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The Effects of Liquid Wastes Disposal on Water Quality. A Case Study of Lokoja Metropolis Kogi State, North central, Nigeria.

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Abstract
The study area, Lokoja metropolis is the capital of Kogi state. As a result of commercial activities and developmental projects on going in the area, large liquid wastes are generated on the daily bases without any form of management and treatment at the risk of water bodies. In this study, water samples are taken from sources close to liquid wastes disposal points in order to evaluate the extent of contamination. WHO criteria and water quality index technique was used to evaluate the water samples. Water samples are taken from wells, surfaces and boreholes, prepared and stored in a refrigerator before being transferred to the laboratory for analysis. Physical elements (pH, TDS, EC, and Temperature) were analysed insitu, while the chemical elements were analysed using titration and Atomic absorption spectrometry. The results indicated pH of the water to be slightly acidic to alkaline (5.0 - 8.0), while the concentration of of E.C, TDS, Na, K, were generally low. The concentration of Ca (101- 306 mg/l) and Mg (107 – 215 mg/l are very high; this may be due to hardness of water. The concentration of SO_4^{2-}, HCO_3^-, Fe, Mn, As, Pb and Zn are below the WHO permissible limit. Elements like Co, Cr, Ni and Al, are below detectable levels. The water quality Index indicated that 80 % of the water in the area is good and portable.
Keywords
Liquid wastes, Disposal, Physico-Chemical, Property, Water Quality Index

I. INTRODUCTION

Kogi State was created in 1991 from parts of Kwara and Benue State and Lokoja was chosen as the State Capital. Lokoja was a historical city and once serves as the administrative headquarter of Nigeria. Lokoja is centrally located and it pride itself as the gate way state to the Federal Capital Territory, Abuja and it also share boundaries with other nine states. Being the state capital, it grew to become cosmopolitan in nature and host different tribes like Ebiras, Okuns, Igalas, Oworos, Nupes, Hausas, Bassas etc. The peoples live majorly along the confluence of river Niger and Benue. The inhabitants are majorly fisher men and farmers. Lokoja is also commercial in nature having Old Market, New Market, West Africa Ceramic industry, Quarries, Building and Construction Companies, Hotels notable among them: Confluence Beach Hotel and Kogi Hotel, Saw Mills, etc. As a result of human activities and the rapid development of the new state, enormous wastes (liquid and solid) are generated every day without adequate arrangement to evacuate it. The wastes Bin provided by the government are not evacuated on daily basis and at times; it is left to overflow to the major roads. The solid waste dump site at Felele is not well taken care of, it is only meant to burn the solid wastes without any other forms of treatment.

Thus, groundwater gets contaminated through the application of fertilizers and pesticides to farms. Even leaching from wastes dump site and septic tanks can find their ways into groundwater system therefore polluted it. The indiscriminate dumping of refuses in the study area couples with the Liquid wastes discharge as a bye product from processing industries, sewages from homes and markets without any form of treatments into the environments necessitates this study. The quality of both surface and groundwater in the study area varies greatly in terms of physical, chemical and biological characteristics as reported in the works of Rufai and Onwuka (2015); Chika et al.(2016); Aboh and Osazuwa (2000); Michael (1998); Graham et al.(2006); Ophori (2006); Adelana et al.(2005); Ugbaja and Edet; (2004); Adelana and Olasehinde (2003); Ofoma et al.(2003); Abimbola et al.(2002); Onsachi et al. (2018), Adelana et al.(2006); Edet and Okereke (2001) and Landnegger (1981).

Statement of the Problem

Water is life and is useful in domestic, agricultural, industrial and recreational activities; the end product of water uses is liquid waste or sewages. The problems that lead to this research are as follows:

(1) Absence of sewage systems to take care of liquid wastes in the study area.

(2) Large amount of industrial wastes are released into the environment and by extension surface and groundwater.

Aim of the Study

The aim of the research is to evaluate the composition of water samples from wells, Boreholes close to wastes dump sites by using Water Quality Index Techniques which are adopted by various authors Isiaku et al.,(2012); Omonona et al., (2014); Igwe and Idris, (2019) in other to classify groundwater as excellent, good, poor, very poor or unsuitable for drinking.

Objectives of the Study

(1) To update the geology of the area.

(2) Describe the distribution of physico-chemical in the surface and groundwater system.

(3) Classify water by using water quality index techniques.

Location, Accessibility and Relief of the Study Area.

Lokoja, the study area is located between latitudes $7^o\ 18^1\ 00^{11}$ - $7^o\ 51^1\ 30^{11}$ N and Longitudes $6^o\ 44^1\ 00^{11}$ and $6^o\ 45^1\ 00^{11}$ E with a total land area of 50 km^2. it share political boundaries with Niger, kwara and Nassarawa states respectively and the Federal Capital Territory to the North, Benue state to the East , Adavi and Okehi local government areas to the South and kabba Bunu to the West. In addition, table 1 depicted the locations and the co-ordinates of the sampling points.

The general relief is undulating and is characterized by high hills. The Niger-Benue trough is a Y-shaped lowland area which divides the sub-humid zone into three parts. The land rises from about 300meters along the Niger-Benue confluence reaching up to 600 meters above the sea level in the uplands. Lokoja is drained by river Niger and River Benue and their tributaries. It has been deeply dissected by erosion into the tabular hills separated by river valleys. The flood plains of the River Niger and Benue River valleys at Lokoja, is made up of hydromorphic soils which is a mixture of coarse alluvial and colloidal deposits. The alluvial soils along the valley of the river are sandy, while the adjoining laterite soils are deeply weathered and grey or reddish in colour. The soils are generally characterized by a sandy surface horizon overlying a weakly structured clay accumulation.

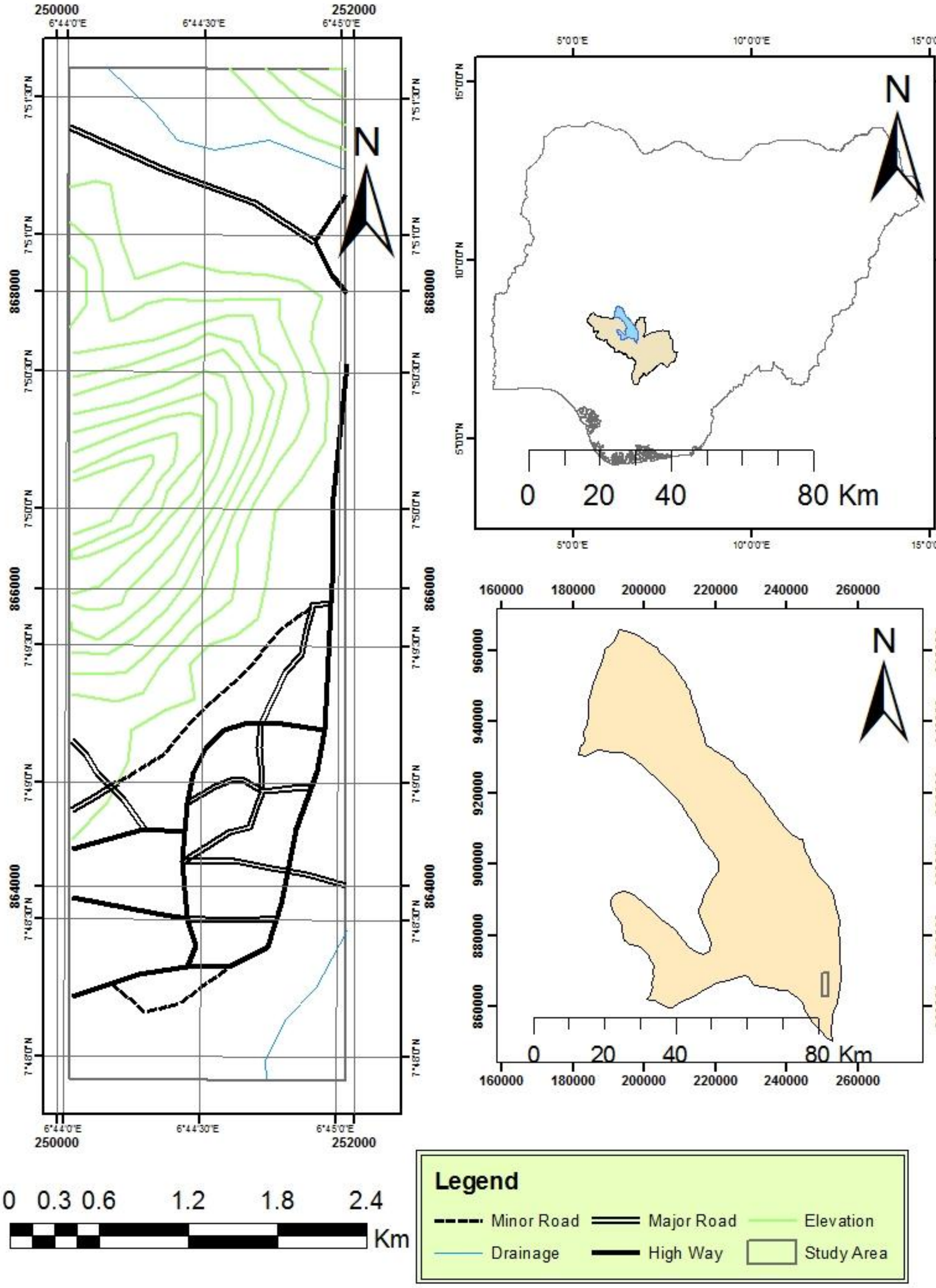

Fig. 1: Topographical Map of the Study Area and inset is the kogi state

Table 1: Locations and Co-ordinates of the Study Area.

S/no	Location	Latitude	Longitude	Elevation	Source
1	Federal University Permanent Site Junction (1)	006°41’82”	07°31’ 32”	127m	SW
2	Federal University Permanent Site Junction (2)	006°41’84”	07°30’ 33”	129m	SW
3	Federal University Permanent Site Junction (3)	006°41’84”	07°31’ 32”	126m	SW
4	Federal University Permanent Site Junction (4)	006°41’85”	07°31’ 33”	127m	SW
5	Felele (1)	006°43’ 39”	07°51’ 27”	78m	BH
6	Felele (2)	006°43’ 36”	07°51’ 27”	76m	BH
7	Felele (3)	006°44’37”	07°50’ 26”	74m	BH
8	Felele (4)	006°43’ 38”	07°51’ 27”	70m	BH
9	New motor pack (1)	006°42’ 43”	07°52’ 29”	76m	WW
10	New motor pack (2)	006°43’ 46”	07°51’ 29”	71m	WW
11	New motor pack (3)	006°43’ 44”	07°51’ 30”	71m	WW
12	New motor pack (4)	006°41’ 46”	07°51’ 29”	68m	WW
13	Kabawa (1)	006°44’ 82”	07°49’ 67”	44m	WW
14	Kabawa (2)	006°44’ 91”	07°49’ 67”	45m	WW
15	Kabawa (3)	006°44’ 93”	07°49’ 66”	44m	WW
16	Kabawa (4)	006°44’ 92”	07°49’ 67”	44m	WW
17	Apakariya Junction (1)	006°45’ 96”	07°49’ 38”	49m	SW
18	Apakariya Junction (2)	006°45’ 98”	07°49’ 38”	47m	SW
19	Apakariya Junction (3)	006°44’ 99”	07°49’ 38”	49m	SW
20	Apakariya Junction (4)	006°46’ 94”	07°49’ 38”	50m	SW
21	Kabawa Hausa (1)	006°45’ 87”	07°49’ 35”	53m	BH
22	Kabawa Hausa (2)	006°44’ 89”	07°49’ 35”	50m	BH
23	Kabawa Hausa (3)	006°44’ 90”	07°49’ 35”	56m	BH
24	Kabawa Hausa (4)	006°44’ 89”	07°49’ 39”	53m	BH
25	Natako Park (1)	006°42’ 77”	07°50’ 51”	45m	SW
26	Natako Park (2)	006°42’ 78”	07°51’ 51”	43m	SW
27	Natako Park (3)	006°42’ 79”	07°50’ 52”	43m	SW
28	Natako Park (4)	006°42’ 70”	07°50’ 51”	43m	SW
29	New Market (1)	006°45’ 79”	07°57’ 55”	45m	SW
30	New Market (2)	006°45’ 69”	07°53’ 55”	45m	SW
31	New Market (3)	006°45’ 72”	07°52’ 54”	45m	SW
32	New Market (4)	006°45’ 79”	07°49’ 58”	45m	SW
33	Kasara (1)	006°45’ 86”	07°50’ 56”	56m	SW
34	Kasara (2)	006°44’ 89”	07°51’ 56”	58m	SW
35	Kasara (3)	006°44’ 80”	07°51’ 56”	53m	SW
36	Kasara (4)	006°44’ 98”	07°52’ 56”	53m	SW
37	Old Market (1)	006°43’ 85”	07°49’ 80”	73m	WW
38	Old Market (2)	006°43’ 95”	07°51’ 80”	73m	WW
39	Old Market (3)	006°43’ 75”	07°51’ 80”	73m	WW
40	Old Market (4)	006°43’ 95”	07°51’ 80”	73m	WW

SS= Surface water, BH= Boreholes, WW=Well water

Geology of the Study Area

The study area is dominantly underlain by the Precambrian Basement Complex (Fig.3); however, part of the area is underlain by Cretaceous sediment which unconformably overlies the Basement Complex. Migmatite covers about half of the study area outcropping at the southwest, west, northwest and central parts of the area. The South and the southeast parts of the area are underlain by undifferentiated older granite, mainly porphyroblastic granite, granite gneiss with porphyroblastic gneiss and fine grained biotite granite. The northern part of the area is made of ridges (Mount Patti) of Cretaceous sediments of the Southern Bida Basin (Lokoja Sub- Basin). The ridges are dominantly composed of feldspathic sandstone and siltstone which are separated by the biotite hornblende gneiss. Thick alluvial deposit occurs around the Rivers Niger and Benue drainage system

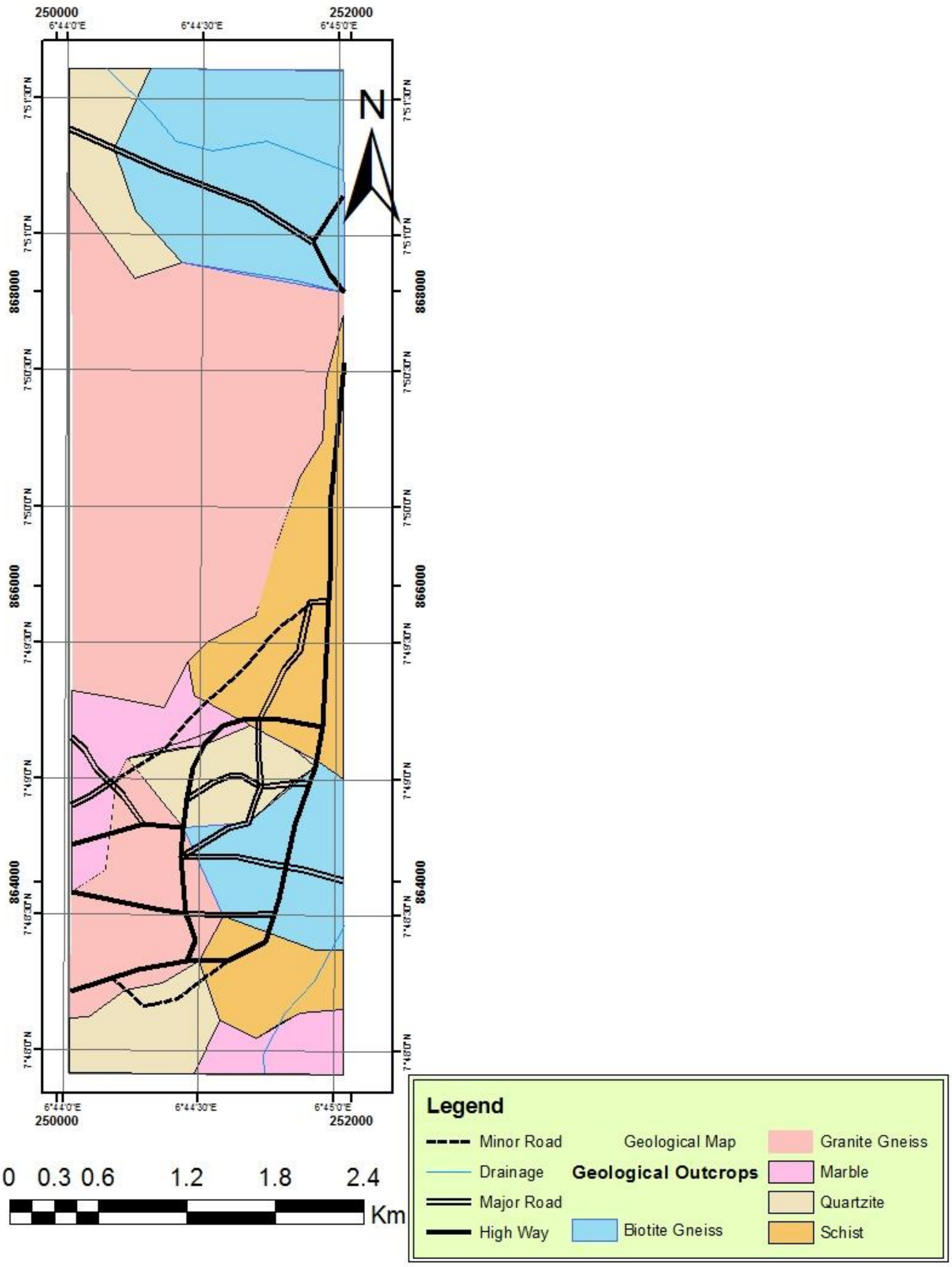

Fig. 3: Geological Map of the Study Area.

Hydrogeology of the Study Area

Lokoja, located in the plains of River Niger at the confluence with River Benue, falls within both the crystalline and sedimentary hydrogeological provinces but the study area sit on basement complex.

The study area contains the confluence point where River Niger and River Benue meet. The Niger River basin is 2.3million km^2 bound by latitudes 5°N and 23°N and longitudes 12°W and 17°E. The river rises in Guinea and flows for about 4,200 km through Mali, Niger and Nigeria before reaching the Atlantic Ocean. Its main tributary,

The Benue River flows west from the Cameroon and joins the Niger at Lokoja. Precipitation in the basin is variable. It ranges from 2,700 mm/yr close to the river mouth to almost none in the desert parts. Overall water balance shows that out of the 48,000 m^3/s of water that enters the Niger River basin through precipitation, 42,900m^3/s (89%) is lost in overland flow and 1,100 m^3/s (2%) in stream flow, leaving only 4,000 m^3/s (9%) at the river mouth.

The groundwater availability in crystalline rocks in the area is greatly dependent on the degree of weathering and fracturing of the rocks and the interconnectivity of the fractures. The area is generally drained by Rivers Niger, Benue and River Mimi, a tributary of River Niger. Aquifers found in this area are recharged directly by precipitation but can also be recharged by infiltration from Rivers Niger, Benue and Mimi. Groundwater abstraction is mainly by hand-dug wells, boreholes and from springs.

Table 5: Summary of Major ionic data in groundwater.

Parameter	Unit	Min.	Max.	Mean	SD	WHO[2014]
Temp.	o^c	28.0	31.9	29.96	0.88	Ambient
pH		5.00	8.0	6.72	0.76	6.5 – 8.50
EC	**µS/cm**	0.20	0.89	0.55	0.25	0.23 – 0.89
TDS	mg/l	418.00	623	510.97	52.00	418 – 623
Alkalinity	mg/l	8.20	12.6	10.33	1.24	50
Na^+	mg/l	49.99	87.54	66.35	11.4	20 – 200
K	mg/l	12.65	77.90	39.68	16.53	100
Ca^{2+}	mg/l	101.21	306.00	215.94	51.00	75
Mg^{2+}	Mg/l	107.89	215.32	138.68	24.23	20 – 50
Cl^-	mg/l	2.90	9.08	7.18	1.62	200
HCO_3^{2-}	mg/l	30.10	55.38	39.81	7.35	200
SO_4^{2-}	mg/l	1.48	6.00	2.45	1.08	100 – 200
NO_3^-	mg/l	0.49	1.00	0.73	0.20	50
Fe^{2+}	mg/l	0.01	0.04	0.02	0.01	0.3
Mn^{2+}	mg/l	0.01	0.03	0.01	0.005	0.001
As^{3+}	mg/l	0.01	0.14	0.02	0.02	0.01
Pb^{2+}	mg/l	0.01	0.13	0.03	0.03	0.01
Zn	Mg/l	0.001	0.017	0.02	0.104	-

Co, Cr, Cu, Ni, Al =BD (Below Detectable level).

Physico-chemical Properties of Water

Table 5 shows the summary of physico-chemical properties of groundwater in the study area. The temperature of groundwater in the study area varies between 28.0 ^{O}C – 31.9 ^{O}C with an average of 29.9 ^{O}C. The pH value ranges from 5.0 to 8.0 with standard deviation of 0.76. The pH of 5.0 shows that some groundwater in the area is slightly acidic. The electrical conductivity (EC) has a minimum value of 0.20 and a maximum value of 0.89 µs/cm with an average value of 0.55 µs/cm and standard deviation of 0.25. The values are within the WHO standard regulation for groundwater quality. The WHO range of total dissolved solid (TDS) is 418 – 623 mg/l. The mean value of 510.97 mg/l and standard deviation of 52.0 are within the permissible limits of WHO, indicated that the water is fresh. The Alkalinity of groundwater range from 8.20 – 12.6 mg/l, with standard deviation of 50.0 mg/l. The low alkalinity of groundwater in the area can be attributed to acidic nature of groundwater in the area. The sodium has minimum concentration of 49.99 mg/l, the maximum concentration is 87.54 mg/l, and standard deviation is 11.4 and these values lies within the WHO range of 20.0 – 200.0 mg/l. The minimum concentration (12.65 mg/l) and maximum concentration (77.90mg/l) of potassium are far below the 100 mg/l permissible limit of WHO. The minimum and maximum concentration of calcium in the groundwater are 101.21 mg/l and 306.0 mg/l respectively and are far higher than the 75.0 mg/l required by WHO for good quality water. The high concentration of calcium is due to the hardness of water. The concentration of magnesium range from 107.89 – 215.32 mg/l, average concentration is 138.68 mg/l, standard deviation is 24.23 and WHO range is 20 – 200 mg/l. The high concentration of magnesium is due to the application of animal manure and fertilizer. The concentration of chloride (2.9 – 9.0 mg/l) is far below the 200 mg/l required for good quality water. The bicarbonate concentration range from 30.1 – 55.38 mg/l with mean concentration of 39.81 mg/l, while the standard deviation is 7.35. The minimum, maximum, and the mean concentration of sulphates are 1.48mg/l, 6.0 mg/l, and 1.08 mg/l respectively. The standard deviation is 1.02, the WHO value range is 100.0 – 200.0 mg/l. The Iron (Fe), Manganese (Mn), Arsenic (As), Lead (Pb), and Zinc (Zn) are below the WHO permissible limit for good groundwater quality. The following elements: cobalt (Co), chromium (Cr), Nickel (Ni), and Aluminum (Al) are below the detectable levels.

Classification of water based on water quality index
Calculating Water Quality Index (WQI)

- Parameters are rated and assigned weights according to their benefits to man.
- To calculate WQI, the following 4 steps are involved
- Step 1: each of the parameters is assigned weight (wi) according to its relative importance in the overall quality of water for drinking.

S/N	Parameters	WHO Standard Mg/l	Weight (wi)	Relative weights (Wi)
1	pH	7.0 - 8.5	4	0.0577
2	Colour (pt.co.)	15	2	0.0338
3	Turbidity	5	2	0.0338
4	TDS (mg/l)	1500	5	0.0847
5	EC (µs/cm)	1000	4	0.0677
6	TSS (mg/l)	1000	2	0.0338
7	Hardness (mg/l)	NS	2	0.0338
8	BOD (mg/l)	6	3	0.0508
9	COD (mg/l)	10	2	0.0338
10	Nitrate (mg/l)	45	5	0.0847
11	Chromium (mg/l)	0.05	2	0.0338
12	Sulphate (mg/l)	200	5	0.0847
13	Calcium (mg/l)	75	3	0.0508
14	Iron (mg/l)	0.3	1	0.0169
15	Chloride (mg/l)	250	5	0.0847
16	Zinc (mg/l)	3	1	0.0169
17	Lead (mg/l)	0.01	2	0.0338
18	Nickel (mg/l)	0.02	3	0.0508
19	Copper (mg/l)	0.3	4	0.0677
20	Manganese (mg/l)	0.2	2	0.0338
			$\sum$ wi = 59	$\sum$ = 1.0000

Step 2: Calculating the relative weight, Wi:
wi is the weight assigned to the parameter, Wi is the relative weight of the elements, n is the numbers of parameters and is computed using the formula.

$$Wi = \frac{wi}{\sum_{i=1}^{n} wi} \qquad \text{Eqn. 1}$$

Step 3: Calculating quality rating:

$$Qi = \frac{Ci}{Si} \times 100 \qquad \text{Eqn. 3}$$

Where Qi = Quality rating,
Ci = Concentration of each chemical parameter in each water sample,
Si = Drinking water standard for each chemical parameter according a specified guide line.
Step 4: Calculating Sub Index.
Where Si = Sub Index of the i^{th} parameter

$$SIi = Wi \times Qi \qquad \text{Eqn.4}$$

The overall Water Quality Index (WQI) can be calculated by adding together each Sub Index values of the water samples as follows:

$$WQI = \sum SIi$$

Water types after, APHA 2018

Table 6: Water Quality Index and Quality of water.

S/N	Water Quality Index (WQI)	
1	< 50	Excellent water
2	50 – 100	Good
3	100 – 200	Poor
4	200 – 300	Very poor
5	> 300	Unfit for Drinking

Table 7: Water quality Index and classification of water quality in the Study Area.

Locations	Samples sources	WQI	Water types
FUL Felele (1 - 4)	Surface water	96.8 – 97.5	Good
Felele (1 – 4)	Boreholes	102.1 – 104.8	Poor
New Motor Pack (1-5)	Well water	81.95 – 83.06	Good
Kabbawa (1 -3)	Well water	167.01 – 168.94	Poor
Apakariya (1 – 4)	Well water	99.98 – 100.20	Good
Kabbawa Hausawa (1 – 8)	Boreholes	85.97 – 87.20	Good
New Market (1 -5)	Surface water	88.25 – 90.01	Good
Kasara (1 – 4)	Surface water	68.02 – 69.70	Good
Old market (1 – 4)	Well water	70.25 – 80.26	Good

Table 6 shows the classification of groundwater based on water quality index. The water samples taken from Felele which is out sketch of the town which serve as government approved dumpsite has water quality index (WQI) range of 102.1 – 104.8 which indicated poor water quality according to table 7. Water from wells located round Kabbawa (Old residential areas) has water quality index (WQI) range of 167.01 - 168.94 which also indicated poor groundwater quality. This may be due to indiscriminate dumping of refuses and poor sanitary habits of the peoples living in the area, since they lack modern sanitary system. Every other water samples taken from Federal University Lokoja Site, New Motor Park, Apakariya, Kabbawa Hausawa, New Market, Kasara and Old Market have water quality index that ranges between 68.0 – 98.0 which indicated good quality water.

The Effects of Liquid Wastes disposal on water quality.

The effects of liquid wastes disposal on water can be assessed based on water quality index which classify water into excellent, good, poor, very poor and unfit for drinking. The liquid wastes disposed did not have much adverse effects on the quality of water in the study area because:

(1) About 80 % of water in the study area falls under good classification

(2) The toxic metals which would have had adverse effects on the water and by extension on human's health were not present.

II. CONCLUSION AND RECOMMENDATION

Conclusion

Based on the analysis of chemical and physical elements, the water in the area is good for drinking and other domestic activities. The values of water quality index indicated good quality water. However, there are some recommendations to militate against likely effects of liquid wastes on water in the nearest future.

Recommendations

The following are the recommendations arising from this research:

(1) Indiscriminate dumping of refuse should be discouraged because it will pollute the environment and in the long run, contaminate the water bodies.

(2) Boreholes and wells should not be located close to dumpsites.

(3) Industries, Factories, quarries should endeavor to treat and manage their effluence discharge properly before being discharge to the environment.

(4) Penalty should be imposed on defaulters.

(5) House hold should be encouraged to own modern PWC system.

(6) Government should do more in waste evacuation.

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