ANALYSIS OF GROUNDWATER QUALITY AROUND SOME DUMPSITES IN JOS METROPOLIS, PLATEAU STATE, NIGERIA.

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Abstract

This study assessed groundwater quality around some dumpsites in Jos metropolis, Plateau State, Nigeria. Water samples were collected from sixteen (16) different wells at the peak period of both dry and rainy seasons from three (3) strategic areas that have major dumpsites in Jos. Six were taken within (0-30 meters) to dumpsites and the other ten far away (30-150 meters) from the dumpsites, physico-chemical properties of groundwater samples was analyzed in the laboratory. Two basic laboratory techniques were used, that is,: the gravimetric and volumetric techniques, parameters analyzed in the laboratory include, Biological Oxygen Demand, Total Dissolved Solid, Chloride, pH, Turbidity, Iron, Nitrate, Electrical conductivity, E.coli. The results obtained (mean values) were compared with the World Health Organization and Nigerian Standards for drinking water quality. The concentrations of the analyzed parameters for the dumpsite leachate were generally above WHO and NSDWQ standards, indicating that the leachate could contaminate groundwater. From the findings of the research it was discovered that many wells in the study area located close to the dumpsite (0-30 meters) have levels of concentration of pollutants of physico- chemical (in wells close to dumpsites) compared to wells far from dumpsites < 30m. Generally, the concentrations of the analyzed parameters decreased with increasing distance from the dumpsite, indicating that the groundwater sources closer to the dumpsite are at higher risk of getting contaminated than those farther away from the dumpsite as indicated by the values of Water Quality Index (WQI) for samples close to and far from dumpsites. The study recommended that adequate and proper planning, design and construction, and strategic management disposal of waste as well as dumpsite to be outlawed and provision of modern sanitary landfills be provided to ameliorate and alleviate the incessant groundwater contamination amongst others.

Keywords: *Groundwater, Water quality, Dumpsites, Pollutants, Leachate, Physico-chemical properties*

INTRODUCTION

Water is a vital natural source and life originated from water about 3.2 billion year ago, as two third of any living organism consists of water and 90 percent of cell content is also water. Biochemical reactions in living organisms require an aqueous medium; therefore, water is important for the survival of living organisms. (Matta, 2015;Matta,2014). Water sources is generally categorized into two, that is, surface and groundwater. Where groundwater comprises water that exists beneath the land surface held within openings or pores of soil and geological formations. Trimmer (2000) defines groundwater as the water that naturally occurs in porous rock materials underground. Serra (2006) defines groundwater as that part of the subsurface water that is in the zone of saturation including underground stream, loosely all subsurface water as distinct from surface water. Similarly, Bellamy (2007) sees groundwater as the water beneath the surface of the ground within the zone of saturation consisting largely of surface water that has seeped and stays in porous rocks and can collect pollutants from surface water which drains rapidly, leaching pollutants from the surface. Richard (1999) affirms that groundwater is a source of fresh water that lies beneath the earth's surface and supplies wells and springs. Globally, groundwater tends to experience some level of contamination owing to leaching from waste dumps and industries (Mahananda, Mohanty & Behera, 2010). The contamination of groundwater comes from different sources in the environment which includeleachate from dumpsites, effluents from industries, abattoir activities and pesticides (Iornumbe & Onah, 2008) as well as from animal faecal discharges into surface and groundwater due to washing by rainfall (Oko, 2008). Groundwater quality comprises the physical, chemical and biological qualities (Phillips, Gerlach, Lauchnor, Mitchell, Cunningham & Spangler, 2013). The quality of groundwater resource depends on the management of human waste, the geology of an area as well as the natural physico-chemical characteristics of the catchments areas (Saba & Baba, 2004), It becomes polluted when its quality is disturbed, whether the physico-chemical or the biological water quality parameters. Hence, it is necessary to obtain physico-chemical and biological characteristics of the groundwater so as to compare and monitor water quality and to determine the type of treatment that may be required before use.

Much has been written on the quality of groundwater, the impact of dumpsite leachate on the surface and groundwater has given rise to a number of studies in recent years (Mor, Ravindra, Dahiya & Chandra, 2006). These include a study by Adebibu, (1985) on the quality assessment of groundwater in the vicinity of dumpsites in Lagos, Nigeria. Akinbile (2012), who worked on environmental impact of leachate pollution on groundwater supplies in Akure, Nigeria. Mohammed (2011), in his study on the effects of refuse dumps on groundwater quality in Minna, Niger State, Afolayan, Ogundele & Odewumi, (2012) also conducted a study on hydrological implication of solid waste disposal on groundwater quality in urbanized area of Lagos State, Nigeria. Yaya & Okafor (2010) also analyzed the microbial status of groundwater and surface water in the federal capital city of Nigeria (Abuja) taking samples during the dry season and rainy season. All the studies conducted on groundwater quality from the review done where conducted outside Jos, except for a study by Beka, Aga & Eziashi (2009) that was conducted in Jos metropolis, the study conducted by Beka et al (2009) analyzed the chemical quality of Groundwater from hand dug wells in Jos metropolis and environs, similarly, Ramadan, (2017) study on water quality assessment of wyitt and environs, part of Jos-Bukuru metropolis, while this study analyzed the quality of groundwater around three major dumpsites within Jos metropolis. Such a study therefore, to the best knowledge of the researcher has not been carried out using three dumpsites as reference points. The city of Jos with its teeming population has outstripped the ability of the State Water Board to supply and distribute portable water. It therefore relies mostly on bore holes and hand dug wells for its water needs, areas near waste dumpsites have great possibility of groundwater contamination because of the potential pollution source of leachate originating from the nearby site. Such contamination of groundwater resource poses a substantial risk to local resource users and to the natural environment, it is as a result of this that the study aimed at examining the groundwater quality around some dumpsites in Jos, Plateau state. It is therefore important to study the water quality in areas especially those around these dumpsites to examine its impact on groundwater quality

THE STUDY AREA

Jos metropolis is in the North Central geo-political zone of Nigeria with a population of about 900,000 residents based on the 2006 census and is the administrative capital of Plateau State. It is boundedby latitudes $9^{0}45^{'}3.4^{''}$N and $10^{0}0^{'}2.3^{''}$N and longitudes $8^{0}45^{'}$E and $9^{0}0^{'}1.2^{''}$E, with an approximate areal coverage of 496.1km^{2}(fig 1 & 2)) and it is accessible through numerous networks of tarred and untarred roads linking different communities. It is situated at an elevation of 4.062 ft (1.238m) above sea level.

Jos metropolis has a unique weather when compared to other states in Nigeria, it is the of weather that is described as tropical and is classified with a symbol Aw based on the Koppen classification of climate, the rainfall is described as orographic and convectional type, this is due to the location and the numerous hills found in the city of Jos. The average annual temperature is 22.8^{0}C, the average annual rainfall is 1400mm. the driest month is January with 0mm of rain, in July precipitation reaches its peak, with an average of 298mm.

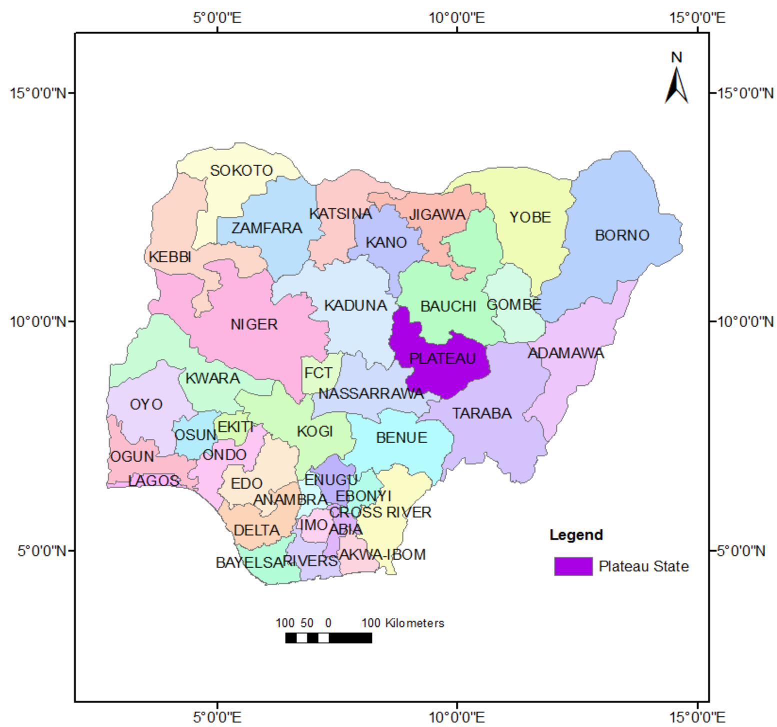

Figure 1: Nigeria Showing Plateau State
Source: Department of Geography and Planning, University of Jos, 2019.

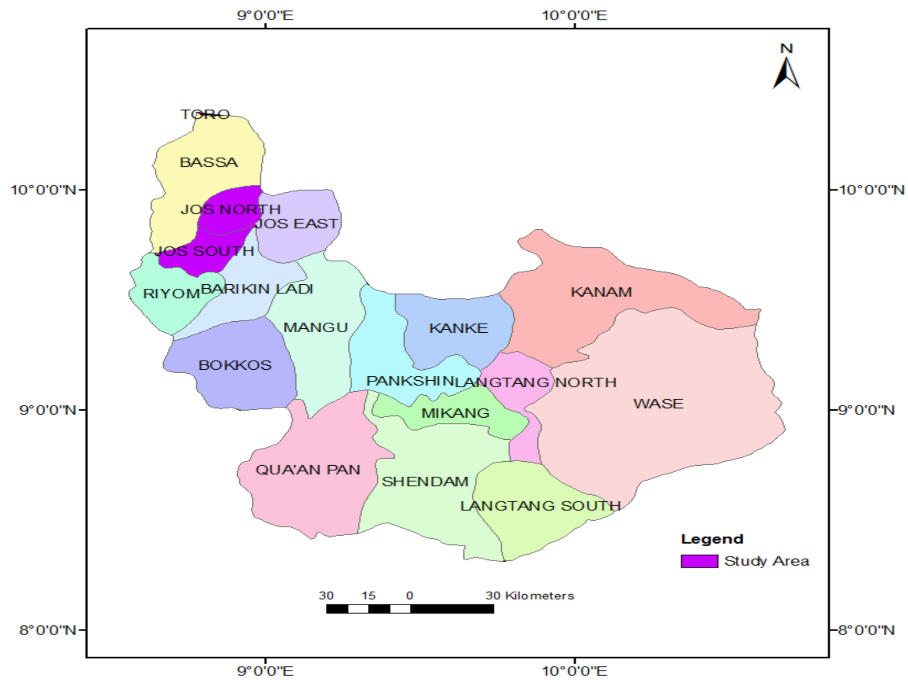

Figure2: Plateau state, Jos metropolis (Study Area)

Source: Department of Geography and Planning, University of Jos, 2019.

METHODOLOGY

This study employed the use of both primary and secondary data. The primary data sources were gotten from the field in the form of water samples. Groundwater samples were collected from sixteen wells in locations surrounding the dumpsites, the coordinates of each sampling point was taken using Garmin GPS 72H. Water samples were designated as BK 01- BK 05, JN 01 – JN 05, BSA 01- BSA 05 as shown on Table 1 and were immediately taken to the National Agency for Food and Drug Administration and Control(NAFDAC) for physicochemical analysis in NAFDAC laboratory in Kaduna and results were obtained for interpretation. While the secondary data were gotten from documents of government agencies such as Plateau Environmental Protection and Sanitation Agency (PEPSA), Plateau State Ministry of Lands, Survey and Town Planning, Plateau State Water Board amongst others. A total of thirty two samples were collected from one type of groundwater source in the area, that is sixteen groundwater samples was collected in the months of March (peak of dry season) and another sixteen groundwater samples was collected in the month of August (peak of rainy season). Purposive sampling was done at random. To collect the water samples, an approximate 1litre plastic bottle was used to collect the sample water. Each of the bottles was sterilized using methylated spirit, rinsed rigorously with the sample water, and properly labeled with ink and masking tape. Ice blocks were used to maintain the temperature of the water and to preserve them, because the cooler temperature helps contaminants from breaking down during transit. Laboratory results of groundwater samples were compared with the minimum permissible limits of World Health Organization and Nigeria Standards for Drinking Water Quality. Water quality Index for samples collected close to dumpsites and samples far from dumpsites was calculated using Water Quality Index (WQI).

Table 1: Points of Sample collection and Distance of Wells from Dumpsite in the Study Area in Meters

Sampling site	Sample code	Coordinates		Distance(m)
		Latitude (N)	**Longitude(E)**	
Jos South	BK 01	09^{0}48’19.2”N	008^{0}50’46.2”E	6.2m
	BK 02	09^{0}48’17”N	008^{0}50’41.9”E	6.4m
	BK 03	09^{0}48’18.2”N	008^{0}50’41.6”E	24.7m
	BK 04	09^{0}48’18.8”N	008^{0}50’41.5”E	37.1m
	BK 05	09^{0}48’19.6”N	008^{0}50’41.9”E	43.2m
Bassa	BSA 01	09^{0}55’17.7”N	008^{0}49’17.6”E	10m
	BSA 02	09^{0}55’15.3”N	008^{0}49’13.9”E	15.5m
	BSA 03	09^{0}55’22.8”N	008^{0}49’24.4”E	52.5m
	BSA 04	09^{0}55’21.6”N	008^{0}49’23.8”E	89.6m
	BSA 05	09^{0}55’22.4”N	008^{0}49’24.7”E	142m
Jos North	JN 01	09^{0}54’50.1”N	008^{0}53’44.5”E	6.2m
	JN 02	09^{0}54’51.4”N	008^{0}53’44.7”E	12m
	JN 03	09^{0}54’51.1”N	008^{0}53’45”E	24m
	JN 04	09^{0}54’49.9”N	008^{0}53’46.4”E	60m
	JN 05	09^{0}54’49.1”N	008^{0}53’46.9”E	77.2m

Source: Field survey 2019

RESULTS AND DISCUSSION

Tables 2 – 5 revealed that, Sampling point BSA 02 has high concentration of Nitrate (N0-3), higher than the WHO standard limits at the distance of 15.5m to the dumpsites. Concentration of pH was lower than the World Health Organization (WHO) standard in Bk 04 and Bk 05 within the range of 37.1m – 43.2m to the center. Therefore, spatial variation occurs within the examined variables. Concentrations of conductivity was higher further away from the waste dumpsites. Only nitrates, fluorides and chlorides adhered to the distance decay principle of reducing concentrations with increasing distance. All wells within the range of 24.7m – 142m to the center of the dumpsites, were not seriously affected.

Table 2: Mean Values of groundwater samples (collected in dry and rainy season) compared with WHO and NSDWQ Standards.

S/N	SAMPLIN CODES	pH	TDS (mg/l)	Turbidit (NTU)	BOD (ppm)	Fluorid (mg/l)	Nitrat (mg/l)	E.C (us/cm)	Iron (mg/l)	E.coli (cfu/ml)	Chlorid (mg/l)	
		6.5-8	**500**	**5**		**1.5**	**10**	**1000**	**0.3**		**250**	**WHO**
		6.5-8	**500**	**5**		**1.5**	**50**	**1000**	**0.3**		**250**	**NSDWQ**
1	BK 01	8.17	60	14.7	2.8	1.92	0.33	582.28	1.1	0	120.1	
2	BK 02	7.3	120	17.9	5.6	1.52	0.25	627.9	0.2	0	57.5	
3	BK 03	6.86	80	9.2	4.8	1.1	0.01	480.25	0.25	0	72.8	
4	BK 04	6.42	160	6.4	6.1	0.88	N.s	565.6	0.38	<10	46.6	
5	BK 05	5.9	100	5.9	2.2	0.8	N.s	720.29	0.08	<10	48.9	
6	JN 01	7.08	120	4.5	3.2	0.92	0.021	624.82	0.4	0	251.2	
7	JN 02	8.1	320	12.3	1.2	0.65	0.305	802.1	0.09	<10	122.1	
8	JN 03	7.45	180	14.9	1.6	1.48	0.26	729.5	0.88	0	80.5	
9	JN 04	6.8	60	16.8	2.6	1.2	N.s	498.07	0.12	0	78.8	
10	JN 05	7.21	80	8.8	2.9	1.35	0.013	820.68	0.26	0	27.3	
11	BSA 01	7.44	160	8.8	1.7	1.22	0.4	920.6	0.54	0	131.9	
12	BSA 02	6.22	210	26.8	2.5	1.66	0.405	430.52	0.18	<10	66.1	
13	BSA 03	6.82	80	20.8	2.8	1.8	0.203	582.82	0.15	0	46.6	
14	BSA 04	6.94	125	8.4	2.3	0.62	N.s	1206.9	0.65	0	24.5	
15	BSA 05	6.75	210	6.2	4	0.5	N.s	759.68	0.2	0	43.7	
16	C1 (Control)	6.83	100	19.2	3.8	1.2	N.s	561.7	0.1	0	65.4	

Source : Laboratory Analysis (2019)

Table 3: Parameter concentration with distance from Jos South dumpsite

S/N	Code	Distance	Parameters with high concentration
1	BK 01	6.2 m	Nitrate, iron
2	BK 02	6.4 m	BOD, fluoride, nitrate
3	BK 03	24.7 m	
4	BK 04	37.1 m	
5	BK 05	43.2 m	

Source: Field survey 2019

Table 4: Parameter concentration with distance from Jos North dumpsite

S/N	Code	Distance	Parameters with high concentration
1	JN 01	6.2 m	Chloride, iron
2	JN 02	12 m	Nitrate, iron
3	JN 03	24 m	
4	JN 04	60 m	
5	JN 05	77.2 m	

Source: Field survey 2019

Table 5: Parameter concentration with distance from Bassa dumpsite

S/N	Code	Distance	Parameters with high concentration
1	BSA 01	10 m	
2	BSA 02	15.5 m	Nitrate
3	BSA 03	52.5 m	
4	BSA 04	89.6 m	
5	BSA 05	142 m	

Source: Field survey 2019

Table 6: WQI for samples close to dumpsites(6m from dumpsites)

Parameters	Test Results (Vn)	Relative Weight (Wi)	Quality Rating (Qi)	Weighted Value {(Wi) *(Qi)}
Ph	6.8	0.04000	88.4	3.54
Turbidity	46.78	0.11764	6.66	0.784
BOD	27.32	0.03333	326.6	10.88
TDS	93	0.00200	24	0.048
Electrical Conductivity	624.7	0.13333	94.36	12.58
Nitrate	30.52	1.00000	2.8	2.8
Fluoride	30.9	1.00000	6	6
Chloride	0.626	0.02500	135	3.375
Iron	1.15	10.0000	121	1200
E- Coli	0.00	0.00000	0	0
		11.5513		1254.047

WQI* = =<u>1254.047</u>= *108.563
11.5513

Table 7: WQI of samples far from dumpsites (100m from dumpsites)

Parameters	Test Results (Vn)	Relative Weight (Wi)	Quality Rating (Qi)	Weighted Value {(Wi) *(Qi)}
pH	6.65	0.04000	88.4	3.54
Turbidity	23.4	0.11764	6.6	0.78
BOD	60	0.03333	50.0	1.6
TDS	80	0.00200	6.0	0.012
Electrical Conductivity	699.8	0.13333	44.79	15.971
Nitrate	30.0	1.00000	13	30
Fluoride	10.	0.10000	30.1	13.01
Chloride	1.70	0.00000	0	0
Iron	0.71	0.02500	55	1.375
E-Coli	0.0	0.00000	0	0
		1.0763		66.288

WQI* = <u>66.288</u>= *61.588
1.0763

Table 8: Water quality classification based on Arithmetic WQI method

WQI	Value Water Quality
0-50	Excellent
50-100	Good water
100-200	Poor water
200-300	Very poor water
>300	Water unsuitable for drinking

Source: Brown *et al.*, 1972

From the result of the laboratory analysis of groundwater samples in Jos South (table 2), the level of turbidity ranges from 5.9 – 17.9NTU, all the samples from BK 01 to 05 fall within the permissible limits of WHO standard (50NTU). In Jos north, the turbidity of the sampled wells varied from 4.5 to 16.8NTU which fall within the permissible limit of WHO, also the turbidity of the sampled wells in Bassa ranges from 6.2 to 26.8NTU which fall within the WHO acceptable limit.

The conductivity of the sampled water in Jos South were found to be between the range 480.25- 720.29 µs/cm, all the samples from BK 01 to 05 fall within the permissible limit of WHO standard (15000µs/cm). In Jos North the conductivity of the sampled wells fall within the permissible limit of WHO which ranges from 498.07 to 802.1µs/cm, the conductivity from the sampled wells in Bassa ranges between 430.52 to 1206.98µs/cm, all the samples BSA 01 to 05 fall within the permissible limit of WHO.

It was observed that the electric conductivity values have exhibited an increasing trend in some of the wells owing to the fact that the dissolution of salts, minerals and other soil constituents. Most of the inorganic salts such as NaCl, are responsible for the increasing the electrical conductivity values of groundwater systems.

From the result of the analysis of groundwater samples of the study area, Total Dissolved Solids (TDS) ranges from 60 – 160 mg/l, the TDS in Jos South with the sampling codes BK 01 to BK 05 falls within the permissible limit of WHO. Jos North with the sampling codes JN 01 to 05 fell within the permissible limit of WHO standard, TDS from the sampled wells ranges from 60 to 320 mg/l, Bassa with the sampling codes BSA 01 to 05 also fell within the permissible limit of WHO, TDS from the sampled wells in Bassa ranges from 80 to 210 mg/l

The pH of the sampled groundwater were found to be between the range of 5.9 – 8.17, two of the samples in Jos south (BK 05 and BK 04) do not meet up with the standard set by WHO (2011), it falls below the standard set by WHO, which makes the water acidic, but three of the samples (BK 01, 02 and 03) falls within the permissible limit of WHO. Jos North (JN 01 to 05) were found to be between the range of 6.8 to 8.1 which falls within the acceptable limit of WHO standard, one sample in Bassa with the sampling code BSA 02 fell below the standard set by WHO (2011) which makes it slightly acidic, but samples BSA 01, 03, 04 and 05 fell within the permissible limit of WHO standard.

From previous studies like that of Longe & Balogun (2010), it was discovered that the pH level of all the groundwater samples are generally acidic and were below the WHO and NSDWQ standard for potable water.

The concentration of iron in the sampled groundwater in Jos South ranges from 0.08 – 0.38mg/l, sample BK 02, 03 and 05 falls within the permissible limit of WHO standard, while sample BK 01 and 04 exceed the permissible limit of WHO standard. The concentration of iron in the sampled groundwater in Jos north ranges from 0.09 to 0.88 mg/l, samples JN 02, 04 and 05 fell within the permissible limit of WHO standard while samples JN 01 and 03 exceed the accepted limit of WHO, the samples collected at Bassa ranges from 0.15 to 0.65 mg/l, the samples BSA 02, 03 and 05 are within the permissible limit of WHO, while samples BSA 01 and 04 exceed the permissible limit of WHO (0.3 max). Iron is a lustrous, ductile, malleable, silver-gray metal. Its presence in human tissue for extended periods may cause conjunctivitis, choroditis and retinitis. A common problem for human is iron deficiency, which may lead to anemia. A man needs an average daily intake of 7mg of iron and a woman 11mg. Presence of Iron in water can lead to change of color of groundwater (Rowe, Quigley & Booker, 1995) and stain washed clothing (Adams, 2001),

The concentration of fluoride of the sampled groundwater in Jos South fall within the range of 0.8 – 1.92 mg/l, sample BK 03, 04 and 05 falls within the permissible limit of i.5mg/l of the WHO standards, while sample BK 01 and 02 exceed the accepted limit of WHO standard. Fluoride concentration in Jos North is within the range of 0.65 to 1.48 mg/l, all the samples JN 01 to 05 fell within the permissible limit of WHO standard, in Bassa, the fluoride concentration is within the range of 0.5 to 1.8 mg/l, samples BSA 01, 04 and 05 fall within the permissible limit of WHO, while BSA 02 and 03 exceed the permissible limit of WHO standard.

from the result of the analysis of groundwater samples in Jos South, the level of BOD ranges from 2.2 – 6.1mg/l. Samples BK05, 04 and 01 fall within the accepted limit 5.0mg/l of WHO standard, sample BK 02 and 03 exceed the permissible limit of WHO standard. In Jos North the level of BOD ranges from 1.2 to 2.9 mg/l, all the samples JN 01 to 05 fall within the permissible limit of WHO standard, from the result of the analysis, the level of BOD in Bassa ranges from 1.7 to 4 mg/l the samples BSA 01 to 05 fall within the WHO permissible limit.

From the result of the analysis, the concentration of chloride is within the range of 46.6-120.1mg/l in Jos South fall within the permissible limit of 250mg/l set by WHO (2011). In Jos North the concentration of chloride is within the range of 78.8-251.2 mg/l, samples JN 02, 03, 04 and 05 fall within the permissible limit of WH0, while sample JN 01 exceed the permissible standard set by WHO, the concentration of chloride in Bassa fall within the range of 24.5-66.1 mg/l, therefore the sampled groundwater in Bassa fall within the permissible limit of WHO standard.

The groundwater sampled in Jos South ranges within 0-<10 cfu/ml, samples BK 01, 02, and 03 fall within the permissible limit of WHO, while sample BK 04 and 05 exceeds the permissible limit by WHO (0 max). In Jos North, the concentration of E.coli ranges from 0-<10 cfu/ml, four of the samples with the code JN 01, 03, 04 and 05 fall within the permissible limit of WHO, and sample JN 02 exceed the permissible limit, in Bassa, the samples fall within the range of 0-<10 cfu/ml, samples with the code BSA 01, 03, 04 and 05 fall within the permissible limit while sample BSA 02 exceed the permissible limit of WHO standard.

The concentration of the nitrate found in groundwater in Jos South is within the range of 0.01 -0.33ppm, samples BK 01 and 02 exceed the permissible limit of WHO, BK 03 fall within the acceptable limit while BK 04 and 05 are not significant, that of Jos North is within the range of 0.013 – 0.305 mg/l, sample JN 02, and 03 exceed the permissible limit of WHO, sample JN 01 and 05 fall within the permissible limit of WHO and sample JN 04 is not significant. The concentration of nitrate in Bassa ranges from 0.203-0.405, samples BSA 01,02 and 03 exceed the permissible limit of WHO, while samples BSA 04 and 05 are not significant.

From the previous studies conducted, these studies only focused on physico-chemical qualities of well water, researchers such as Beka et al (2009), Balogun & Longe (2008). Lasisi (2011), Afolayan, Ogundele & Odewumi (2012), Akibile (2012) as well as Yusuf (2012) also analyzed physico-chemical well water properties and heavy metal concentration. The research conducted in previous studies was based only on well water concentration, while this research went further to test for the significant difference between the obtained results and that of World Health Organization and it was conducted around selected dumpsites in Jos metropolis.

The study of Balogun & Longe (2008) revealed that the concentration of hydrogen ion (pH) increased from 6.13mg/l in 2008 to 7.22mg/l in 2011, there was a reduction (17.21%) in 2012 to 6.16mg/l. Mean concentration of dissolved oxygen increased from 3.19mg/l in 2008 to 3.87mg/l in 2011. A further increase (21.02%) was recorded in 2012. Nitrates both increased by 48.31% respectively. Of the heavy metals, Iron increased (75%) from 0.01mg/l to 0.04mg/l between 2011 and 2012, while recording a significant drop from 0.08mg/l to 0.01mg/l in the three years period between 2008 and 2011. From the above analysis, heavy metals have a tendency to be significantly depleted over a 3-year period.

In the study carried out by Beka et al (2009), the results showed that the nitrate concentration were noticed to be predominant within the most developed areas resulting from sewage and waste dumpsites.

Similarly, the Water Quality Index (WQI) analysis carried out for the groundwater samples in the study area revealed that most samples exhibited poor water quality as such considered unfit for drinking, the results from Water Quality Index on tables 6, 7 and 8 rates samples close to dumpsites, with a distance of 6 metres from dumpsites as poor with a score of 108.563 and samples far from dumpsites with a distance of 100 metres from dumpsites were rated good with a score of 61.588. The findings here is line with a study by Akinbile & Yusoff, (2011) analyzed water quality of selected wells around dumpsites in Akure, the study randomly collected samples from nine (9) different wells and concentration levels of ten (10) physico-chemical parameters were determined to ascertain how fit groundwater in the area is for human consumption. Laboratory analysis of samples and inferential statistics was used to determine the difference between the laboratory values of the samples and World Health Organization standards for drinking water. The results revealed that there was significant difference between the levels of concentration of the selected parameters of samples and World Health Organization standards for drinking water. The study recommended that water from open hand dug wells in the area should be treated before human consumption.

CONCLUSION

Groundwater is a universally valuable renewable resource for human life and economic development. Growth and development on the earth surface has rendered fresh water particularly groundwater of certain areas of the world useless despite its availability in large quantity. The study observes indiscernible migration of decomposed waste into leachate from the base of the dumpsite to be the point source of groundwater pollution. This obviously limits groundwater functions for various purposes (such as domestic, industrial and agriculture). Implication of the groundwater pollution could also be attributed to different health related problems.

The results obtained from this study shows that the groundwater of Jos metropolis is not totally pure. A high level of contamination was recorded for some of the parameters that were analyzed. It can therefore be concluded that the groundwater of the study area especially wells close to dumpsites is not good enough for direct consumption following evidence of high concentration of BOD, iron, nitrate, fluoride, and E.coli in most of the wells.

From the result obtained in the analysis, it can also be said that dumpsites alone is responsible for groundwater contamination of the study area, because the parameters tested from the samples collected at the control point all fall within the acceptable limit of the World Health Organization.

RECOMMENDATIONS

Toward the control of groundwater vulnerability to pollution through waste dumpsites, there is need for adequate and proper planning, design and construction, and strategic management disposal of waste. Ordinary landfills or dumpsites need to be outlawed and provision of modern sanitary landfills should be provided to ameliorate and alleviate the incessant groundwater contamination.

Government is to locate new waste dumpsites away from the general population to avoid contamination of their water supply. There is also a need for public awareness about the specific purpose of which the groundwater in the study area can be used for and incase of domestic use, necessary purification methods should be applied for health safety.

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