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CHEMICAL SPECIATION OF SOME HEAVY METALS AND HUMAN HEALTH RISK ASSESSMENT IN WATER AROUND MUNICIPAL DUMPSITES IN JOS, BUKURU AND RAYFIELD, PLATEAU STATE, NIGERIA

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ABSTRACT

The impact of solid waste disposal on water quality is gaining importance worldwide due to seepage of toxic metals through the soil into the groundwater. Urbanization, industrialization and changes in our life styles have compounded the problem of solid waste management in Nigeria. Poor waste management threatens the health of humans and animals, particularly those living close to these pollution point sources.The study area covers Jos-Bukuru and environs in North Central Nigeria. This study was aimed at investigating the chemical species present in groundwater as a result of the impact of solid waste dumpsites in the study area and to evaluate the contributions of the dumpsites to the chemical and physicochemical properties of groundwater around the dumps. Five (5) major dumpsites (Bauchi Road Jos, Rukuba Road Jos, Building Materials Market, Rayfield and Bukuru Town) were sampled for this study. Ten water samples from hand dug wells (two from each site) close to the dumpsites and three controls were collected and analysed for chemical composition and further speciation analysis was conducted on the chemical result to assess the various species present in the waters and possible human health related issues. Results show that the mean values of the pH, temperature, EC, TDS, of the water samples all fall within the WHO permissible limits for portable drinking water. Content of trace elements are generally low in the waters but toxic metal species such as Ba^{+2}, Mn^{+2}, Ni^{+2}, Zn^{+2}, Cd^{+2}, and Pb^{+2} are common to all the water sources. This study shows that different dumpsites have impacted differently on waters in their different environments. There is the need to curtail the excesses of dumping waste in these areas so as not to add to the exiting contents of toxic metal species in the waters.

Keywords: Solid Waste Dumpsites, Water Quality, Chemical Species, Mineral Phases and Health.

INTRODUCTION

Water contamination with heavy metals is potentially damaging to the ecosystem (Chai et al., 2007) and this is because unlike organic pollutants, metals cannot be biodegradable and their residence time in different medium can be thousands of years. This therefore implies that a better understanding and evaluation of the distribution and potential hazards of heavy metals in municipal solid waste dumpsites are increasingly needed to ensure the safety of the environment (Ekere et al. 2020).

Solid waste management has become a serious environmental problem and a major growing concern for urban areas, especially in the developing parts of the world (Abdus-Salam, 2009, Nwofe, 2015, Ebikapade &Jim, 2016, The World Bank 2022). In most of the developing countries, it is a common view to find huge waste dumps within the residential and industrial areas and on minor and major roads owing to inadequate regulatory bodies and enforcement system. This practice constitutes serious health and environmental concern due to the phytotoxicity effect of these metals to plants and animals (Ellis & Salt, 2003, Jarup, 2003). Thus waste deposited at open dumpsites and poorly managed, waste creates a number of adverse environmental impacts including leachate, which could pollute soil and groundwater (Ideriah et al., 2004). Leachates from dumpsites are said to be of particular interest when it contains potentially toxic heavy metals like Zn, Cu, Pb, Cd, Ni, Co and Mn. (Odukoya & Abimbola, 2010). These metals are known to bioaccumulate in soil and water and have long persistence time and consequently enter the food chain (Vasiliadou & Dordas, 2009).

However, it is generally recognized that the particular behavior of trace metals in the environment is determined by their specific chemical forms rather than their total concentration because knowledge of the total concentration of heavy metals present in soil and water provides limited information about their potential behavior and bioavailability (Tessier et al., 1979, Hu et al., 2011 & Kotoky et al., 2003).

Chronic low-level intake of heavy metals may deplete body stores of iron and vitamin C, induce anemia and immunosuppression, promote renal damage and neuro-toxicity, generate vascular complications, and lead to epidermal hyperpigmentation and keratosis (Yu et al., 2006, Navarro & Rohan, 2007 & Mishra, 2009). These manifestations are detrimental to human health due to the severity and irreversibility of the damaged invoked upon the individual and the prolonged period of time required for producing clinical symptoms. Moreover, exposure to heavy metals such as Cd, As and Pb may induce carcinogenesis of various organs including the liver, lungs, bladder and skin (Mishra, 2009 & Wasserman et al., 2008).

Many works have been carried out on the speciation of heavy metals in soils and groundwater in different parts of Nigeria but little data is available regarding the chemical forms and health risk of heavy metals in groundwater around municipal dumpsites in Jos, Bukuru, Rayfield and environs, North Central Nigeria. In view of these, it was necessary to carry out this research within the study area to access the various chemical species of some toxic heavy metals in groundwater around some dumpsites of the study area.

MATERIALS AND METHODS

Description of the Study Area

The study area is part of the Jos-Bukuru Metropolis in Plateau State, North Central Nigeria. The area covers parts of Jos North, Rayfield and Bukuru (Fig. 1 & 2)

Geographically the area falls between latitudes $9^0$41’37.41” and $9^0$59’48.48”N and longitudes $8^0$44’57.24” and $8^0$56’23.45”E of Naraguta Sheet 168NE covering an area extent of about 660km^2 within the Younger Granite Province of Nigeria.

The climate of the study area has two main seasons; the wet or rainy season and the dry season which is typical of the tropical climate. The wet season comes between April and November with its peak in July and August. The dry season on the other hand comes between the months of November and March with relative low humility of about 25% (Udo 1970).

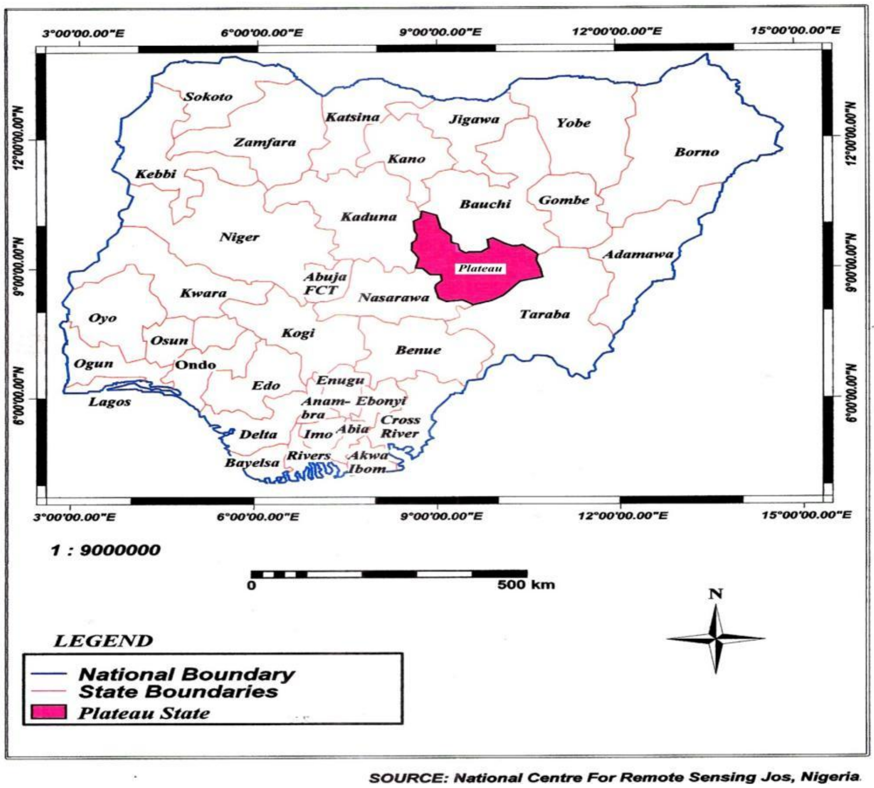

Figure 1: Map of Nigeria Showing Plateau State

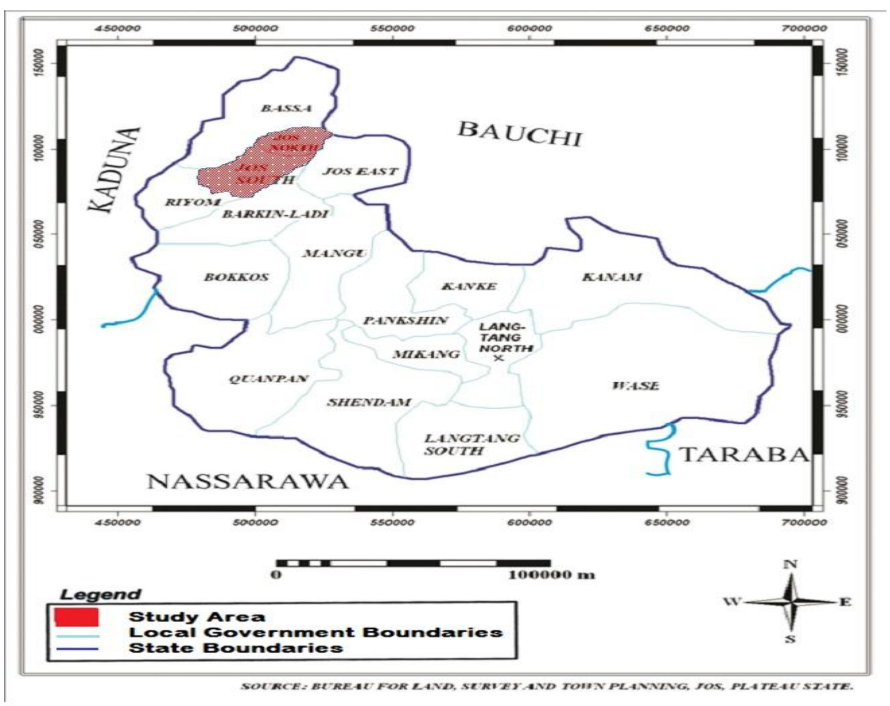

Figure 2: Location Map of the Study Area (Jos North and Jos South). Source: Bureau for Land, Survey and Town Planning, Jos, Plateau State.

Sample Collection

A total of ten (10) water samples (two from each dumpsite at distances ranging from 40m to 120m) were collected from hand dug wells around five (5) major solid waste dumpsites within the study area for hydrogeochemical analysis. Three (3) control water samples were also collected from areas without visible solid waste dumpsites. The water samples were collected using plastic samplers after rinsing with the water at each location. 500ml plastic bottles were used to store the sampled water in the field with proper labeling for easy identification. The pH, total dissolved solute (TDS), electrical conductivity (EC), temperature, colour, static water level (SWL) are the physico-chemical parameters which were measured insitu and recorded in the field. The samples for the determination of trace elements were preserved immediately with nitric acid (HNO_3) to prevent the elements from reacting and adsorption with the containers. All procedures (sampling, acidification, storing and analysis) were carried out in order to minimize contamination.

Laboratory Analysis

Geochemical analysis of trace elements of interest was carried out at the Bureau Veritas Minerals (ACME) Laboratory, Canada using Inductively Coupled Plasma-Mass Spectrometry. Statistical analysis was done using Wateq4F software for ionic species modelling in water.

RESULTS

The pH of the water from hand dug wells around the dumpsites ranges from 6.3(weakly acidic) – 10.3(basic) with a mean of 7.84 and the temperature of these wells ranges from 23.5^{o}C – 26.3^{o}C with a mean of 24.78^{o}C (Table 1). The electrical conductivity (EC) of the well water around the dumpsites ranges from 0023us/cm – 0635us/cm with a mean of 178.08us/cm while the total dissolved solids (TDS) ranges from 0011ppm - 0296ppm with a mean of 83ppm (Table 1). Further, analysis of trace elements was shown in Table 2.

Results of Speciation Analysis of Water

Table 3 shows the results of speciation analysis of one of the ten groundwater samples collected from the study area. The various components, major species and saturated mineral phases present in the water samples were identified in the speciation analysis. Mineral phases of -5 to less than 0 indicate under saturation while mineral phases of zero (0) are at equilibrium and mineral phases of 5 and above are saturated in the system.

Compositions of the Hand Dug Wells (Physico-chemical and Chemical)

The temperature of water depends on the total dissolved solids (TDS promotes reactivity which generates heat), dissolved oxygen, rate of plant growth, metabolic rate of organisms and resistance in organisms.

Acidic nature of groundwater can be attributed to the breakdown of organic matter derived from vegetation cover and humus buried in waste and sediments and the subsequent percolation of rain water through the soils that increased free CO_2, nitrates and ammonia which could have been drained down to shallow water tables. (Ofoma et al., 2005). The acidity of water will affect its corrosiveness and the speciation of some of its other constituents. Consumption of water having low pH over a long period of time may lead to derangement of the acid-base balance in the body system which may cause metabolic acidosis, with respiration becoming deep and rapid in severe cases (Ofoma et al., 2005). The high pH noticed in some wells in the study area may be due to leaching from the dumpsites very close to the wells (Table 1).

Table 1: Physico-chemical Measurements for Water Samples from the Study Area

S/N	Sample I.D.	Location	Elevation (m)	SWL (m)	pH	Temperature (°C)	TDS (ppm)	EC us/cm	Colour	Distance from Dump (m)	Direction
1	WSP 1	N9° 50' 08.6" E8° 51' 49.1"	1258	2.5	7.7	24.6	248	635	Colourless	20	North
2	WSP 2	N9° 50' 04.2" E8° 51' 50.6"	1264	3	7.4	25	296	595	Colourless	70	South
3	WSP 3	N9° 47' 01.5" E8° 52' 11.7"	1270	1.8	6.3	23.5	68	134	yellowish-colourless	80	South West
4	WSP 4	N9° 47' 11.5" E8° 52' 16.8"	1267	6	7.5	23.8	117	237	Colourless	40	North East
5	WSP 5	N9° 55' 28.9" E8° 49' 22.7"	1250	8.5	10.3	25.3	55	117	Colourless	120	North East
6	WSP 6	N9° 55' 17.7" E8° 49' 17.5"	1249	2.5	8.2	26	82	165	yellowish-whitish	100	Soutth East
7	WSP 7	N9° 57' 59.1" E8° 53' 39.3"	1127	2.5	7.4	25.3	66	133	Colourless	120	South East
8	WSP 8	N9° 57' 54.8" E8° 53' 27.6"	1136	9	7.6	24.7	52	107	Colourless-yellowish	130	South South West
9	WSP 9	N9° 50' 18.0" E8° 54' 35.8"	1291	3	9	26.3	29	58	Colourless	50	South East
10	WSP 10	N9° 50' 24.4" E8° 54' 35.8"	1293	3.5	9	25	11	23	Colourless	70	North East
11	Control 1	N9° 49' 15.5" E8° 52' 41.8"	1250	6	7.1	24.4	15	30	Colourless	Rayfield	South East
12	Control 2	N9° 57' 34.5" E8° 52' 10.4"	1142	8	7.4	24	23	49	Colourless	Mista Ali	North
13	Control 3	N9° 57' 48.8" E8° 53' 05.6"	1137	1.8	7	24.2	17	32	Colourless	Unijos	North
	Min		**1127**	**1.8**	**6.3**	**23.5**	**11**	**23**			
	Max		**1293**	**9**	**10.3**	**26.3**	**296**	**635**			
	Mean		**1225.69**	**4.47**	**7.84**	**24.78**	**83**	**178.08**			

WHO standard for potable water (2008) for PH, Temperature, TDS and EC are 6.5-8.5, 30-32°C, 500-2000mg/l and 750-1000us/cm respectively.

Table 2: Trace Elements Concentration in Groundwater Samples from the Study Area

Analyte	Al	Ag	As	Au	B	Ba	Be	Bi	Br	Cd	Co	Cr	Cs	Cu	Fe	Ga	Ge	Hf	Hg	In	Li	Mn	Mo	Nb
Unite	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**
MDL	**1**	**0.05**	**0.5**	**0.05**	**5**	**0.05**	**0.05**	**0.05**	**5**	**0.05**	**0.02**	**0.5**	**0.01**	**0.1**	**10**	**0.05**	**0.05**	**0.02**	**0.1**	**0.01**	**0.1**	**0.05**	**0.1**	**0.01**
Sample																								
WSP1	71	<0.05	0.9	<0.05	7	391.15	3.53	<0.05	102	0.16	4.87	1.1	0.13	0.6	10	<0.05	<0.05	<0.02	<0.1	<0.01	1.7	688.53	0.2	<0.01
WSP2	336	<0.05	0.6	<0.05	10	392.19	1.63	<0.05	75	<0.05	1.29	<0.5	0.14	1.2	10	<0.05	<0.05	<0.02	<0.1	<0.01	1.5	97.35	<0.1	<0.01
WSP3	633	<0.05	<0.5	<0.05	<5	116.95	0.55	<0.05	45	<0.05	0.62	0.6	0.11	1.1	148	0.09	<0.05	<0.02	<0.1	<0.01	1.6	35.69	<0.1	0.04
WSP4	4	<0.05	<0.5	<0.05	8	131.06	<0.05	<0.05	28	<0.05	<0.02	0.5	0.05	0.8	10	<0.05	<0.05	<0.02	<0.1	<0.01	0.4	0.38	0.3	<0.01
WSP5	453	<0.05	<0.5	<0.05	<5	21.77	<0.05	<0.05	10	<0.05	0.15	<0.5	0.08	1.2	10	1.38	<0.05	<0.02	<0.1	<0.01	0.3	2.52	1.6	<0.01
WSP6	1060	<0.05	<0.5	<0.05	<5	73.03	0.1	<0.05	7	<0.05	0.22	0.7	0.06	0.9	232	0.3	<0.05	<0.02	<0.1	<0.01	2.8	12.52	0.1	0.16
WSP7	85	<0.05	<0.5	<0.05	<5	121.72	0.23	<0.05	18	<0.05	1.02	<0.5	0.03	0.7	83	<0.05	<0.05	<0.02	<0.1	<0.01	0.8	134.47	<0.1	<0.01
WSP8	180	<0.05	<0.5	<0.05	6	116.36	0.21	<0.05	9	<0.05	3.08	<0.5	0.02	2.6	10	0.05	<0.05	<0.02	<0.1	<0.01	0.7	598.91	<0.1	<0.01
WSP9	29	<0.05	<0.5	<0.05	<5	25.08	<0.05	<0.05	14	<0.05	0.04	<0.5	0.03	0.3	27	<0.05	<0.05	<0.02	<0.1	<0.01	0.1	12.77	0.2	<0.01
WSP10	140	<0.05	<0.5	<0.05	<5	20.07	<0.05	<0.05	9	<0.05	0.08	<0.5	0.03	0.4	57	<0.05	<0.05	<0.02	<0.1	<0.01	0.3	8.57	<0.1	<0.01
Min	**4**					**20.07**									**10**							**0.38**		
Max	**1060**					**392.19**									**232**							**688.53**		
Mean	**299.1**					**140.94**									**59.7**							**159.17**		
Control WSP	**156**	**<0.05**	<0.5	<0.05	<5	**20.69**	**1.97**	<0.05	6	<0.05	1.04	<0.5	0.05	0.7	**<10**	**<0.05**	<0.05	<0.02	<0.1	<0.01	5.1	**7.5**	**<0.1**	<0.01
Control WSP	**33**	**<0.05**	<0.5	<0.05	<5	**118.15**	**0.05**	<0.05	<5	<0.05	0.92	1.4	0.06	0.4	**<10**	**<0.05**	<0.05	<0.02	<0.1	<0.01	7	**11.57**	**0.1**	<0.01
Control WSP	**42**	**<0.05**	<0.5	<0.05	<5	**4.47**	**0.4**	<0.05	<5	<0.05	<0.02	<0.5	0.01	0.8	**46**	**<0.05**	<0.05	<0.02	<0.1	<0.01	47.8	**2.02**	**1.5**	<0.01

Analyte	Ni	P	Pb	Pd	Pt	Rb	Re	Rh	Ru	Sb	Se	Sn	Sr	Ta	Te	Th	Ti	Tl	U	V	W	Zn	Analyte	Ni
Unite	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**PPB**	**Unite**	**PPB**
MDL	**0.2**	**10**	**0.2**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.05**	**0.05**	**0.5**	**0.05**	**0.01**	**0.02**	**0.05**	**0.05**	**10**	**0.01**	**0.02**	**0.2**	**0.02**	**0.5**	**MDL**	**0.2**
Sample																							**Sample**	
WSP1	0.3	<10	<0.2	<0.01	<0.01	69.8	<0.01	<0.01	<0.05	<0.05	<0.5	<0.05	306.2	<0.02	<0.05	<0.05	<10	0.42	2.3	0.4	<0.02	18.5	WSP1	0.3
WSP2	0.9	<10	1	<0.01	<0.01	97.37	<0.01	<0.01	<0.05	<0.05	0.5	<0.05	224.9	<0.02	<0.05	<0.05	<10	0.62	3.69	0.3	<0.02	23.9	WSP2	0.9

WSP3	1.3	<10	1.4	<0.01	<0.01	15.15	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	55.06	<0.02	<0.05	<0.05	<10	0.09	0.37	1	<0.02	5	WSP3	1.3
WSP4	<0.2	<10	<0.2	<0.01	<0.01	16.06	<0.01	<0.01	<0.05	0.08	<0.5	<0.05	228	<0.02	<0.05	<0.05	<10	0.05	0.09	1.1	<0.02	13.1	WSP4	<0.2
WSP5	1.4	<10	<0.2	<0.01	<0.01	34.08	<0.01	<0.01	<0.05	0.63	<0.5	<0.05	429.6	<0.02	<0.05	<0.05	<10	0.04	0.09	7	0.08	2.8	WSP5	1.4
WSP6	0.8	<10	0.3	<0.01	<0.01	9.39	<0.01	<0.01	<0.05	<0.05	<0.5	<0.05	125.8	<0.02	<0.05	0.16	20	0.02	0.15	0.8	<0.02	10.1	WSP6	0.8
WSP7	0.6	<10	0.5	<0.01	<0.01	10.32	<0.01	<0.01	<0.05	<0.05	<0.5	<0.05	66.94	<0.02	<0.05	<0.05	<10	0.06	0.14	0.4	<0.02	14	WSP7	0.6
WSP8	0.5	<10	1.8	<0.01	<0.01	8.6	<0.01	<0.01	<0.05	<0.05	<0.5	<0.05	100.7	<0.02	<0.05	<0.05	<10	0.06	0.15	<0.2	<0.02	33.1	WSP8	0.5
WSP9	<0.2	<10	<0.2	<0.01	<0.01	6.86	<0.01	<0.01	<0.05	<0.05	<0.5	<0.05	33.84	<0.02	<0.05	<0.05	<10	0.06	0.03	<0.2	<0.02	1.1	WSP9	<0.2
WSP10	<0.2	<10	0.6	<0.01	<0.01	6.18	<0.01	<0.01	<0.05	<0.05	<0.5	<0.05	26.13	<0.02	<0.05	<0.05	<10	0.03	0.12	<0.2	<0.02	1.4	WSP10	<0.2
Min													**26.13**										**Min**	
Max													**429.6**										**Max**	

Table 3: Major Species and Saturated Mineral Phases Present in Water Sample One (WSP1)

WSP1				
Component	**Major Spacies**	**Percentage of Total**	**Saturated Mineral Phases**	**Log IAP/KT**
Ag	$AgCl_2$ -1	97.92	Alunite	6.15
Al	$Al(OH)_2$-1	95.56	Basaluminate	10.28
As	H_2AsO_4 -1	93.65	Cr_2O_3	16.32
Ba	Ba 2	99.09	$FeCr_2O_4$	20.89
Br	Br -1	100	Diaspore	6.87
Ca	Ca 2	100	Gribbsite (c)	5.57
Cd	$CdCl_2$ aq 0	50.74	Goethite	7.76
	$CdCl_3$ -1	39.87	Se metal<Se=	8.71
Cl	Cl -1	98.82		
Cr	$Cr(OH)_2$ 1	95.12		
Cs	Cs 1	100		
Cu	$CuCl_2$ -1	98.83		
Fe	FeCl+ 1	98.83		
K	k 1	100		
Li	Li 1	100		
Mg	Mg 2	99.99		
Mn	MnCl 1	56		
	$MnCl_2$ aq 0	32.66		
Na	Na 1	100		
Ni	$NiCl_2$ 0	82.73		
NO_3	NO_3 -1	100		
Pb	$PbCl_2$ aq 0	40.36		
Pb	$PbCl_3$ -1	40.07		
Rb	Rb 1	100		
Se	$HSeO_3$ -1	99.91		
SO_4	$BaSO_4$ aq 0	42.41		
	$CaSO_4$ aq 0	32.28		
Sr	Sr 2	100		
U	UO_2)4OH_7 1	90.1		
Zn	$ZnCL_3$ -1	39.71		
	$ZnCL_2$ aq 0	28.1		

DISCUSSION

The electrical conductivity (EC) of the well water around the dumpsites ranges from 0023us/cm – 0635us/cm with a mean of 178.08us/cm (Table 1). These values are below the WHO (2004) of 400 – 1400us/cm and Nigerian Standard for Drinking Water Quality (NSDWQ, 2007) of 1000us/cm and agree with the average conductivity value of 85.8us/cm for groundwater reported by Schoeneich (2000). Water passing through clay soils tends to have higher conductivity because of the presence of materials that ionize when washed into the water (Fetter, 2007). The conductivity of the study area indicates that the groundwater is flowing through non clayey bedrocks. Granite is composed of inert materials which do not ionize easily, therefore under normal circumstances and except for other influences, the conductivity of water in the study area will be low. It has been reported (Majo-Oyovwikowhe & Shuiab, 2009; Olukosi et al., 2006) that highly populated areas have groundwater with high concentration of dissolved ions while converse is the case for areas of low population, and that these are observed mostly in situations where the groundwater sources are located close to points of domestic effluent discharges and septic tanks. They concluded that the chemistry of groundwater in an area is influenced greatly by human activities.

The total dissolved solids (TDS) falls below WHO of 500 – 600ppm and NSDWQ level of 500ppm (Table 1) and also compares with that reported by Schoeneich (2000). The TDS is a quantitative measure of the sum of organic and inorganic solutes in water. There is a direct linear relationship between TDS and conductivity as an increase in one will result in a direct increase in the other. (Bauder et al., 2007). Results of TDS and conductivity in this study in Table 1 agree with this hypothesis. The values of TDS and conductivity of WSP1 and WSP2 in Table 1 confirms that the greater the TDS in water, the greater the conductivity.

The trace elements composition of water around the dumpsites are within the WHO permissible limits with some measured values in ppb and most below the detection limit of the equipment (Table 2).

Content of trace elements are generally low in the waters making it looks safe for human consumption buts species identified in the water include $AgCl_2$, $Al(OH)_4$, H_2AsO_4, Ba^+, Br^-, Ca^+, Cd^{+2}, $CdCl_2$, Cl^-, $Cr(OH)_3$, Cs, $CuCl_2$, FeCl, K^+, Li^+, Mg^{2+}, Mn^{+2}, MnCl, Na^+, Ni^{+2}, $NiCl_2$, NO_3^-, Pb^{+2}, $PbCl_2$, Rb^+, $HSeO_3$, $CaSO_4$, $MgSO_4$, Sr^{2+}, $UO_2(OH)_3$, Zn^{+2} and $ZnCl_3$ (Table 3). Toxic metal species in the water include; (Ba^{+2}, Mn^{+2}, Ni^{+2}, Zn^{+2}, Cd^{+2}, and Pb^{+2}). Ba^{+2} is common to all sources. Ni^{+2}, Zn^{+2}, Mn^{+2} are common to Bukuru, Rukuba Road, Bauchi Road and Rayfield, Cd^{+2} is common to Bauchi Road and Rayfield while Pb^{+2} is common to Bauchi Road water sources. The saturated mineral phases identified in water of the study area include Alunite, Basaluminite, Cr_2O_3, $FeCr_2O_4$, Diaspore, Gibbsite, Goethite, Se metal < Se=, U_3O_8, Uraninite and Ag metal (Table 3).

Possible Health Risk of Water Use by Inhabitants

The presence of these toxic species in waters around these solid waste dumpsites gives a reason for worry and makes the water unsafe for human consumption. These toxic species could accumulate in the human system and cause health challenges such as Parkinson-like syndrome which occurs when there is an overloading of Mn in the human system. Renal dysfunction, nasal epithelial deterioration, pulmonary congestion with an overload of Cd (Tsalev & Zaprianov, 1984), rapid onset of pulmonary congestion and inability to oxygenate hemoglobin, followed by development of lesions of the lungs, liver, kidney, adrenal glands and spleen with an overload of Ni in the human body (Carl and Edward, 1994) and an overload of Pb will cause anemia, erythrocyte protoporphyrin and plumbism. These give enough reason why solid waste dumpsites should be located away from residential areas and properly managed. Inhabitants around such vicinities should also be sensitized on the dangers of living around such hazardous areas.

CONCLUSION

This study has assessed the effect of dumpsites on groundwater quality in the vicinity of some dumpsites in Jos, Bukuru, Rayfield and environs. Water from hand dug wells at close proximity to dumpsites were analysed for physico-chemical parameters, chemical composition and micrological activities of the water. The mean values of the pH, temperature, EC and TDS all fall within the WHO permissible limits for portable drinking water. Content of trace elements are generally low in the waters buts species identified include $AgCl_2$, $Al(OH)_4$, H_2AsO_4, Ba^+, Br^-, Ca^+, Cd^{+2}, $CdCl_2$, Cl^-, $Cr(OH)_3$, Cs,

$CuCl_2$, FeCl, K^+, Li^+, Mg^{2+}, Mn^{+2}, MnCl, Na^+, Ni^{+2}, $NiCl_2$, NO_3^-, Pb^{+2}, $PbCl_2$, Rb^+, $HSeO_3$, $CaSO_4$, $MgSO_4$, Sr^{2+}, $UO_2(OH)_3$, Zn^{+2} and $ZnCl_3$. Toxic metal species include (Ba^{+2}, Mn^{+2}, Ni^{+2}, Zn^{+2}, Cd^{+2}, and Pb^{+2}). The presence of these toxic metal species makes the water unsafe for human consumption and if consumed directly it could pose some health challenges to the human system over time. All these factors put together make the groundwater around dumpsites in the study area unfit for human consumption.

It is therefore recommended that a proper and active solid waste management system be put in place in the study area and inhabitants of the study area be sensitized on the dangers of consuming water from the wells around the dumpsites even after purifying the water.

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