savage effluents and was into the water body.

 doi:10.20944/preprints201801.0076.v1

4.2. CONCENTRATIONS OF CATIONS IN THE SURFACE AND GROUND WATER RESOURCES OF THE STUDY AREA

Calcium (Ca^{2+}):

The World Health Organization standard showed that the guideline maximum concentration for calcium is 100mg/L (10). The results of the analysis carried out on the samples collected from the surface water resources of the study area shows the concentrations of calcium to be 4.38mg/L, 4.21mg/L and 3.64mg/l in rain water, pond water 1 and 2 and stream water respectively for calcium in the samples collected from the surface water, the average was 4.113mg/l. This concentration is below the maximum concentration guideline of the World Health Organization (WHO, 2011) Standard for drinking water meaning that the surface water is safe for drinking. However, the results of the ground water (Hand dug wells and boreholes) concentration ranges from 4.120mg/l, 4.101mg/l, 2.90mg/l, 2.64mg/l, 2.11mg/l to 1.48mg/l. Their average concentration is 2.89.mg/l (Table 3.7). Therefore, the concentration of calcium (Ca^{2+}) in both surface and ground water fall below the World Health Organization standard limit and is considered safe for drinking.

Magnesium (Mg^{2+}):

The World Health Organization standard showed that the guideline maximum concentration for magnesium (Mg) is 50mg/l (10). The results of the analysis on the surface water sample from the study area are 2.64mg/l, 2.50mg/l, 2.49mg/l and 2.103mg/l in RW, PW1&2 and SW respectively. The average concentration is 2.433mg/l. This concentration is below the maximum concentration guideline of the WHO, 2011 standards for drinking water, meaning that the surface water are safe for drinking. However, the results of the ground water

(Hand dug wells and boreholes) concentrations ranges from 1.94mg/l, 1.90mg/l, 1.81mg/l, 1.92mg/l, 2.53mg/l to 1.21mg/l. Their average concentration is 1.885mg/l. Therefore, the surface and ground water concentration falls below the World Health Organization standard limit and is safe for drinking.

Potassium (K^+):

The World Health Organization standard for the guidelines maximum concentration for potassium is 12.00mg/l (10). The results of the analysis show that the concentrations of potassium in the surface water are 3.51mg/l, 4.11mg/l, 3.04mg/l and 3.61mg/l respectively, their average concentration is 3.568mg/l. This shows that the concentration is below the permissible limit of the concentration of potassium in drinking water by the World Health Organization. However, the results of ground water (Hand dug wells and boreholes) concentrations ranges from 2.11mg/l, 2.38mg/l, 2.04mg/l, 2.87mg/l, 3.31mg/l and 3.73mg/l. Their average concentration is 2.743mg/l. Therefore, the concentration of potassium (K^+) in both water resources fall below the World Health Organization standard limit and the waters are considered safe for drinking.

Sodium (Na^+)

The World Health Organization standard for the guideline maximum concentration for sodium is 200mg/l (10). The results of the analysis from the surface water resources of the study area showed that the concentrations of sodium are 0.13mg/l, 0.782mg/l, 0.63mg/l and 0.67mg/l respectively. Their average concentration is 0.553mg/l. This concentration is below the maximum concentration guidelines for World Health Organization Standards for drinking water, meaning that the water is safe for drinking. However, the results of the ground water (Hand dug wells and boreholes) concentrations ranges from 0.37mg/l, 0.13mg/l, 0.48/l, 0.38mg/l, 3.41mg/l their average concentration is 1.588mg/l to 4.76mg/l. The ground water concentrations also fall below the World Health Organization standard limit and are therefore safe for drinking.

4.3 CONCENTRATIONS OF HEAVY METALS IN THE SURFACE AND GROUND WATER RESOURCES OF THE STUDY AREA

Lead (Pb^{2+}):

The World Health Organization shows that the standard guideline maximum concentration for lead is 0.010mg/l and the maximum admissible concentration is to be 0.005mg/l. The results of the analysis carried out on samples collected from the surface water of the study area shows that the concentrations of lead is 0.031mg/l, 0.071mg/l, 0.07mg/l, 0.30mg/l respectively. Their average concentration is 0.118mg/l (Table 3.10). The concentration is above the World Health Organization standard limit for drinking water. However, the concentration of lead (Pb) in the ground water ranges from 0.044mg/l, 0.043mg/l, 0.046mg/l, 0.05mg/l, and 0.034mg/l to 0.031mg/l (Table 4.3). Their average concentration is 0.041mg/l (Table 4.10). Therefore, the concentration of lead (Pb) in the surface and ground water resources is higher than World Health Organization permissible limit. This shows that the surface water and ground water may not be safe for drinking. This increase may probably be as a result of the human activities in the environment.

Cadmium (Cd^{2+}):

The World Health Organization standard showed that the guideline maximum concentration for cadmium (Cd) is 0.003mg/l and the maximum admissible concentration to be 0.005mg/l. The results of the analysis carried out on the samples collected from the surface water resources of the study area show that the concentrations of cadmium range between 0.004mg/l, 0.075mg/l, and 0.073mg/l to 0.062mg/l respectively (Table 3.3). Their average concentration is 0.054mg/l. This shows that the concentration of cadmium (Cd) is above the concentration of World Health Organization standard limit for drinking water. However, the concentrations of Cadmium (Cd) in the ground water range from 0.04mg/l, 0.05mg/l, 0.04mg/l, 0.06mg/l, and 0.014mg/l to 0.011mg/l. Their average concentration is 0.036mg/l (Table 3.10). Therefore, the concentration of cadmium (Cd) in surface and ground water resources is higher than World Health Organization permissible limit. This showed that the surface water and the ground water in the study area may not be safe for drinking. This increase may probably be as a result of the human activities in the environment.

Zinc (Zn^{2+}):

The World Health Organization standard shows that the guideline maximum concentration for zinc (Zn) is 3.00mg/l (10). The results of the analysis from the surface water resoures of the study area show that the concentrations are 0.16mg/l, 0.22mg/l, 0.23mg/l and 0.13mg/l respectively. Their average concentration is 0.185mg/l. This shows that the concentration of zinc is below World Health Organization standard limit for drinking water. However, the concentrations of zinc (Zn) in the ground water range from 0.12mg/l, 0.104mg/l, 0.101mg/l, 0.102mg/l, and 0.12mg/l (Table 3.3). The average concentration is 0.092mg/l (Table 3.10). Therefore, the concentration of zinc in both surface and ground water resources are lower than the World Health Organization permissible limit, meaning that both waters are safe for drinking.

Nickel (Ni^{2+}):

The World Health Organization standard shows that the guideline maximum concentration for nickel (Ni) is 0.020mg/l (10). The results of the analysis from the surface water resources show that the concentrations are 0.071mg/l, 0.06mg/l, 0.051mg/l and 0.35mg/l respectively. Their average concentration is 0.133mg/l . But the concentration of nickel is above the World Health Organization for the surface water. However, the concentration of nickel in the ground water ranges from 0.030mg/l, for hand dug wells 1 - 4, 0.039. 0.045 for HPW to 0.02mg/l therefore, the concentration of nickel in ground water is higher than the World Health Organization permissible limit and may not be safe for drinking, except for motorized borehole that has 0.02mg/l. This increase may probably be as a result of the human activities in the environment.

4.4 CONCENTRATIONS OF TRACE ELEMENTS IN THE SURFACE AND GROUND WATER RESOURCES OF THE STUDY AREA

Iron (Fe):

The World Health Organization standard showed that the guideline maximum concentration for iron (Fe) is 0.300mg/l and the maximum admissible concentration for iron is 0.20mg/l (10). The results of the analysis carried out on the samples collected from the surface water for iron (Fe) is 0.74mg/l, 0.241mg/l, 0.25mg/l and 0.42mg/l respectively. Their average concentration is 0.213mg/l. While the ground water concentration ranges from 0.13mg/l, 0.12mg/l, 0.14mg/l, 0.12mg/l, and 0.33mg/l to 0.19mg/l. The average concentration is 0.172mg/l. The surface and ground water resources of the study and ground water resources of the study area show that seven (7) of the ten (10) water samples analyzed for iron (Fe) is within the exception of rain water, stream water and hand pump well that has the value of 0.74mg/l, 0.42mg/l and 0.33mg/l respectively. The high level of iron recorded in this work might be due to the natural occurrence of iron in the geological strata of the soil, corrosion of iron and steel materials in the case of rain water hand pump well or leachates from dump sites and vehicles (2).

Manganese (Mn)

The World Health Organization standard guideline of maximum concentration for manganese (Mn) is 0.05mg/l (10). The results of the analysis from the surface water for Manganese (Mn) are below detective limit and 0.00mg/l except for the rain water that recorded a value of 0.010. Their average concentration is 0.003mg/l. While the ground water is also below dilution limits and 0.00mg/l. This shows that both concentrations are below the permissible limit by World Health Organization. The water is therefore, safe for drinking.

Copper (Cu):

The World Health Organization standard shows that the guideline maximum concentration for copper (Cu) is 0.05mg/l (10). The results of the analysis from the surface water resources show that the concentrations are 2.01mg/l, 3.46mg/l, 3/61mg/l and 2.88mg/l respectively. Their average concentration is 2.99mg/l. However, the concentration of copper (Cu) in the ground water resources ranges from 2.19mg/l, 2.18mg/l, 2.18mg/l, 2.19mg/l, 2.41mg/l and 0.70mg/l. It has an average concentration of ground water as 1.975mg/l. The concentration of copper (Cu) in both surface and ground water resources of the area is above the permissible limit by World Health Organization. This increase could be as a result of sediment dissociation, acid rain or water can also lead to corrosion of copper pipes and copper galvanized roofing sheet and so not safe for drinking.

4.5 VALUES OF PH, TOTAL DISSOLVED SOLIDS AND ALKALINITY IN THE SURFACE AND GROUND WATER RESOURCES OF THE STUDY AREA

PH:

The World Health Organization standard limits for PH is 6.5 – 8.5. The results of the analysis from the surface water for PH are 6.95, 7.18, 6.96 and 7.06 respectively. Their average concentration is 7.04. The ground water concentration ranges from 7.22, 7.01, 6.82, 6.76, and 7.21 to 7.66. Their average concentration is 7.113. These results show that the PH concentration in both surface and ground water resources of the study area are below the permissible limits by World Health Organization. Therefore, the water is safe for drinking.

Total Dissolved Solid:

The World Health Organization standard limit for Total Dissolved Solid (TDS) is 500mg/l. The results of the analysis from the surface water for TDS is 0.00mg/l, 20.0mg/l, 20.0mg/l, and 20.0mg/l respectively as shown in Table 4.5 above. Their average concentration is 15.0mg/l. the ground water concentration ranges from 380.0mg/l, 20.0mg/l, 20.0mg/l, 20.0mg/l, 360.0mg/l to 20.0mg/l. Their average concentration is 136.67mg/l. these results obtained from the analysis of both surface and ground water of the area shows that the water in the area is safe for drinking, since it within the World Health Organization limit of 500mg/l

Alkalinity:

The World Health Organization standard guideline of maximum concentration for alkalinity is 100mg/l. The results of the analysis carried out on the samples collected from the surface water for alkalinity is 43.33mg/l, 13.33mg/l, 100.0mg/l and 80.0mg/l respectively (Table

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 9 January 2018 doi:10.20944/preprints201801.0076.v1

4.5). Their average concentration is 89.165mg/l. While the ground water concentration ranges from 206.67mg/l, 250.0mg/l, 120.0mg/l, 130.0mg/l, and 493.33mg/l to 193.33 respectively. Their average concentration is 232.22mg/l. The surface and ground water resources of the study area show that three (3) out of the ten (10) water samples analyzed for alkalinity is within the WHO limits of 100mg/l, with the exception of pond water one, Hand dug well (1), (2), (3) & (4), Hand pump water and motorized borehole that has the values of 133.33mg/l, 206.67mg/l, 250.0mg/l, 120.0mg/l, 130.0mg/l, 493.33mg/l and 193.33mg/l respectively. The high level of alkalinity recorded in those samples might not be far from the nature of soil that contains high level of $HC0_3^-$, $S0_3^{2-}$ and $C0_3^{2-}$.

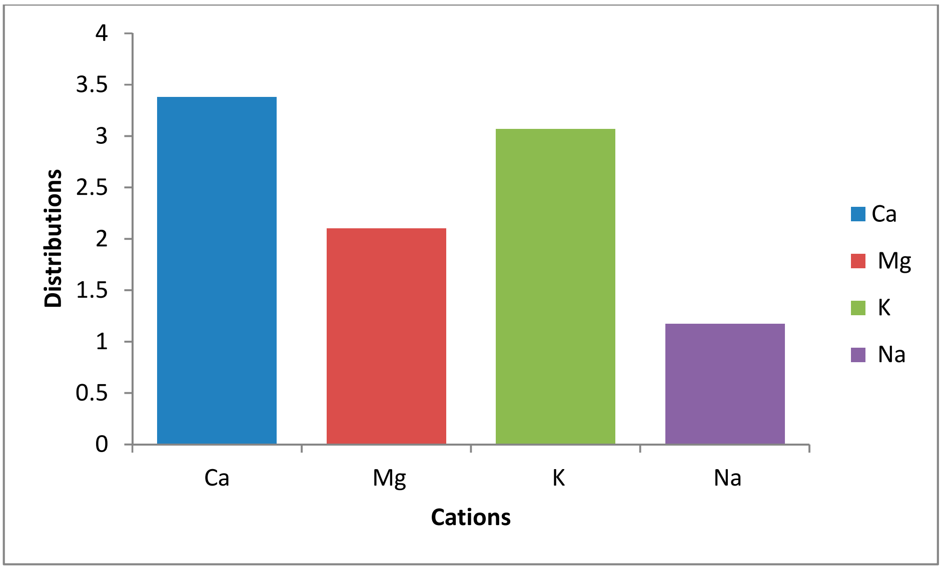


Figure 7: Average Distribution of cations in the Water Resources of the Study Area

From the distribution of cations in the water resources of the study area, it was observed that the concentrations of all the cations analyzed (Ca, Mg, K and Na) are gradually rising due to the human activities on the water resources of the study area. These activities include indiscriminate dumping of refuse, gaseous emission from vehicles, application of fertilizers on farm land, e.t.c. in this analysis, calcium has the highest rate of distribution as shown above. This is followed by potassium, magnesium with sodium been very low. The average values of each analyzed cations from the distribution graph are: 3.503mg/l (Ca^{2+}), 2.159mg/l (Mg^{2+}), 3.156mg/l, (K^{+}) and 1.071mg/l (Na^{+}). This shows that the average concentration of these cations fall below the value of World Health Organization standard for drinking water: 100.00mg/l, 50mg/l, 12.00mg/l and 200.00mg/l respectively. This simply means that the water is safe for drinking, considering the average and individual concentrations of cation in the water resources of the study area.

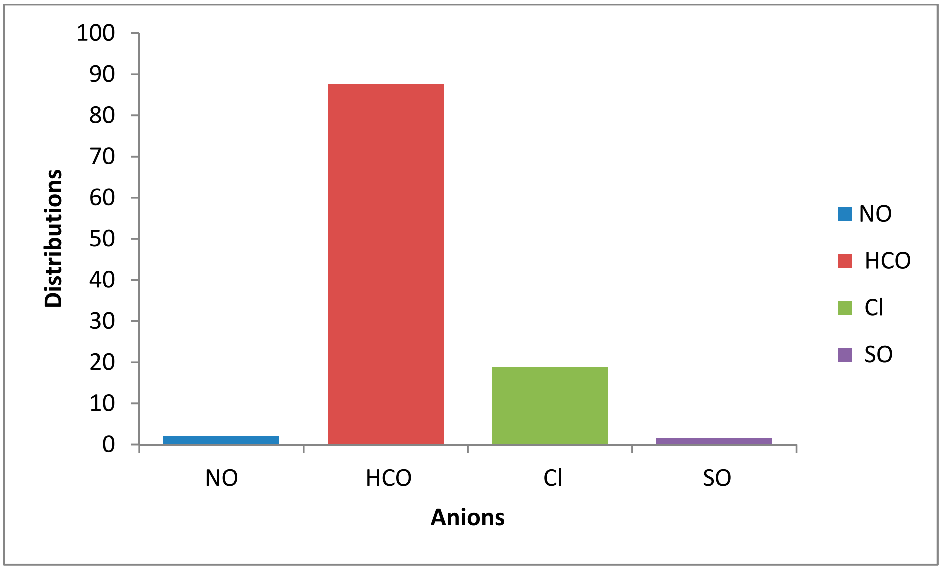


Figure 8: Average Distribution of Anions in the Water Resources of the Study Area.

From the above figure, it can be observed that the average concentration of hydrogen trioxocarbonate (iv) ion ($HC0_3^-$) is very high in the study area, with an average concentration of 80.209mg/l. Followed by chloride concentration of 18.376mg/l, Nitrate (2.645mg/l) and sulphate (1.848mg/l) of all the anions distribution in the water resources of the study area, bicarbonate ion has an average concentration, which is more than the WHO standard of 50.00mg/l while other fall below standard.

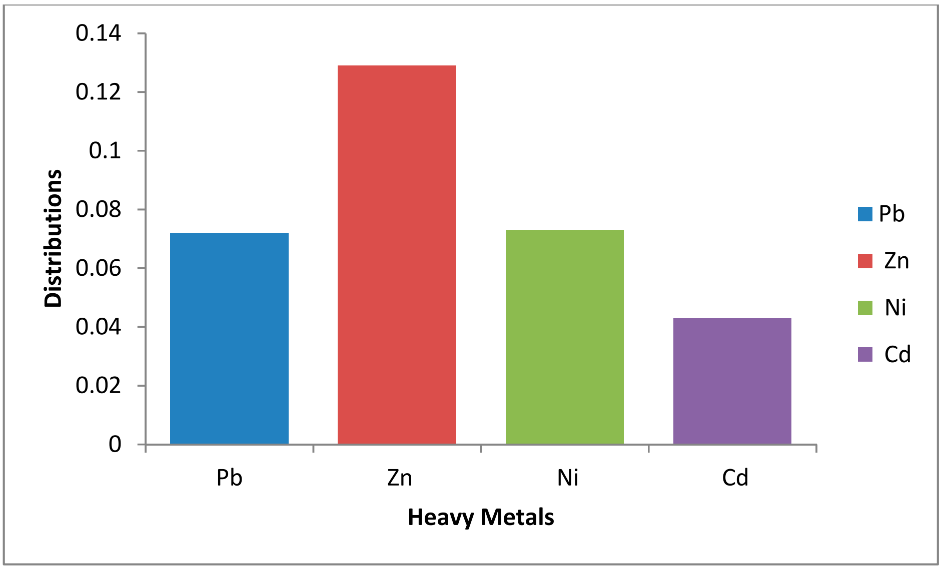


Figure 9: Average Distribution of Heavy Metals in the Water Resources of the Study Area

The figure above shows that the average concentration of Nickel (Ni) is very high in the study area with an average concentration of 0.266mg/l against the WHO standard of 0.020mg/l. Also lead (Pb) has an average concentration of 0.080mg/l as against the WHO standard of 0.010mg/l, Cadmium (Cd) average concentration is 0.045mg/l against WHO of 0.003mg/l while that of zinc (Zn) average concentration is 0.139 as against the WHO standard of 3.000mg/l. The average concentration above showed that Lead, Cadmium and Nickel exceeded the maximum permissible limit by World Health Organization. While that of zinc is falls below WHO standard. Therefore, necessary precaution should be taken to reduce likely sources of wastes in the environment.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 9 January 2018 doi:10.20944/preprints201801.0076.v1

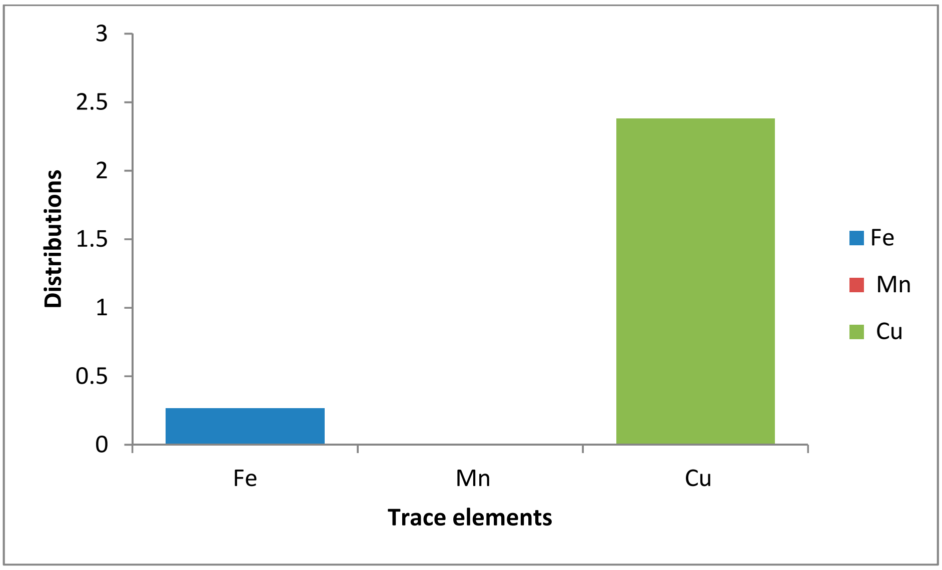


Figure 10: Average Distribution of Trace Elements in the Water resources of the Study Area.

The figure above showed that the average concentration of Copper (Cu) in the water resources of the study area is very high with an average concentration of 2.483 as against the World Health Organization standard of 0.050mg/l that of Iron (Fe) is 0.193mg/l compared to WHO, 2011 of 0.300mg/l and Manganese (Mn) has an average concentration of 0.002mg/l as against the WHO, 2011 of 0.050mg/l. The average concentration of Copper (Cu) exceeded the maximum permission limit by World Health Organization. Therefore, precautions should be taken to reduce further concentration. While the other observed trace elements fall below WHO standard.

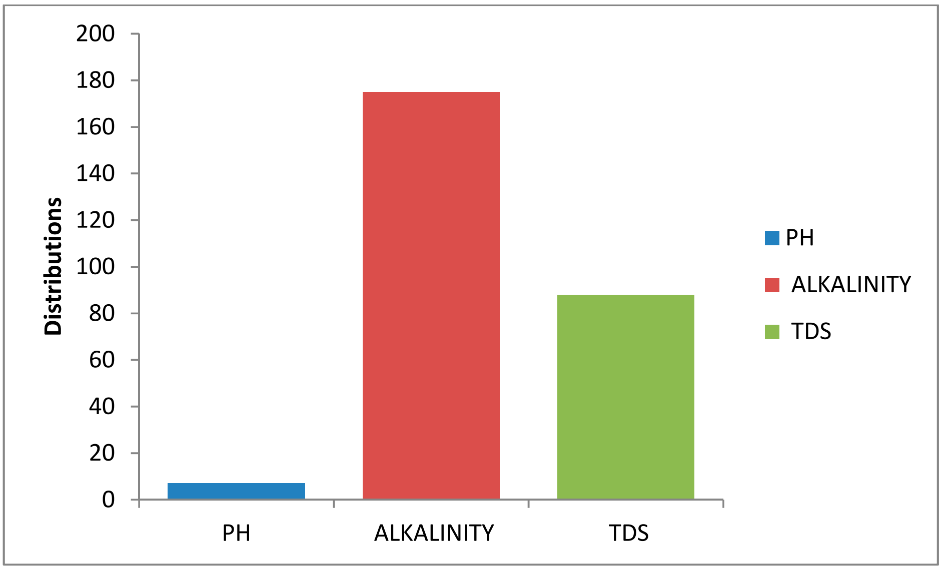


Figure 11: Average Distribution of PH, Alkalinity and TDS in the Water Resources of the Study Area.

Figure 4.13 revealed that the average concentration of Alkaline is very high in the study area, it has an average concentration of 174.999mg/l as against WHO, 2011 of 100.00mg/l. This is follow by the average concentration of TDS with 88.00mg/l as against WHO, 2011 of 500.00mg/l. While that of PH is 7.083 as against the WHO standard of 6.5 – 8.5. However, the average concentration of Alkalinity is far higher than the WHO standard. The other observed parameter (PH and STD) falls below the World Health Organization standards.

5.0 CONCLUSION

It was observed in the results obtained that in all the physico-chemical analysis carried out in the study area, all the cations (Ca^{2+}, Mg^{2+}, K^{+} and Na^{+}) conformed to WHO standard limits for drinking water. Also majority of the anions conformed to WHO standard limits for drinking water except for the concentration of $HC0_3^-$ in most of the individual water samples. However, the level of PH and TDS are within the WHO limits for drinking water, while the alkalinity concentration in seven (7) sampled water sources fell above the WHO limits for potable water. However, the microbiological analysis carried out to determine the microbial loads in the water samples revealed that most of all the water samples analyzed the area is not fit for drinking (Table 4.26). The heavy presence of microbial loads (Total Bacterial Count, Total Coliforms Count and E. Coli in the sampled water makes it unfit for human consumption except in sample water G, I and J where the microbial loads fall below the WHO limits for drinking water.

The results also showed that there are slightly high concentrations of dissolved Anions, Heavy Metals and Trace Elements most especially $HC0_3^-$ in sample B, E, F, G, H, I and J. Iron (Fe) in sample A and D, Lead (Pb^{2+}) in all the samples analyzed, Nickel (Ni^{2+}) in all samples except sample J, Copper (Cu) in all samples and Cadmium (Cd) in all water samples analyzed. Both the PH and TDS concentrations in water conformed to the WHO permissible limits for good quality water. The high alkalinity for ground water (Samples: E, F, G, H, I and J) and pond water sample B is traceable to the nature of the sediments that is rich in alkaline minerals. Their individual sample location concentrations have risen above the limits of World Health Organization (WHO) permissible for drinking water. The high concentration may be as a result of domestic waste disposal along the water, the use of chemicals for weeds control, the use of chemical for agricultural produce and also from the underlying rocks of the area. Water as a

 doi:10.20944/preprints201801.0076.v1

solvent is capable of dissolving the minerals of the underlying rocks and wastes which in turn percolates into the ground as contaminants to the ground water of the area, while others flows into the surface as run-off into streams and ponds in the area.

Moreover, the increase in improper waste disposal, use of chemicals in controlling weeds and fertilizers usage without taking into consideration the environmental effects on both ground and surface water resources of the area, may pollute the water resources of this area thereby making it unfit for human consumption.

The microbial analysis of the water samples in the area revealed heavy presence of indicator organisms in samples A, B, C, D, E, F and H respectively. This makes the water quality of these locations unfit for human consumption. This is because their concentrations in the water samples are higher than the World Health Organization.

 doi:10.20944/preprints201801.0076.v1

APPENDIX

WATER QUALITY OF WORLD HEALTH ORGANIZATION (WHO) STANDARDS.

PARAMETERS	W.H.O DESIRABLE LEVEL
Appearance	CLEAR
Odour	UN-OBJECTIONABLE
Colour	5
Turbidity	5
PH	7.0 – 8.5
Temp	-
Conductivity	-
Total Alkalinity	75
Total Hardness	75
Magnesium Hard	150
Suspended Solid	-
Iron	0.1
Nitrogen Nitrate	20
Sulphate	150
Fluoride	0.0
Calcium Hargness	75
Chlorine (free)	0.1
TDS	600
Chloride	75

 doi:10.20944/preprints201801.0076.v1

Manganese	0.1
Copper	0.05
Lead Pb^{2+}	0.05
Calcium	75
Total viable plate count	10
Coliform count	10
E. Coli	0
Streptococcus faecalis	NIL
Yeast/Mould cfu/ml	0
Clostridium welchii	NIL

ACKNOWLEDGEMENT

The authors wish to acknowledge the Kogi State Rural Water Supply Agency (RUWASSA), Nigeria, for providing certain logistics in the course of the research. The Department of Geology, University of Fort Hare is also acknowledged for support in the course of this research.

REFERENCES

1. Gucharan, S., Jagdishi S. Water supply and Sanitary Engineering, 6th Edition. Standard Publishers. Distributors - Nai Saraki New Delhi, India. (2003).pp.128-131.

   ISBN 10: 8180140296 ISBN 13: 9788180140297

2. Punimia, B.C, Ashok J., Arun, J. Water supply Engineering, 2nd Editions, Laxi Publications (P) Ltd. New Delhi, India (1995). pp. 256-261 ISBN 8170080924, 9788170080923 .
3. Terrence .M. (1991). Water supply and Sewerage. Edition, 5, illustrated. Publisher, McGraw-Hill, (1979). Original from, the University of Michigan. Digitized, Dec 4, 2007.
4. Olanrewaju, V.O, Olorundemi, M.O and Alade, O.; Chemical characteristics of groundwater from some parts of the basement complex of Nigeria. Journal of Mining and Geology, (accepted)
5. Omada J.I., Omali .A, and Awodi J.I., Physico-chemical characteristics of surface water in parts of Lokoja metropolis, central Nigeria. Journal of Nigerian Association of Hydrogeologists, (2009). vol. 19, pp.56-62. (Accessed Sept. 2017)

6. Ajibade, O.M., Omosanya, K.O and G.O.Odunsi. Groundwater contamination and flow direction of urban aquifer, Ibadan, Southwestern Nigeria. Proceedings, Annual Conference of the Nigerian Association of Hydrogeologists on Water Resources Development and Climate Change. 2010 .p.10.
7. J. E. Yang, J. J. Kim, E. O. Skogley and B. E. Schaf. A Simple Spectrophotometric Determination of Nitrate in Water, Resin, and Soil Extracts. Soil Science Society of America Journal Abstract -1997.Vol. 62 No. 4, p. 1108-1115 DOI;10.2136/sssaj1998.03615995006200040036x
8. Brady , K.B.C. Groundwater chemistry.1998 volume 2, pp 2-3
9. United States Geological Survey (USGS). New Reporting Procedures Based on Long-Term Method Detection Levels and Some Considerations for Interpretations of Water-Quality Data Provided by the U.S. Geological Survey National Water Quality. U.S. Geological Survey Open-File Report By Carolyn J. Oblinger Childress, William T. Foreman, Brooke F. Connor, and Thomas J. Maloney Reston, Virginia 1999 99–193

10. World Health Organisation (WHO) Library Cataloguing-in-Publication; Data Guidelines for drinking-water quality - 4th edition. (2011). ISBN 978 92 4 154815 1 (NLM classification: WA 675). World Health Organization, Geneva.