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COMPARATIVE ANALYSIS OF WATER QUALITY IN LOKOJA METROPOLIS FOR DRINKING AND AGRICULTURAL PURPOSES

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ABSTRACT

The quality and suitability of different water sources within Lokoja metropolis for drinking and irrigation purposes has been evaluated. A total of twelve (12) water samples from surface and subsurface water from selected points within Lokoja metropolis were analyzed for their physical and chemical parameters. Results indicate high concentrations of Fe, Pb and Cd in surface water whereas Sewage has high concentrations in total dissolved solid, Fe, Pb, Cd, NO_3^- and SO_4^{2-} species. The Hydrochemical facies study indicate that the surface water belongs to HCO_3-SO_4 and HCO_3-SO_4-NO_3 type while the groundwater is classified into Ca-HCO_3, Ca-Na-HCO_3 and HCO_3.This indicates cation exchange between groundwater and recently recharged meteoric water. It is recommended that proper waste disposal management be enforced to maintain the quality of the groundwater in the study area.

Keywords: Lokoja, wastes, water quality, water type

INTRODUCTION

Rain water enters unconfined aquifer and ends up as groundwater by infiltration through the soil profile. Groundwater is generally pure but may be polluted by the chemical elements with which it comes in contact during its journey to the underground storage. Surface water is highly prone to contamination especially in populated and industrial areas; by heavy metals such as arsenic, antimony, cadmium, chromium, copper, lead, selenium. According to Omofonmwan and Eseigbe (2009) the generation of waste from households, industries, farms, abattoirs and market due to improved standard of living resulted in the contamination of groundwater in Benin metropolis, Nigeria. Some water pollutants have local effect while others have widespread implications. Some pollutants are stable in the environment and hence, produce chronic effect after their ingestion for a protracted period of time. Others produce acute effect which manifest shortly after exposure to fairly high concentration (Miller, 1988).

Omada *et al*., (2009) studied the physico-chemical characteristics of surface water in parts of Lokoja metropolis, Central Nigeria and reported that in view of the uncontrolled disposal of wastes in the Adankolo and Kabawa areas of Lokoja, there was the need to constantly monitor the water quality in these areas. Further works have been undertaken to examine the effects of sewage from dumps on the quality of surface and ground water in the

Lokoja metropolis. Emphasis is laid on the concentrations of some major and minor elements in sewages and waste dumps to determine the nature of pollutants and contaminants. The water quality is also correlated with concentrations of these elements in surface and underground water in the area. The study area lies between longitudes $6^{0}44^{1}54.24^{11}$E to 6^{o} 44^{1} 19.38^{11}E and latitudes $7^{o}49^{1}$ 13.53^{11}N to 7^{0} 48^{1} 15.93^{11}N on sheet 247 Lokoja (Fig. 1). It is located within Lokoja Sub basin of the Bida Sedimentary Basin, Northcentral Nigeria.

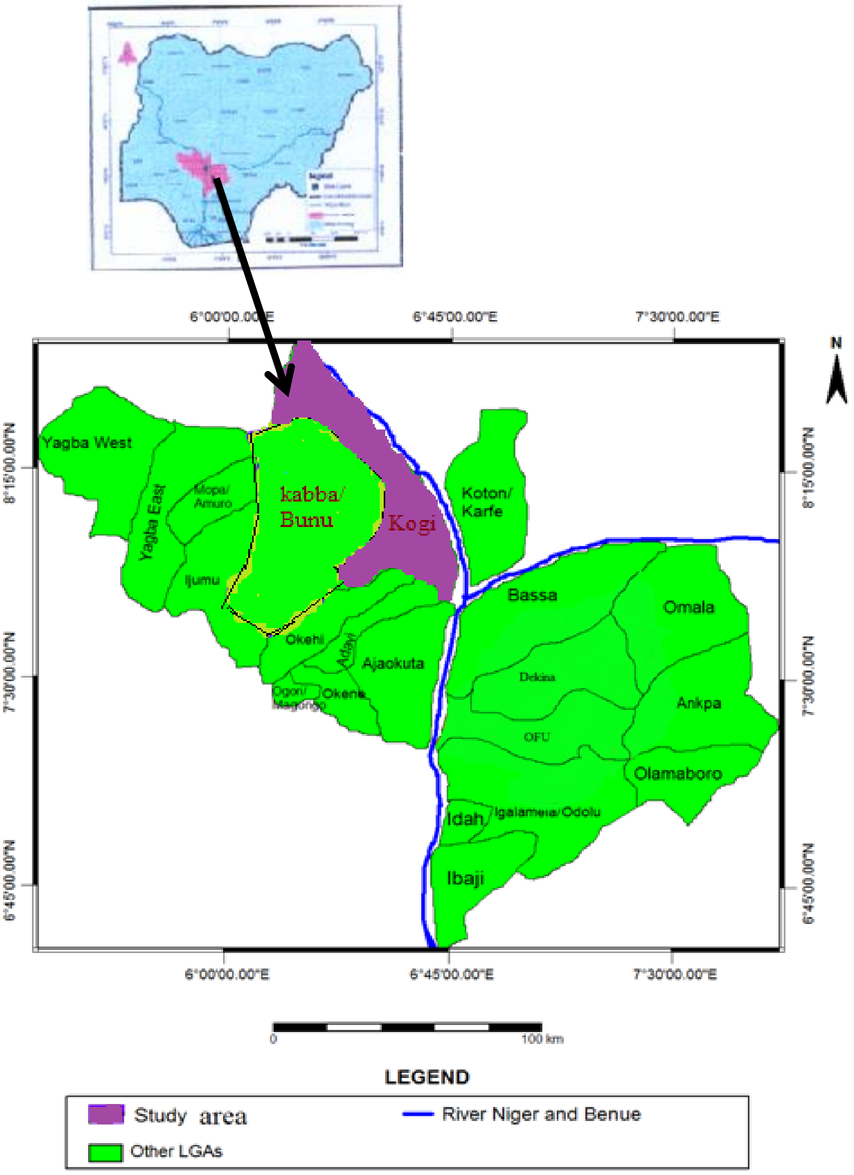

Fig. 1: Map of Kogi State showing the study area (Modified from Political Map of Kogi State, 2010).

Insert: Map of Nigeria showing Kogi State

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REGIONAL GEOLOGY

Lokoja metropolis is located on an undulating terrain of the Basement Complex overlain to the north by the sedimentary rock. (Omada *et al*., 2009). The Mid-Niger Basin is a NW-SE trending intracratonic sedimentary basin extending from Kontagora in Niger State to Lokoja in the south. The basin is a gently down wapped trough whose genesis may be closely connected with the Santonian orogenic movement of Southeastern Nigeria and the Benue Trough (Obaje, (2009). Jones (1958) subdivided the sediments into the Central or Northern Bida Sub basin and Southern Bida Sub basin. The Southern Bida Sub basin comprises the Campanian to Maastrichtian Lokoja Formation, the Patti Formation and the Agbaja
Ironstone (Adeleye and Dessauvagie, 1972) (Fig. 2).

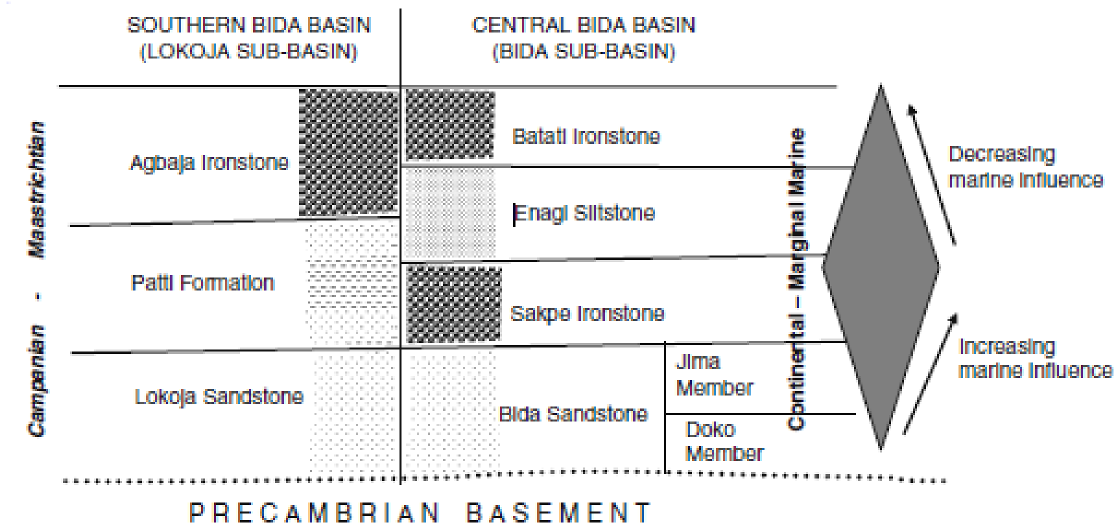

Fig. 2. Lithostratigraphic units of the Northern Bida Basin and the Southern Bida Basin. (after Akande *et al.*, 2005)

The Lokoja Formation is exposed between Lokoja and Koton-Karfe and was interpreted as a continental (alluvial fan) deposit (Adeleye 1989, Braide 1992). It is a lateral equivalent of the Bida sandstone in the Central or Northern Bida Sub basin which consists of conglomerates, coarse to fine grained sandstone, siltstone and claystone with sub-angular to sub-rounded pebbles (64-256mm in diameter). In addition, granular sized quartz grains are distributed in the clay matrix. Outcrops of the Patti Formation occur between Konto-Karfe and Abaji and consist of sandstone, siltstone, claystones and shale interbedded with bioturbated ironstone (Figure 3). The interbedded claystones are generally massive and kaolinitic, whereas the interbedded grey shales are carbonaceous. The sandstone units of the Patti Formation are texturally and minerologically matured compared to the Lokoja sandstone (Ojo, 1995). The Formation extends laterally into the Central or Northern Bida Sub basin to form the Sakpe Ironstone and Enagi Siltstone. The Agbaja Formation is the youngest oolitic ironstone unit in the Southern Bida Sub Basin and its lateral equivalent is the Batati Formation in the Central of Northern Bida Sub Basin (Figure 2). The Agbaja Formation consists of sandstone and claystone which is interbedded with oolitic, concretionary and massive ironstone beds (Abimbola *et al.*, 1997). The environment of deposition of the ironstone appeared to have been influenced by marine wave actions which reworked kaolinitic muds into concentric oolites commonly with nuclei of pyrite or siderite that are presently replaced by iron oxides.

Previous works on the hydrogeology of the studied area is very scanty. Some of the notable scholars who have worked within the area include"Omada, *et al.*, (2009) and Omali, (2014). They reported that the groundwater in Lokoja metropolis is stored in weathered regoliths and in fractured basement rocks within the area. Ayuba *et al.*, (2013), also reported that the groundwater chemical compositions of Lokoja metropolis are controlled predominantly by weathering of litho units of the basement rocks and by drainage from domestic wastes in the area.

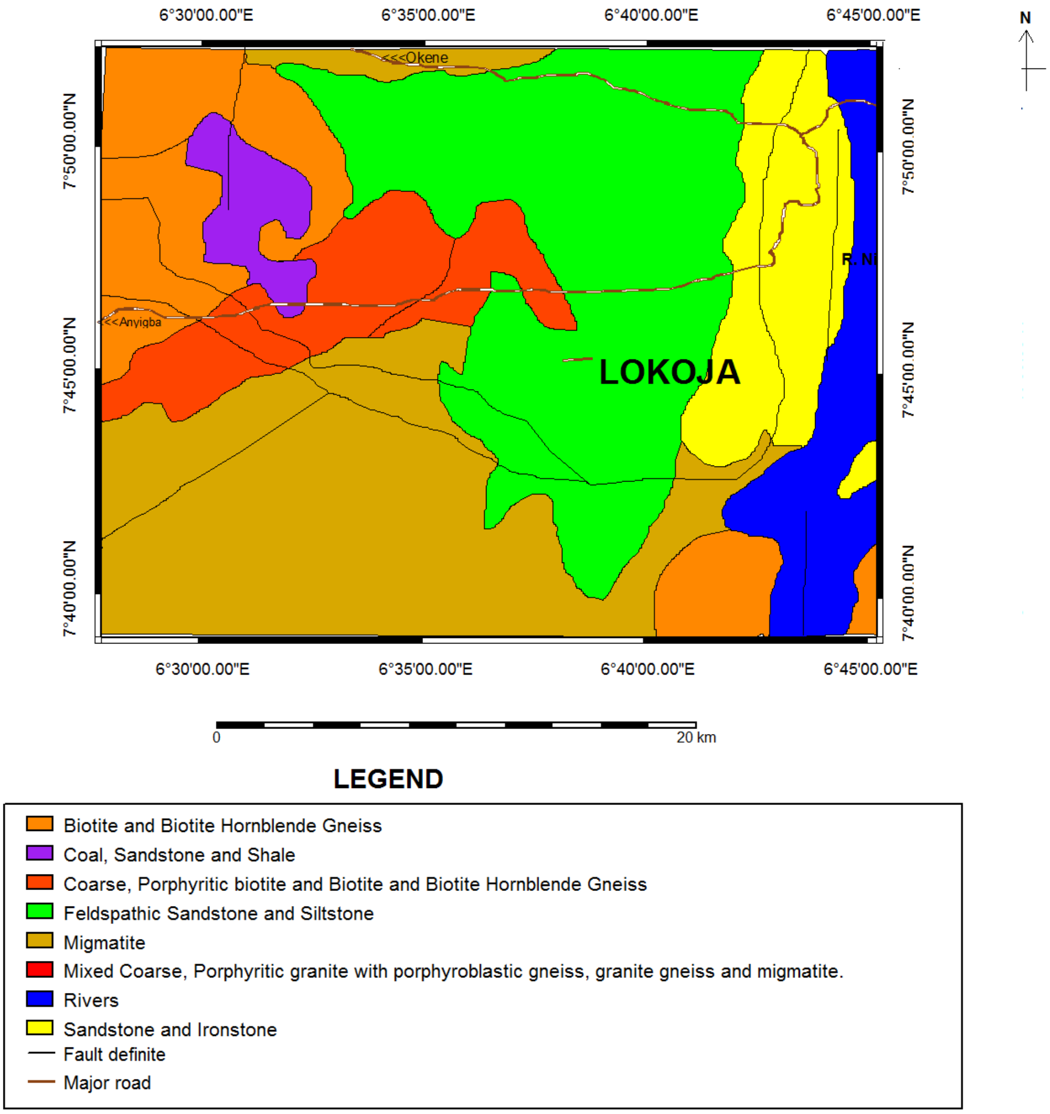

Figure 3: Geological Map of the Study Area (Odaudu, 2014)

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MATERIALS AND METHODS

Samples of surface water, ground water and effluents from industrial areas were studied. Sampling of surface water was done upstream in River Niger. The Samples were taken from five different locations at interval of 50 meters at locations where waste dumps directly recharge/ flow into the River Niger. Groundwater samples were obtained from hand-dug-wells and boreholes. Effluents were collected into a bottle from drainage channels flowing into the river directly. Each sampling bottle was allowed to get filled to the brim and capped. Parameters such as colour, temperature, pH, electrical conductivity, total dissolved solids (TDS) and dissolved oxygen (DO) were taken at each location in the field for water and effluent samples. In addition, 0.5 liters of water samples were taken for laboratory analyses. The samples were protected from heat and contamination by chemicals. Cationic compositions were determined using Atomic Absorption Spectrophotometer (model 210 VGP). The method of Anderson and Ingram (1989) was used for the determination of nitrate concentration in the research. In determining the suitability of groundwater for irrigation purpose, the percentage sodium (Na %), sodium adsorption ratio (SAR) and bicarbonate hazard of the water samples were calculated using the following equations from Ayers and Wescot (1994) :

$$\text{Percentage Sodium (Na \%)} = \left(\frac{Na^{+} + K^{+}}{\mathrm{Ca^{2+} + Mg^{2+} + Na^{+} + K^{+}}}\right) \times 100$$

$$\text{Sodium adsorption ratio (SAR)} = \frac{Na^{+}}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$

Bicarbonate hazard (meq/l) = $HCO_3^- - (Ca^{2+} + Mg^{2+})$

All ionic concentrations are expressed in mill equivalents per liter (meq/l).

Plate 1: (a) Sewage flowing into River Niger **(b)** Cattle being reared by the riverside **(c)** Poor waste disposal by the riverside **(d)** Mechanic workshop by the riverside.

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RESULTS AND DISCUSSION

Physical Characteristics

The average temperature of surface water, groundwater and sewage in the study is 27.70ºC. According to Ige and Olasheinde (2008) temperature values relatively keep ionization and dissolution at a low level. The water samples are light brown to colourless and dark brown. The average pH values are 6.58, 6.04 and 6.60 for surface water, ground water and sewage respectively. This means that pH value for surface water conforms to the WHO and SON standards while that of groundwater is acidic (Table 2). The average electrical conductivity increases from 0.34 µs/cm in surface water to 0.92µs/cm in groundwater and 1.02 µs/cm sewage samples. This trend is expected in view of the composite nature of the sewage which, among the three categories of samples, records the highest volume of total dissolved solids (TDS) of 721.50 mg/l (Table 1).Turbidity increases from 8.36 mg/l in ground water to 21.88 mg/l in surface water and 140.00 mg/l in sewage water (Table 2). Turbidity is higher in surface water than groundwater because of enrichment of the river by runoff from human settlements. The dissolved oxygen has least concentration in sewage with 3.87 mg/l, 4.94 mg/l in surface water and 6.75 mg/l in ground water (Table 2). Ayers and Wescot (1994) recorded the following ranges for suitability of water for irrigation with respect to physical parameters such as EC, TDS and pH.

Table 1: Guidelines of Water Quality for Irrigation (Ayers and Wescot 1994)

Parameters	No Restriction	Moderate Restriction	Severe Restriction
EC(µs/m)	< 0.7	0.7-3.0	>3.0
TDS(mg/l)	<450	450-2000	>2000
pH	Normal range: 6.5-8.4		

According to the guidelines presented in Table 1, all surface water samples analyzed are considered to have no restrictions for irrigation purposes (Table 2). However, all groundwater samples fall within the range of no restriction (LT1 and LT2) to moderate restrictions (LT3, LT4 and LT5) (Table 2). All sewage samples fall within the range of moderate restrictions for irrigation use. Surface water samples from LT1 and LT2 as well as all groundwater samples fall within the range with no restriction and are all considered safe for irrigation purposes.

The pH values for all the water samples fall within the normal range for irrigation purpose except the surface sample LT2 and groundwater samples LT1 and LT2 which fall below the normal range.

TABLE 2: Showing the Concentration of Different Parameters for Surface water, Groundwater and Sewage, from the Study Area with WHO and SON standards

	Surfacewater *						Groundwater *						Sewage *				
PARAMETER	(LTI)	(LT2)	(LT3)	(LT4)	(LT5)	Mean Value	(LTI)	(LT2)	(LT3)	(LT4)	(LT5)	Mean Value	S_1(LT2)	S_1(LT4)	Mean Value	1	2
Colour	Colourless	Colourless	Light brown	Light brown	Dark brown		Colourless	Colourless	Colourless	Colourless	Colourless		Light brown	Light brown			
Temp. °C	28.50	28.00	27.50	27.50	27.00	27.70	26.00	27.00	27.00	27.00	27.00	26.80	27.50	27.00	27.25		
PH	6.50	6.40	6.70	6.60	6.70	6.58	5.00	5.50	6.60	6.60	6.50	6.04	6.50	6.70	6.60	6.5-8.5	6.5-8.5
EC µs/cm	0.29	0.28	0.30	0.37	0.44	0.34	0.60	0.61	0.92	1.27	1.19	0.92	0.89	1.14	1.02		1000
Concentration in mg/l																	
TDS	429.00	436.00	600.00	949.00	462.00	575.20	225.00	201.00	232.00	258.00	200.00	223.20	636.00	807.00	721.50	500-1500	1500
Sus solid	4.50	5.50	4.49	4.87	3.00	4.47	0.90	0.90	0.30	0.50	0.30	0.58	25.00	28.00	26.50		
Turbidity	22.00	23.20	21.60	22.60	20.00	21.88	9.00	9.60	7.00	8.55	7.65	8.36	142.00	138.00	140.00		
Alkalinity	47.00	44.00	49.82	57.00	56.50	50.86	30.00	32.00	40.00	48.00	51.00	40.20	56.00	60.00	58.00		
T. Hardness	34.50	32.00	35.00	38.00	35.00	34.90	25.00	28.00	51.00	51.00	55.00	42.00	68.00	31.00	49.50		
Do	5.00	4.90	5.00	5.10	4.72	4.94	6.32	6.80	6.84	6.90	6.90	6.70	3.80	3.94	3.87		
Cations concentration in mg/l																	
Na	3.22	2.23	3.27	4.11	4.79	3.52	2.20	2.31	1.80	1.81	1.61	1.95	4.82	5.97	5.40	200	200
K	1.57	2.38	2.19	1.58	0.58	1.66	1.49	1.42	0.87	0.55	0.33	0.93	3.48	3.49	3.49		
Fe	0.42	0.51	0.29	0.34	0.29	0.37	0.12	0.14	0.13	0.13	0.09	0.12	0.44	0.41	0.43	0.30	0.30
Mg	0.25	0.25	0.23	0. 23	0.20	0.23	0.12	0.12	0.11	0.10	0.08	0.53	2.10	2.50	2.30	150	150
Zn	0.18	0.16	0.18	0.20	0.24	0.19	0.10	0.11	0.70	0.90	0.78	0.52	1.20	1.10	1.15	4.00	3.00
Ca	2.89	2.45	2.89	3.21	3.53	2.99	2.22	2.23	2.25	2.55	2.85	2.42	3.09	1.98	2.54	200	200
Pb	0.02	0.03	0.01	0.01	0.01	0.02	BDL	BDL	BDL	BDL	BDL	0.00	0.18	0.20	0.19	0.05	0.01
Cd	0.08	1.10	0.09	0.10	0.90	0.45	BDL	BDL	BDL	BDL	BDL	0.00	0.40	0.40	0.40	200	0.003
Anions concentration in mg/l																	
NO_3^-	15.00	15.20	17.22	18.23	20.23	17.18	1.40	1.56	1.25	0.92	1.35	1.30	98.6	102	100.30	70	50-70
F^-	2.14	2.04	2.00	1.82	1.00	1.80	0.52	0.68	0.70	0.77	0.87	0.71	2.28	2.2	2.24		
CO_3^-	5.60	5.40	4.90	4.50	3.72	4.82	0.30	0.38	0.30	0.30	0.28	0.31	6.70	7.10	6.90		400
HCO_3^-	44.00	42.00	40.00	37.00	33.00	39.20	69.00	72.00	45.00	37.00	20.00	48.60	84.00	85.00	84.50		600
PO_3^-	3.46	3.42	3.00	2.49	1.89	2.85	1.90	1.81	1.52	1.08	0.80	1.42	10.8	8.71	9.76		
Cl^-	1.92	1.68	1.46	1.28	0.87	1.44	0.50	0.56	0.40	0.46	0.22	0.43	12.2	9.72	10.96	400	300
SO_4^{2-}	29.00	27.00	22.00	17.00	14.23	21.85	8.20	8.25	5.23	3.20	3.00	5.58	122.00	118.00	120.00	250	100
Composition of anions and cations																	
Cl^-	0.69	0.63	0.58	0.56	0.43	2.89	0.12	0.13	0.15	0.21	65.00	65.61					
SO_4^-	7.69	7.51	6.49	5.49	5.17	32.34	1.49	1.43	1.45	1.09	0.65	6.11					
HCO_3^-	91.64	91.86	92.92	93.95	94.39	464.76	98.39	98.43	98.39	98.70	34.34	428.25					
Anions						499.99						499.97					
Ca^{2+}	36.76	40.66	39.91	40.22	42.36	199.91	1.09	1.09	0.14	1.51	0.93	3.76					
Mg^{2+}	5.24	6.84	5.24	4.80	3.90	26.02	97.58	97.55	98.77	97.39	43.21	434.5					
$Nat^+ + K^+$	57.99	52.50	54.86	55.03	53.68	274.06	1.32	1.35	1.10	1.10	55.88	60.75					

* This study 1) WHO 2011, World Health Organization, water standard maximum permissible limit

2) SON 2007, Standard Organization of Nigeria, water standard maximum permissible limit

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Hydrogeochemistry

Cationic Components

The average concentration of lead in samples of surface water is 0.02 mg/l and that of groundwater is below detection limit while that of sewage is 0.19 mg/l (Table 2). Though the average concentration of lead in surface water falls below the maximum permissible level for WHO standard of 0.05mg/l and higher than the maximum permissible level for SON standard of 0.01 mg/l (Table 2), the concentration in sewage is expected higher due to high density of population and presence of mechanic workshops in the study area (plate 1d). The concentration of zinc in surface water samples ranges from 0.01 mg/l to 0.24 mg/l with an average concentration of 0.19mg/l (Table 2) while groundwater samples have an average concentration of 0.52 mg/l and sewage has an average concentration of 1.15mg/l. The Zn concentrations for both surface water and groundwater samples fall below the maximum permissible level for WHO and SON standard of 4.00 mg/l and 3.00 mg/l, respectively. The average concentration of iron (Fe) in surface water is 0.37 mg/l while that of groundwater is 0.12mg/l and that of sewage is 0.43 mg/l. This concentration of Fe in surface water is slightly above WHO and SON limit of0.30mg/l (Table 2). This slight increase in surface water could be as a result of pollution from corroding metal in the study area (plate 1a, c and d). The average concentration of sodium (Na) in surface water is 3.52 mg/l, and 1.95 mg/l in groundwater while that of sewage is 5.40 mg/l (Table 2). The concentration of potassium (K) is 1.66 mg/l, 0.93mg/l and 3.49 mg/1 in surface, groundwater and sewage respectively. Calcium ranges in concentration from 2.99 mg/l in surface water to 2.42 mg/l in groundwater and 2.54 mg/1 in sewage (Table 2). Magnesium is low in the samples with 0. 23 mg/l and 0.53mg/l in surface water and groundwater, respectively and has an increase concentration of 2.30 mg/1 in sewage. The concentration of Na, K, Ca and Mg in both surface and ground water are below the maximum permissible limit for standard organization of Nigeria (SON) and the World Health World Health Organization (WHO) guideline for drinking water quality (Table 2).

Also the high concentration of Pb, Zn, Fe, Na, K and Mg in sewage are as a result of pollution from industrial wastes (plate 1c and d).

Anionic Components

The average concentration of fluoride in surface water is 1.80 mg/l while that in groundwater is 0.71 mg/l and that of sewage is 2.24 mg/1 (Table 2). Chloride concentration is 1.44 mg/l, 0.43 mg/l and 10.96 mg/1in surface, groundwater and sewage, respectively (Table 2). The concentration of chloride fall below the minimum permissible limit for WHO and SON standards. The low concentration of chloride in the samples analyzed could be attributable to dilution of this anion as a result of high volume of water. The average concentration of Nitrate in surface water is 17.18 mg/l, while that of groundwater is 1.30 mg/l and sewage is 100.30 mg/l (Table 2). The changes in the concentration of nitrate in groundwater could be as a result of feedlots and fertilizer entering into the environment as a result of development. High concentration of nitrate causes blue baby disease or methemoglobinemia which threatens the oxygen carrying capacity of the blood. The average concentration of phosphate in surface water is 2.85 mg/l, and groundwater is 1.42 mg/l while that of sewage is 9.76 mg/1(Table 2).Sulphate has an average concentration of 21.85 mg/l and 5.58mg/l for surface water and groundwater respectively. The concentration of sulphate in sewage is 120 mg/l. The concentrations of sulphate for surface water and groundwater are below WHO and SON standard of 100-250 mg/l. The average concentration of carbonate and bicarbonate (CO_3^- and HCO_3^-) in surface water is 4.82mg/l and 39.20mg/l respectively. Groundwater contains 0.31mg/l and 48.60mg/l of carbonate and bicarbonate, respectively, and sewage contains 6.90 mg/1 and 84.50 mg/1of carbonate and bicarbonate, respectively. These concentrations are below SON limit of 600mg/l.

Water Characteristics

Plots of the chemical composition of the groundwater in the study area on Piper's (1994) trilinear diagram indicates that sodium and calcium ions are the dominant cations while bicarbonate (HCO_3) is the dominant anions (Fig. 4).

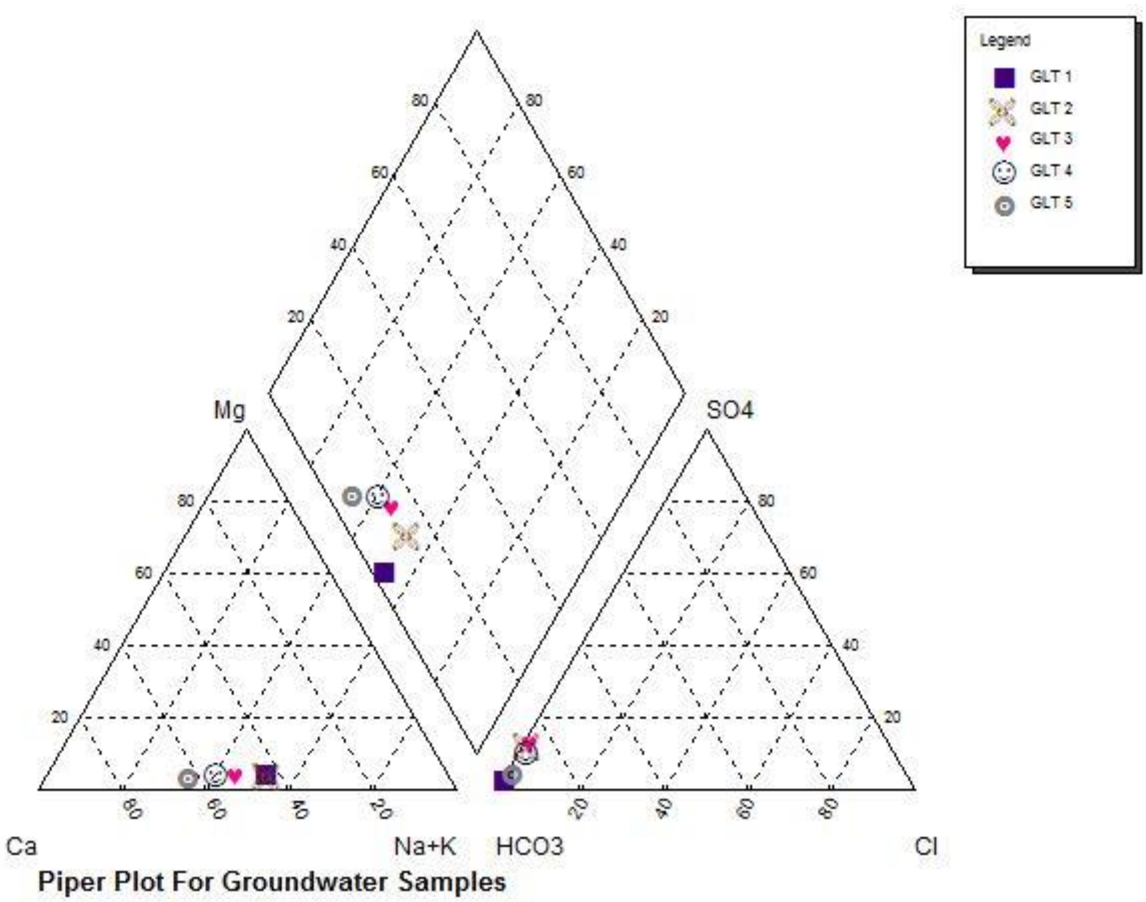

Fig. 4: Plots on Piper Trilinear diagram of Groundwater samples from study area (Modified after Piper 1994)

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The water samples therefore belong to six water types namely: HCO3-SO4, HCO3-SO4-NO3, SO4-HCO3-NO3, Ca-HCO3, Ca-Na-HCO3 and HCO3 water types.

The fact that water chemistry is a time dependent dynamic system (Olasehinde et al. 1998), it is required that regular monitoring of the water quality be undertaken at least once every year. This is to ensure protection of the groundwater which already is at risk of pollution. Figure 5 shows three clusters on the diamond component of the piper diagram.

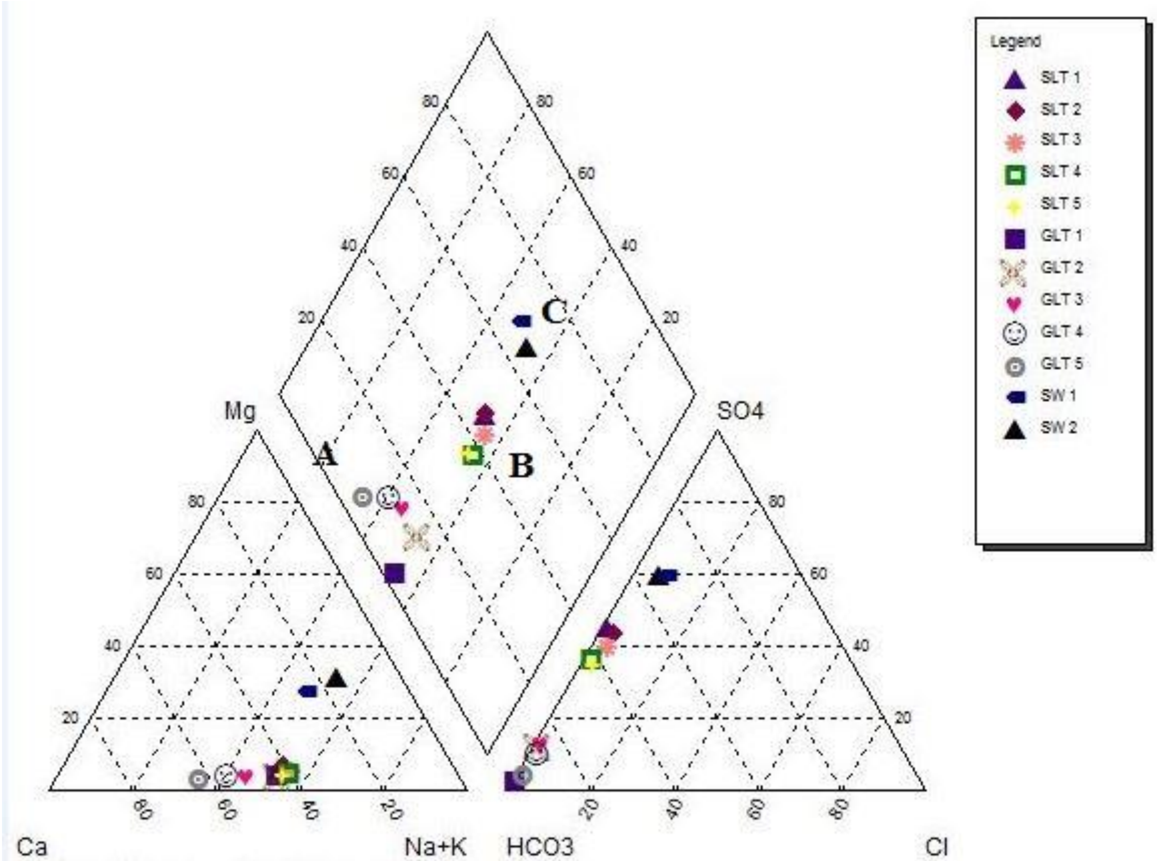

Fig. 5: Plots on Piper Trilinear diagram for all water samples analyzed (Modified after Piper 1994).

The First cluster (A) represent the ground water samples which are the least polluted, the second (B) represents surface water which shows more level of contamination and the third (C) which is sewage and as expected has the highest level of contamination. Groundwater in this area could gradually transformation from the A cluster position to B cluster and even C cluster. This should be avoided.

Correlation Matrix

There exists high positive correlation between Sodium and Potassium (0.64), Sodium and Magnesium (0.76), Sodium and Iron (0.62), Sodium and Copper (0.62), Sodium and Lead (0.70), Sodium and Fluoride (0.61), Sodium and Chloride (0.71) Sodium and carbonate (0.79), Sodium and Nitrate (0.83).

Table 3: Correlation Matrix for all water Samples analyzed

	TDS	Na	K	Ca	Mg	Fe	Cu	Zn	Cd	Pb	F	Cl	HCO3	CO3	NO3
TDS	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na		1.00	0.64	0.29	0.76	0.62	0.62	-0.29	-0.13	0.70	0.61	0.71	0.46	0.79	0.83
K			1.00	-0.20	0.83	0.73	0.73	-0.32	-0.11	0.86	0.83	0.84	0.75	0.80	0.84
Ca				1.00	-0.16	0.24	0.24	-0.09	-0.06	-0.52	0.12	-0.06	-0.48	0.27	-0.01
Mg					1.00	0.52	0.52	-0.15	-0.07	0.99	0.59	0.97	0.73	0.67	0.99
Fe						1.00	0.64	-0.31	0.35	0.40	0.91	0.54	0.25	0.95	0.61
Cu							1.00	-0.31	0.35	0.40	0.91	0.54	0.25	0.95	0.61
Zn								1.00	-0.06	0.98	-0.35	-0.14	-0.20	-0.34	-0.19
Cd									1.00	-0.02	-0.41	-0.02	-0.10	-0.16	-0.06
Pb										1.00	0.52	0.97	0.99	0.88	0.99
F											1.00	0.59	0.39	0.95	0.66
Cl												1.00	0.72	0.66	0.98
HCO3													1.00	0.31	0.68
CO3														1.00	0.75
NO3															1.00

Potassium is highly correlated with Magnesium (0.83), Iron (0.73), Lead (0.86), Fluoride (0.83), Chloride (0.84), Bicarbonate (0.75) carbonate (0.80) and nitrate (0.84).

Magnesium has high correlation with Iron, Copper, Lead, Fluoride, chloride, Bicarbonate, Carbonate and Nitrate with values of 0.52, 0.52, 0.99, 0.59, 0.97, 0.73, 0.67 and 0.99 respectively.

Iron has high correlation with Copper, Fluoride, Chloride, Carbonate and nitrate with values of 0.64, 0.91, 0.54, 0.95 and 0.61 respectively. Lead is in high positive correlation with Fluoride, Chloride, Bicarbonate and carbonate with values 0.52, 0.97, 0.99, 0.88 and 0.99 respectively. Chloride correlates positively with Bicarbonate (0.72), Carbonate (0.66) and Nitrate (0.98). Positive correlation also exists between Bicarbonate and Nitrate (0.68) and Carbonate/Nitrate (0.75). This positive correlation in Table 3 depicts that the ions in the water samples are probably derived from the same source.

Suitability of groundwater for irrigation purposes

The quality of water used for irrigation purpose is of great importance for crop productivity, soil maintenance and environmental protection (Tabue *et. al.*, 2012). In this research, bicarbonate hazard, sodium adsorption ratio (SAR) and percentage sodium (Na %) were used to determine the suitability/quality of surface water, groundwater as well as water from sewage within the study area for irrigation purposes. Table 4 shows the classification of water for irrigation purpose based on bicarbonate hazard, Na% and SAR.

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Table 4: Classification of groundwater based on Na %, SAR and bicarbonate hazard (source: Tabue *et. al.*, 2012)

Parameters	**Range (meq/l)**	**Class**
Na %	>200	Above max permissible limit
	20 – 40	Good
	<20	Excellent
SAR	20 – 40	Good
	40 – 60	Permissible
	60 – 80	Doubtful
	>80	Unsuitable
Bicarbonate hazard	0.00 – 1.25	Safe
	1.25 – 2.50	Marginal
	>2.50	Unsuitable

Table 5: Calculated values of bicarbonate hazard, percentage sodium and sodium adsorption ratio for groundwater

Water Type	Location	Na	K	Ca	Mg	HCO3			Bicarbonate
		meq/l	meq/l	meq/l	meq/l	meq/l	%Na	SAR	Hazard
SO4-HCO3-NO3	SW 2	0.26	0.09	0.1	0.21	1.39	53.03	0.66	1.08
HCO3	GLT 1	0.1	0.04	0.11	0.01	1.13	53.85	0.41	1.01
HCO3-SO4	GLT 2	0.1	0.04	0.11	0.01	1.18	53.85	0.41	1.06
HCO3	GLT 3	0.8	0.02	0.11	0.01	0.74	87.23	3.27	0.62
Ca-HCO3	GLT 4	0.08	0.01	0.13	0.01	0.61	39.13	0.30	0.47
Ca-Na-HCO3	GLT 5	0.07	0.01	0.14	0.01	0.33	34.78	0.26	0.18
HCO3-SO4	SLT 1`	0.14	0.04	0.14	0.02	0.72	52.94	0.49	0.56
HCO3-SO4	SLT 2	0.1	0.06	0.12	0.02	0.69	53.33	0.38	0.55
HCO3-SO4-NO3	SLT 3	0.14	0.06	0.14	0.02	0.66	55.56	0.49	0.5
HCO3-SO4-NO3	SLT 4	0.18	0.04	0.16	0.02	0.61	55.00	0.60	0.43
Na-Ca-HCO3-SO4-NO3	SLT 5	0.21	0.01	0.18	0.02	0.54	52.38	0.66	0.34
SO4-HCO3-NO3	SW 1	0.21	0.09	0.15	0.17	1.38	48.39	0.53	1.06

Percentage of Sodium (Na %)

The values of percentage sodium within the study area vary from 34.78 % to 87.23 % and are less than the maximum allowable limit of 200 % (Table 4). Two of the samples fall within the class of 20 to 40 Na % and are considered good for irrigation while the others have percentage sodium values above the 20 to 40 % class but are still below the maximum permissible limit of 200 (Tabue *et. al.*, 2012).

SAR for samples from the study area varies from 0.26 to 3.27. All water samples analyzed Table 5, have excellent quality with respect to sodium adsorption ratio. The use of water with high Na and low Ca, causes the ion exchange complex to become saturated with Na which could destroy the soil structure due to dispersion (Tabue *et. al.*, 2012).

All samples analyzed reveal that water from the study area have bicarbonate hazard below the threshold limits and are therefore suitable for irrigation with respect to this parameter. Water with bicarbonate hazard greater than 1.25 meq/l should not be used for irrigation except on very sandy, highly permeable soils or with some soil chemical amendments such as the application of gypsum.

CONCLUSION

The concentration of physical and chemical parameters of the study area fall within the permissible level of World Health Organization (WHO) 2011 and Standard Organization of Nigeria (SON) 2007 guidelines for drinking water quality with the exception of cadmium and lead. The high concentration of cadmium, lead, iron, nitrate, phosphate and sulphate in surface water and sewage than in groundwater is attributable to pollutions from the environment. Notable pollutants are cadmium (0.45 mg/l) and lead (0.02 mg/l) and may have been introduced from water pipes, batteries, paints, plastic stabilizers and landfill leachate in surface water. Phosphate and Nitrate averaging (2.85mg/l) and (17.18mg/l) respectively are higher in surface water than groundwater because of waste from fertilizer, sewage and human or farm animal waste. Sulphate with an average of 21.85mg/l could be as a result of mineral dissolution and domestic waste .Continuous pollution in the study area can lead to a steady increase in this element which could constitute health hazard in the near future. Based on Piper (1994) trilinear diagram, the surface water is classified as HCO3-SO4 and HCO3-SO4-NO3 type while the groundwater is classified into Ca-HCO3, Ca-Na-HCO3 and HCO3. All water types from Lokoja metropolis are considered suitable for irrigation with respect to Bicarbonate hazard, percentage sodium and Sodium absorption ratio. From the correlation matrix, we can conclude that the ions in the water samples are probably derived from the same source.

RECOMMENDATION

The authors recommend the need for proper refuse collection and disposal management in Lokoja metropolis in order to avert the long term risks of pollution that could arise due to run off and leaching of harmful chemical and germs from open dumps wastes. The Kogi State Environmental Protection Agency (KGSTEPA) should maintain regular and periodic surveillance, evaluation of pollution and contamination status of ground and surface water in the Lokoja metropolis periodically.

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