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EVALUATION OF HEAVY METALS CONCENTRATION IN GROUNDWATER AROUND KASHERE AND ITS ENVIRONS, UPPER BENUE TROUGH, NORTHEASTERN NIGERIA

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ABSTRACT

This research examined the levels of heavy metals in boreholes and hand dug wells within Kashere town and environs. The sampling was carried out at 10 locations in Kashere area of Gombe state. Five samples were collected from boreholes and five from hand dug wells and analyzed for some heavy metals (copper, cadmium, chromium, lead, nickel and manganese) using Atomic Absorption Spectrophotometer (AAS). The result shows that there is high concentration of most of the heavy metals in the groundwater samples with Pb, Ni, Cr, and Cd having mean concentrations above the maximum limit set by W.H.O. It was recommended that a systematic treatment of heavy metals concentration in groundwater sources in the study area be carried out regularly either through; Chemical precipitation, ion exchange or Reverse osmosis.

KEYWORDS: Groundwater; Heavy metals; Boreholes; Hand dug wells; Concentration; AAS, HPI

INTRODUCTION

Water is one of the natural resources that support the existence of human beings and other living organisms on earth. Water occurs in different areas or zones in the earth, there exists surface water occurrence popularly known as "surface water bodies bodies" and "Groundwater bodies" the surface water bodies includes streams, lakes, seas and oceans, whereas, Groundwater bodies refers to water formed beneath the earth sub surface i.e water saturated zone within the different layers or zones of the earth's crust.

Groundwater is an important source of drinking water for humans, it contains larger percentage of the available fresh water resources and it is an important reserve of good quality water. Groundwater is extensively being exploited through the construction of boreholes and hand dug wells in urban and semi urban areas for domestic, agricultural, and industrial usage. Rapid population growth and urbanization leads to an increase in demand and exploration for potable water.

Groundwater pollution is a gradual degradation in water quality through the addition of chemicals, heat or bacteria to a level that constitutes public health hazards, and affects it adversely in terms of domestic, agricultural, and industrial utilization (Akhilesh *et' al* 2009, Musa *et' al*, 2013).The water pollution by heavy metals has become a question of considerable public and scientific concern in the light of the evidence of their toxicity to human and biological system (Anazwa *et al*., 2004). Heavy metals particularly are of great concern, due to their toxicity even at low concentrations (Marcovecchio, *et al*, 2007). These metals include: lead(Pb), cadmium(Cd), zinc(Zn), mercury(Hg), arsenic(As), silver(Ag), chromium(Cr), copper(Cu), iron(Fe), platinum(Pt) and manganese (Mn). Although, some heavy metals at low concentrations are essential to life, at high concentrations, they tend to be harmful. Heavy metals are dangerous because they tend to bio-accumulate resulting in heavy metals poisoning. The high level of heavy metals in natural water bodies can be attributed to some anthropogenic activities such as mining, fuels, farming and improper municipal waste disposal.

Ground water samples from hand dug wells and bore holes distributed in the study area shows some deviation from the normal physical characteristics (Colour, taste etc) especially, when examined physically. moreover, there was no record of any serious research work (published work) carried out to assess the quality of the ground water sources (bore holes and hand dug wells) in the study area, hence the need for the assessment of levels of some heavy metals that are considered to be harmful to humans when taken in excess amount through the available groundwater sources in the study area. Therefore, this research will serve as a baseline study for further research on the levels concentration of these metals in the stream sediments and the rocks distributed in the present area of study.

The aim of the present study is to assess the quality of the groundwater samples (obtained from bore

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holes and hand dug wells) in terms of suitability for domestic utilization, with the objectives of; determining the levels of some heavy metals in the water samples in the study area, determining the pollution index of the water due to the dissolved heavy metals content, in the ground water samples of the study area, and suggest the possible means of treating the water against the heavy metal pollution.

HYDROGEOLOGY OF GOMBE STATE

Gombe State is underlain by two major lithological units that comprises of the crystalline basement rocks that out crops as an inlier towards the southern part of the state, around around Billiri and Kaltungo areas and within Gombe town as 'Gombe inlier' (this covers 2% of the state lithology), whereas, the remaining part is covered by the cretaceous sedimentary rocks (98% of the state) this comprises of Bima sandstones (covers;31.1%), Yolde formation (10.5%), Pindiga Formation (9.9%), Gombe Formation (10.3/%), Keri-Keri Formation (34.2%) and alluvium (1.2%), Zaborski *et al.,(*1997).

From hydrogeological point of view, the stratigraphic sequence in Gombe State is provided by Lovelyn *et al,* 2016 (table 1). The hydrogeology of Gombe State can be discussed under the two main environments mentioned earlier on; the crystalline and sedimentary environment. Crystalline environment has 3 to 4 zones, they compose (mostly of) top soil, weathered, fractured, and fresh crystalline basement rocks, with the weathered, and fractured parts being the water bearing zones in the set up (Dike *et al*.,1994).

The weathered zone has an unlimited water capacity, with thickness of about 10-40meters. While in fractures zone, the aquifer is very rich and its capacity depends on its thickness and lateral extend as well as the inter connectivity of the fractures (Lovelyn, *et al,* 2016).

Table 1: Lithology and storage of formations in Gombe State (adopted from Lovelyn *et al,* 2016).

S/No.	Formation	Lithology	Storage
1	Keri-Keri	Mainly silt, sandy clay and sandstones	Deep layer aquifer
2	Gombe	Sandstones, Siltstone, Clay and iron Stone	Aquifer- Aquicludes
3	Pindiga	Shale with limestone	
4	Yolde	Shaly clay, Sandstones	Aquifer
5	Bima	Medium to coarse grained feldsparthic Sandstone	Aquifer
6	Basement	Granite, Gneiss	Weathered, Fractured zone

THE STUDY AREA

The study area forms part of Kaltungo sheet 173NW, and is located in Akko Local Government area of Gombe State, Nigeria. It lies between Longitudes; 09°57'00"E and 10°0'00"E and latitudes 11°06'00"N and 11°09'020"N(Figure 1), and covers an area of about 25 Km^2.

Prominent settlement within the study area includes Jauro Bose, Garin Alhaji, Jauro Debe, Tumburu Kofaye, Wada Tangale, Wada Bolawa and Kashere town. The area is accessible by means of numerous footpaths and motorable roads that run from Tumu to Pindiga, Kashere, and finally link with Gombe -Yola Federal highway at Billiri town.

The study area (Kashere and environs) is located within the Gongola arm of the upper Benue trough of northeastern Nigeria (Figure 2). The regional stratigraphic sequence of the upper Benue trough of Nigeria has been provided by a number of published research works, including; Zaborski *et al*, (1997), Obaje, *et al.*(2009) and Abubakar, (2006) (Figure 3).

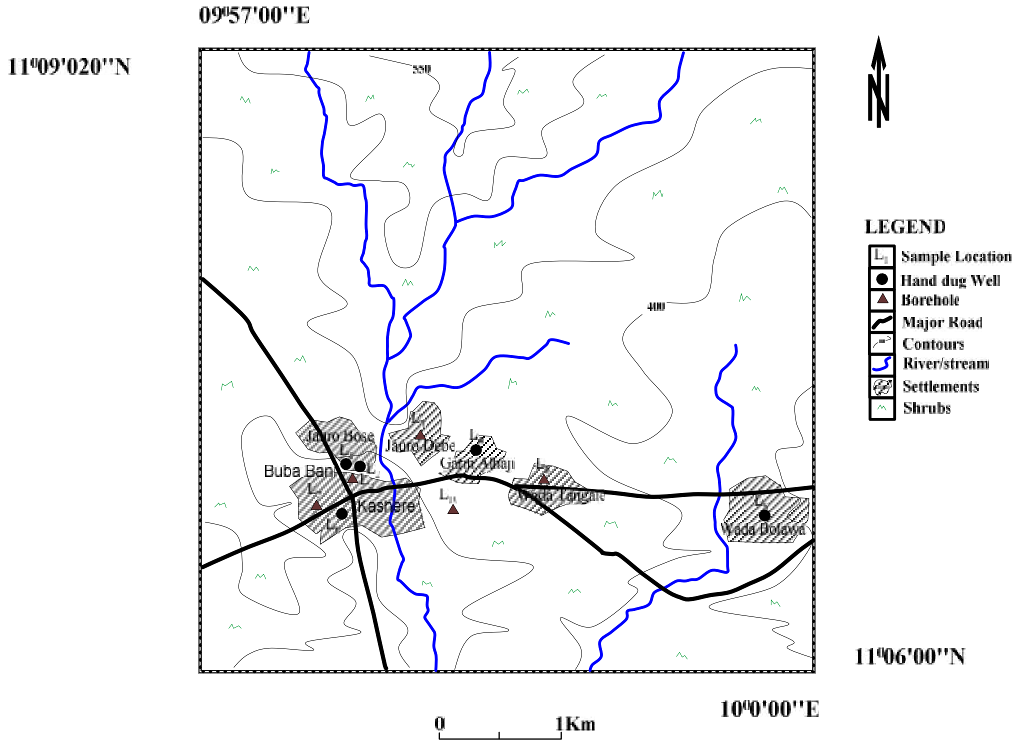

Figure 1: Location Map of the study area showing sampling points (Modified from Federal Surveys Agency, 1976).

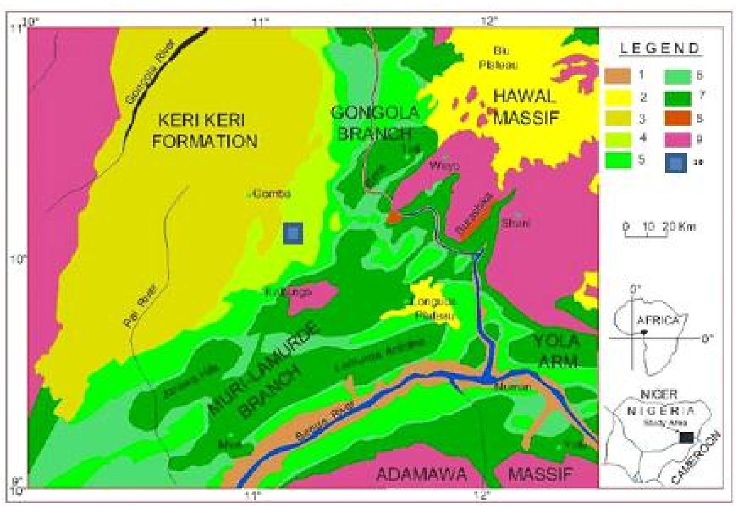

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Figure 2: Geologic map of upper Benue trough showing the study area (modified after Haruna *et al,* 2012). 1. Quaternary Alluvium, 2. Tertiary to Recent volcanism, 3.Keri-keri Formation, 4.Gombe Sandstone, 5. Pindiga Formation, 6. Yolde Formation, 7.Bima Sandstone, 8.Burashika Group (Mesozoic volcanism), 9. Precambrian Granitiods, 10. Present area of study

The oldest Stratigraphic succession in the Upper Benue trough (Figure 3) is the Albian, continental "Bima Sandstone" (Abubakar, 2006.), characterized by fairly homogenous and relatively matured fine to Coarsed grained sandstone at the lower part. Overlying the continental Bima Sandstone conformably is the transitional, late Albian-Cenomanian "Yolde Formation". The Yolde Formation is characterized by variable sandstones that are mostly coarsed grained and cross bedded with alternating Sandstone and dark grey mudstone at the lower part (Thompson, 1958, Carter et al 1963, and Allix, 1983).

Overlying the transitional Yolde Formation is the marine, Turonian-Coniatian "Pindiga Formation" (Figure 3) which is characterized by calcareous beds and clay shale (Abubakar,2006). Overlying the Pindiga Formation unconformably is the Campanian - Maastrichtian "Gombe Formation" (Figure 3). Gombe Formation is characterized by Sandstones, Siltstones and Mudstones materials. The Formation extends due west beneath the Tertiary Kerri-Kerri Formation (Dike, 1995).

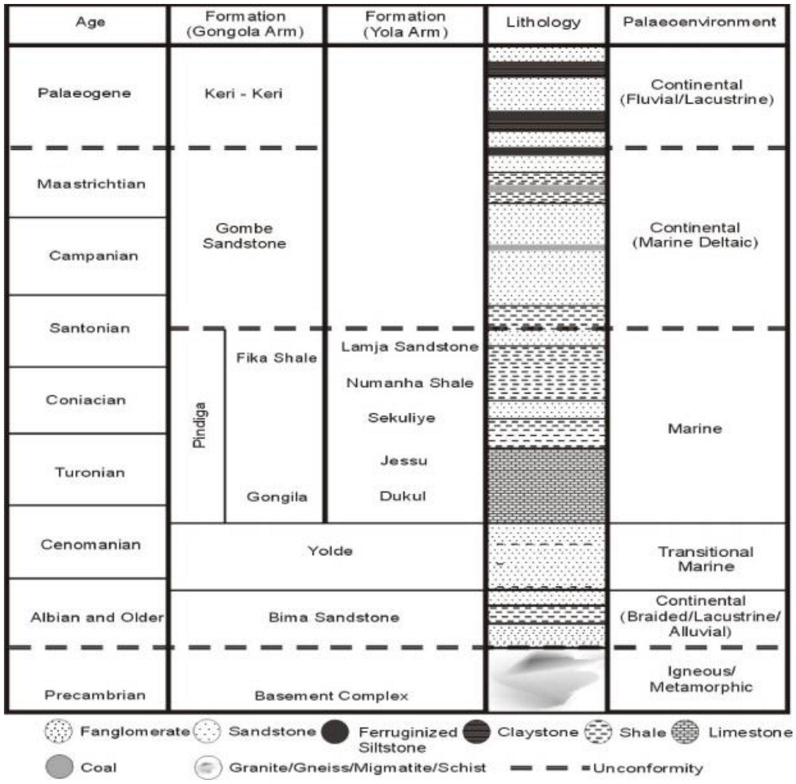

Figure 3: Stratigraphic Succession of the upper Benue trough (After Abubakar,2006)

The Kerri-Kerri Formation, being the youngest Formation in the upper Benue trough is characterized by lateritic sandstones and clay deposits (Carter *et al* 1963).

The Study area (See Figure 4) is underlain mainly by Gombe Formation, which is exposed along stream channels and rugged hills. The formation exposure (outcrop) in the study area consists of alternating sequence of thinly bedded Silts and Shale and sometimes Sandstone of fine to medium grained textures with some flaggy ironstone with vesicles.

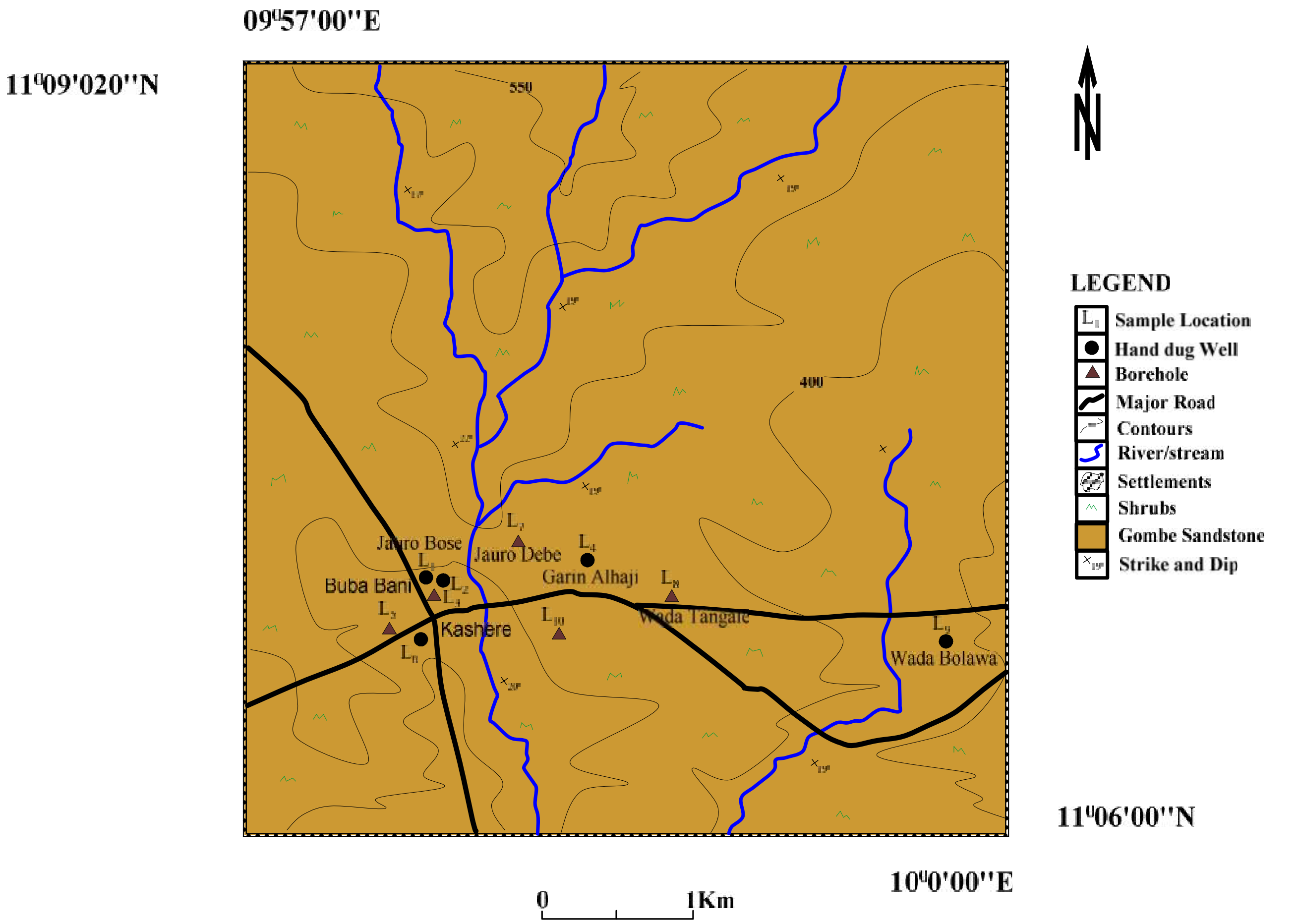

Figure 3: Geological map of the study area showing Sample Points

MATERIALS AND METHODS

WATER SAMPLING AND ANALYSIS:

Water sample were collected from five (5) open wells, and five (5) boreholes in the study area. Plastic bottles were used for the collection of the water samples, before the sampling proper, the plastic bottles were rinsed 2 to three times with the water to be examined. Few drops of Nitric acid were then added to the sampled water to be examined, so that the dissolved metals are kept at ionic form because, this will enable the detection of the dissolved metals by the AAS machine. The sampling locations in the study area (see Figure 1 above)were chosen on the basis of availability of bore holes and hand dug wells in those areas (settlements), these localities includes Kashere town, Garin Alhaji, Jauro Bose, Garin Wurkun, Tumburu village and Buba Bani village which are located in Akko local government areas of Gombe State.

The temperature and pH of the water samples were measured in-situ using Jenway pH and temperature meter. Heavy metals contents were analyzed in Biochemistry Laboratory of Gombe State University Gombe, by using atomic absorption spectrophotometer (AAS)(BUCK 200 model),these metals include; Cd, Cu, Pb, Cr, Ni and Mn.

5ml of the water sample was dispensed and poured into Teflon tube; it was placed into the digestion tube block in a fume cupboard. 20ml of Nitric acid (Conc. HN03) + 20ml of Hcl (Conc. Hcl) were added. It was then Left for some time and the digestion block was switch on to heat the sample to dryness, it was then brought out and distilled water was added to wash the tube. Distilled water was added using 100ml volumetric flask until it was up to 100ml in volume. Reading for various metals using atomic absorption spectrophotometer (BUCK 200 model) was then taken.

TECHNIQUE FORCOMPUTING HEAVY METAL POLLUTION INDEX (HPI)

Heavy metal pollution index (HPI) is a technique of ranking that provides the compound influence of individual heavy metal on the overall quality of water. The ranking is a value between zero and one, showing the relative importance of individual quality considerations and inversely proportional to the recommended standard (Si) for each parameter (Reza & Singh, 2010; Prasad and Mondal, 2008; Prasad & Kumari, 2008, Mohammed *et al.,* 2014). The calculation of HPI involves the following steps: First, the calculation of weightage of ith parameter Second, the calculation of the quality rating for each of the heavy metal Third, the summation of these sub-indices in the overall index

The weightage of ith parameter W i = k / Si………….. **(1)**

Where Wi is the unit weightage and Si the recommended standard for ith parameter, while k is the constant of proportionality. Individual quality rating is given by the expression

Qi = 100 Vi / Si ……………………………………..**(2)**

Where Qi is the sub index of ith parameter, Vi is the monitored value of the ith parameter and Si th and Si the standard or permissible limit for the ith parameter.

The Heavy Metal Index (HPI) is then calculated as follows

HPI= ^{n}i= (QiWi)/^{n}i=Wi ………………………………….**(3)**

where Qi is the sub index of ith parameter. Wi is the unit weightage for ith parameter, n is the number of parameters considered. The critical pollution index value is 100. Si is the standard or permissible limit of the ith parameter.

METAL INDEX (MI) COMPUTATION TECHNIQUE

Metal index (MI) for drinking water justifies possible additive effect of heavy metals on the human health that helps to quickly appraise the overall quality of drinking waters (Bakan *et al*., 2010). Metal pollution Index is given by the term proposed by (Caeiro *et al.,* 2005).

MI = ∑ [Ci/ (MAC)i]

Where MAC is maximum allowable concentration and Ci is mean concentration of each metal. The higher the concentration of a metal compared to its respective MAC value the worse the quality of water. MI value > 1 is a threshold of warning (Bakan *et al.,* 2010). Water quality and its suitability for drinking purpose can be examined by determining its metal pollution index (Mohan *et al.,* 1996; Prasad & Kumari, 2008).

RESULTS AND DISCUSSION

The result of Physico-chemical and heavy metals analysis of ten (10) locations shows that the temperature of the water ranged from 35^{o}C to 36^{o}C (Table 1) which fall within the recommended standard for drinking water quality by WHO (2011). The pH value of the water ranged from 6.55 to 7.90, thus, falling within the standard requirement limits (6.5-8.5) recommended by W.H.O (2011) and NIS (2007). The pH values (Table 1) shows slightly (weakly) acidic water with the lowest value of 6.55 in location 1, which is attributed to discharge of acidic materials in to the ground water through agricultural and domestic activities, while location 4 has the highest pH value of 7.9, which can be attributed municipal waste disposal into the ground water of the study area. The results obtained for the concentration of heavy metals (Cu, Cd, Cr, Ni, Pb, Mn) in the water samples collected from different hand dug wells and boreholes are presented in Table 2. These results were further group into bore holes and hand dug wells and their mean computed and compared with the WHO (2011), and NIS,(2007) maximum permissible limits in Table 3.

Table 1: Results of physico-chemical parameters

Location	Source	Grid location	Elevation(m)	pH	Temperature (^{0}C)
L1	Hand dug Well	N09^{0}55′00.3″ E11^{0}00′42.9″	370	6.55	35^{0}C
L2	Hand dug Well	N09^{0}54′59.5″ E11^{0}00′44.5″	370	7.40	35^{0}C
L3	Hand dug Well	N09^{0}54′57.0″ E11^{0}OO′45.9″	389	7.80	35^{0}C
L4	Hand dug Well	N09^{0}54′56.5″ E11^{0}00′44.5″	375	7.90	35^{0}C
L5	Hand dug Well	N09^{0}545′1.5″ E11^{0}004′3.3″	409	7.70	35^{0}C
L6	Borehole	N09^{0}54′46.6″ E11^{0}004′0.7″	373	7.40	35^{0}C
L7	Borehole	N09^{0}550′9.1″ E11^{0}010′4.0″	368	7.08	35^{0}C
L8	Borehole	N09^{0}55′11.3″ E11^{0}018′.2″	368	7.02	35^{0}C
L9	Borehole	N09^{0}550′8.9″ E11^{0}010′4.3″	356	7.50	36^{0}C
L10	Borehole	N09^{0}544′7.0″ E11^{0}011′2.6″	366	7.01	35^{0}C
Average temperature of the water samples analysed					35.1^{0}C
WHO 2011, Standard temperature values					30 – 32^{0}C
Average pH of the water samples analysed				6.60	
NIS, 2007, Standard pH values				6.5 –8.5	
WHO 2011, Standard pH values				6.5 –8.5	

Table 2: Analytical result of heavy metals concentration.

Sample points	Source/ Co'ordinates	Heavy metal ion concentration in mg/l					
		Cu	Cd	Cr	Ni	Pb	Mn
L1	**Hand dug well** E11^{0}00'42.9" N9^{0}55'00.3"	0.21	0.16	0.11	1.53	6.60	0.44
L2	**Hand dug well** E11^{0}00'44.5" N9^{0}54'59.5"	0.09	0.09	0.05	0.61	Not detected	0.25
L3	**Hand dug well** E11^{0}00'45.9" N9^{0}54'57.0"	0.11	0.07	0.06	0.75	0.40	0.32
L4	**Hand dug well** E11^{0}00'45.5" N9^{0}54'56.5"	0.17	0.07	0.08	0.98	2.23	0.62
L5	**Hand dug well** E11^{0}00'43.3" N9^{0}54'56.5"	0.24	0.06	0.05	0.84	2.73	0.63
L6	**Borehole** E11^{0}00'40.7" N9^{0}54'46.6"	0.21	0.07	0.02	0.89	0.21	0.34
L7	**Borehole** E11^{0}01'04.4" N9^{0}55'09.1	0.18	0.05	0.02	0.78	Not detected	0.64
L8	**Borehole** E11^{0}01'8.20" N9^{0}55'11.3"	0.15	0.06	0.02	0.66	2.23	0.29
L9	**Borehole** E11^{0}01'04.3"N9^{0}55'08.9"	0.19	0.06	0.03	0.50	Not detected	0.59
L10	**Borehole** E11^{0}01'12.6" N9^{0}54'47.0"	0.10	0.09	0.01	1.26	1.12	0.29
	Mean conc. of the Elements	0.17	0.08	0.08	0.88	1.85	0.42
	Min. conc. Of the Element	0.09	0.05	0.01	0.5	0.21	0.25
	Max. conc. Of the element	0.24	0.16	0.11	1.53	6.60	0.64
	Stand. Deviation (Sd)	1.01	1.10	1.20	1.30	1.65	0.16
	WHO(2011) standard	2.00	0.05	0.03	0.02	0.40	0.40
	NIS (2007) standard	1.00	0.003	0.05	0.02	0.01	0.20

Table 3: Comparison of mean concentration values for Boreholes and Hand dug wells with WHO (2011), and NIS (2007) Standards.

Elements	**Borehole (mg/l)**	**Hand dug well (mg/l)**	**WHO (2011) Max. Permissible limit (mg/l)**	**NIS (2007) Max. Permissible limit (mg/l)**
Cu	0.17	0.12	2.00	1.000
Cd	0.07	0.09	0.03	0.003
Cr	0.02	0.07	0.05	0.050
Ni	0.82	0.94	0.02	0.020
Pb	1.19	2.39	0.40	0.010
Mn	0.43	0.45	0.40	0.200

The concentration of Cd, Cr, Ni, and Pb were found to be above the highest permissible value, while the concentration of Cu was found to be below the highest permissible value (Table 1). The concentration of heavy metal are ranked as Pb,> Ni, > Cr,> Cd, > Cu. The minimum and maximum concentration of copper obtained from the hand dug wells and borehole water sample at the ten (10) different sampling points in the study area (table 6) ranges from 0.09mg/l in location two (2) (i.e. Jauro Bose) and maximum of 0.24mg/l in location five (Kashere town). Both boreholes and hand dug wells samples have mean values of 0.17mg/l and 0.12mg/l respectively. These values were observed to be below the maximum permissible limits of (2.0mg/l) set by WHO(2011) and NIS (2007) for drinking water. Copper has the lowest value of standard deviation, which is the measure of the degree of deviation (dispersion) of the data away from the mean concentration of the elements; this indicates that the analytical values for the copper in the study area tend to converge towards the mean values obtained.

The minimum and maximum concentration of Cadmium obtained from the hand dug wells and borehole water sample at the ten (10) different sampling points of the study area (shown in table 6) ranges from 0.05mg/l in location seven (7) i.e. Jauro Debe and 0.16mg/l in location one (Jauro Bose). The maximum permissible limit set by WHO (2011) and NIS (2007) is (0.03mg/l) and 0.003mg/l respectively. Cadmium metal in all the samples analyzed has mean values of0.066mg/l and 0.09mg/l in both boreholes and hand dug wells respectively (table 3).These values were observed to be above the maximum permissible limit set by WHO(2011)and NIS, (2007) for drinking water.

The mean concentration of Cadmium across all the samples was 0.07mg/l as against the WHO, 2011 and NIS, 2007 permissible limit of 0.03mg/l and 0.003mg/l respectively. High concentration of Cadmium in water for drinking and domestic purpose can cause severe damage to lungs and also cause diarrhea, severe stomach pain and vomiting(National Academy of Sciences,1999). Cadmium is a soft light colored metal with vapor pressure causing it to oxidized rapidly to Cadmium oxide in air while, many Cadmium compound are water soluble, thus the possible source of high concentration of Cadmium in the study area may be as a result of the soluble Cds or Cdo which are related to the Gombe sandstone.

The minimum and maximum concentration of Chromium obtained from the hand dug wells and borehole water sample at the ten (10) different sampling points in of the study area (shown in table 2) ranges from 0.01mg/l in location ten (10) i.e. Kashere town to 0.11mg/l in location one. The maximum permissible limit set by W.H.O (2011) is 0.05mg/l. Lower concentration of chromium ions were recorded in all the samples collected excluding samples from location 1, 3, and 4 whose concentration were observed to be above the maximum permissible limit set by W.H.O 2011 and NIS 2007. The mean concentration of the chromium ion for both the borehole and hand dug wells is 0.02mg/l and 0.07mg/l respectively (Table 3). The use of water with high concentration of Cadmium for drinking and domestic purposes can cause cancer to humans (Jarup, 2003).

The minimum and maximum concentration of Nickel obtained from the hand dug wells and borehole water sample at the ten (10) different sampling points in Kashere and environs (as shown in table 2) ranges from 0.5mg/l in location nine (9) i.e Wada Bolawa and 1.53mg/l in location one (Jauro Bose). The maximum permissible limit for drinking water set by both W.H.O 2011and NIS, 2007 is 0.02mg/l. Thus, Nickel has mean values of 0.818mg/l and 0.942mg/l in both the borehole and hand dug wells respectively. The possible source of Nickel in the area may be from municipal waste dumps which are scattered virtually all around the study area and possible anthropogenic sources such as a burning fuel. High concentration was observed at the entire location with mean value of 0.88mg/l as against both WHO, 2011 and NIS, 2007 permissible limit of 0.02mg/l. When use for drinking and domestic purposes at high concentration, Nickel can cause carcinogenic diseases (National Academy of Sciences, 1999).

The minimum and maximum concentration of Lead obtained from the hand dug wells and borehole water sample at the ten (10) different sampling points in the Study area (as shown in table 2) ranges from 0.21mg/l in location six(6) i.e Kashere town and 6.60 mg/l in location one (Jauro Bose). The maximum permissible limit set by NIS, 2007and WHO 2011 is 0.010 mg/land 0.40 mg/l respectively. Lead ions were not detected in Jauro Debe, and parts of Jauro Bose (location 7, 9 and 2). The lead ions detected in locations 1, 4, 5, 8, and 10 were observed to be above the NIS, 2007and WHO 2011 maximum permissible limits of Lead ion concentration in drinking water with the exception of location 6 and 3 (in Kashere town) where the concentration is less than or equals to WHO (2011) and NIS, (2007)water quality standards respectively. The mean concentration values for Lead ion ranges from 1.186mg/l and 2.392mg/l in both boreholes and hand dug wells respectively. The highest value of standard deviation was obtained in Lead, which indicates that the analytical result for lead metal tends to disperse away from the mean concentration of the element. The abnormal Concentration of the Lead ion could be as a result of composed manure deposited on the farms around the study area or also as a result of used of littered petrol in cars, generators and water pumps which can pose a threat to humans that depends on ground water for drinking and domestic purposes as it can cause cancer, interfere with vitamin D as well as damage the nervous system and cause brain disorder(Jarup, 2003, Barbee and Prince, 1999).

The minimum and maximum concentration of Manganese obtained from the hand dug wells and borehole water sample at the ten (10) different sampling points of the study area (as shown in table 2) ranges from 0.25mg/l in location two (Jauro Bose) and 0.64mg/l in location 3 (Jauro Debe). The maximum permissible limits set by W.H.O 2011and NIS, (2007)is 0.4mg/l and 0.2mg/l respectively. The results shows higher Concentration for manganese ions in the Samples analyzed, except those from location 2,8, and 10 whose concentration were observed to be below the maximum permissible limits set by WHO(2011)but above the NIS, 2007 maximum limits for drinking water quality. The mean concentration values ranges from 0.43mg/l and 0.45mg/l at both the boreholes and hand dug wells respectively. Comparison of the mean concentration of manganese across both bore holes and Hand dug wells shows higher concentration of the element in hand dug wells than bore holes; this can be attributed to surface infiltration processes that enable the filtration of the elements at some depth, before reaching the bore holes. The source of high concentration of manganese may be as a result of agricultural activities taking place in the area with the main source from organic fertilizers as well as oxides derived probably from dissolution of rocks of the Gombe formation in the study area. The high level of manganese detected in the water samples analysed can cause neurological disorder, it can also stain clothes, metal pads and precipitate in food, it also promote the growth of algae in the reservoirs(Jarup, 2003)

HEAVY METAL POLLUTION INDEX:

The characterization of the water from the area with the use of the heavy metal pollution index (HPI), gives value to be compared with the critical value to evaluate the level of pollution.(Prasad and Kumari, 2008, Reza and Singh, 2010).

Table 4: Mean HPI of Water in the study area HPI= 987.63

Heavy Metals	Mean Concentration mg/l	Highest permissible value (Si)	Unit weightage (wi)	Sub index Qi	Wi x Qi
Cu	0.17	1.00	1.00	17	17
Cd	0.08	0.03	333.33	266.67	88889.11
Cr	0.08	0.05	20	160	3200
Ni	0.88	0.02	50	4400	220000
Pb	1.85	0.01	100	1850	185000
			$\sum Wi = 503.33$		$\sum WixQi = 497106.11$

The mean of HPI value was found to be 981.63 which are above critical value of 100. This value indicates that the water from the area is polluted with respect to heavy metals. HPI calculated for the various locations indicates location 1 (Table 5, Fig.4) with the highest value this could be as a result of anthropogenic sources from industrial activity, sewage disposal and domestic waste. While, the lowest value was found in location 2. Metal index (Mi) for the area indicates low quality water with value 180.79 (Table 6). This suggests that the water is seriously affected with respect to heavy metal pollution when compared with the Lyulko *et al.*, 2001; Caerio *et al.*, 2005Water Quality Classification scheme (Table 7).using metal index (MI) computed (Table 6).

Table 5: HPI values at various sampling locations

Sampling location	1	2	3	4	5	6	7	8	9	10
HPI	163.70	0.03	9.94	55.34	67.74	5.26	0.05	55.33	0.05	27.80

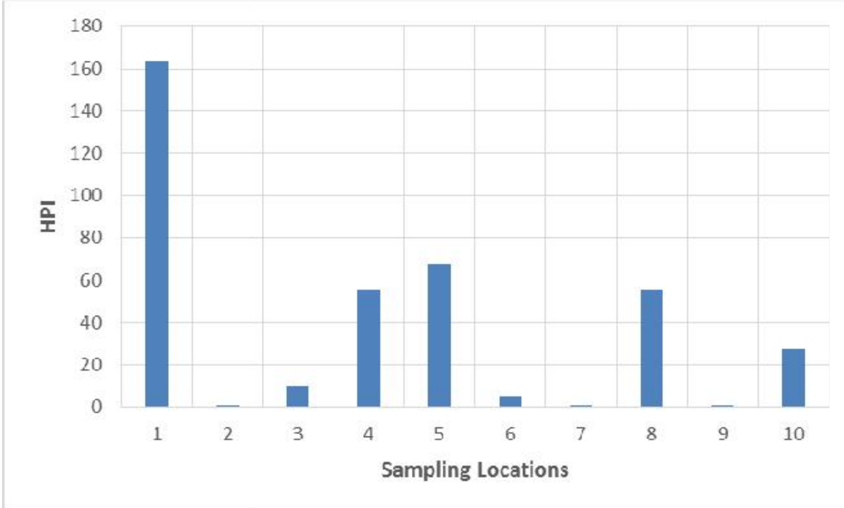

Figure 4: sampling points versus Heavy metal pollution index chart.

Table 6: Metal index

Heavy Metals	Mean Concentration(mg/l)	Highest permitted value (mg/l)	MI
Cu	0.17	1.000	0.170
Cd	0.08	0.003	26.67
Cr	0.88	0.050	17.60
Ni	1.85	0.020	92.50
Pb	0.44	0.010	44.00
$\sum MI = 180.79$			

Table 7: Water Quality Classification using MI (Lyulko*et al.,* 2001; Caerio*et al.,* 2005)

MI	Characteristic	Class
<0.3	Very pure	I
0.3-1.0	Pure	II
1.0-2.0	Slightly affected	III
2.0-4.0	Moderately affected	IV
4.0-6.0	Strongly affected	V
>6.0	Seriously affected	VI

CONCLUSIONS

The result obtained from the analysis indicate the order of concentration of the heavy metals detected in all water samples analyzed to be in the sequence of Pb>Ni>Cr>Cd>Mn>Cu. It has also been observed that, the mean value of Heavy Metals in the water samples analyzed shows abnormal concentration except, Copper (Cu) and manganese (Mn) whose, concentration (in some few sources) is within the acceptable limit set by World Health Organisation (W.H.O. 2011) and Nigerian Industrial Standard (NIS 2007).

However, for the remaining heavy metals measured; Pb, Ni, Cr, and Cd were mostly found to exceed the maximum permissible limit recommended by W.H.O 2011and NIS 2007. Moreover, the analysis indicates that, higher concentrations of the heavy metals are found mostly in the hand dug well (with the exception of Cu) as compared to the boreholes. This could be as a result of surface infiltration from anthropogenic sources.

The result of the heavy metal pollution index and the metal index presented in this research work confirms the pollution of ground water resources in the study area, hence; the water is considered to be unsuitable for consumption without any prior treatments.

It is strongly recommended that one of the following treatment methods should be employed by either Government agencies or individual owners of bore holes and hand dug wells towards remedying the pollution effect of heavy metals contamination in Groundwater sources, these includes;

Chemical precipitation;

This involves the transformation of dissolved contaminants into insoluble solids, thereby facilitating the contaminant's subsequent removal from the liquid phase by physical methods, such as clarification and filtration (NEESA, 1993).

Ion exchange

Ion exchange is a reversible chemical reaction wherein an ion from water or wastewater solution is exchanged for a similarly charged ion attached to an immobile solid particle.

Reverse osmosis

Reverse Osmosis is a membrane process that acts as a molecular filter to remove over 99% of all dissolved minerals. In this process, water passes through the membrane while the dissolved and particulate matter is left behind. The process is very effective for removal of ionic species from solution. The resulting concentrated by-product solutions make eventual recovery of metals more feasible.

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