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IMPACT OF MUNICIPAL SOLID WASTE DUMPS ON SURROUNDING SOIL AND GROUNDWATER IN GOMBE, NIGERIA

Sulaiman M.B.[1*], Maigari A.U.[2] and Sa'idu Danladi[3]
[1]Department of Pure and Industrial Chemistry, University of Nigeria, Nsukka, Enugu State, Nigeria
[2]Department of Chemistry, Federal College of Education (Tech.), P.M.B. 60, Gombe, Gombe State, Nigeria
[3]Department of Integrated Science, Jigawa State College of Education P.M.B. 1002, Gumel, Jigawa State, Nigeria
E-mail: sulaimanmuhammadbashir@gmail.com ([*]*Corresponding Author*)

Abstract: Surrounding soil and groundwater were collected around a municipal solid waste dumpsite in Gombe to study the possible impact of solid waste effect on soil and groundwater quality. The samples were collected in rainy and dry seasons and analysed for heavy metals (Pb, Cd, Zn, Mn, Cr, Cu, Ni and Fe) using atomic absorption spectrometry. It has been found that the metals in the water sample were within WHO and NSDWQ permissible limit except for Cr in both seasons with mean concentration of Cr (0.01 to 1.2 mg/L) which exceeded the WHO permissible limit of 0.05 mg/L. The soil samples in both season show a considerable level of pollution as all the metal determined but within the specified FEPA and WHO limit with the exception Cd which is above FEPA and WHO standard. There was a significant increase ($p<0.05$) in levels of iron, lead, cadmium, nickel, copper, chromium and zinc in soils from the dumpsite and 20 m south of the dump compared to soil from the other site in both seasons and significant increase ($p<0.05$) in manganese concentrations in samples from the dumpsite and from 20m east, and north of the dumpsite compared with samples from the other site in both seasons.
Keywords: Municipal solid waste, Dumpsite, Soil, Groundwater, Heavy metal.

1.0 Introduction

The unsettling problem is that dumping the waste on soil is one means which the soil quality is degraded. The polluted soil affects human health through direct human contact or inhalation of the polluted airborne dust and the consumption of the garden vegetables grown on abandoned dumpsites or around active dumpsites (Anekwe et al., 2002). Rapid increase in population and industrialization in Nigeria have resulted in a dramatic increase in the generation of municipal solid waste (Sulaiman and Maigari, 2016). Continuous disposal of municipal wastes on soil may increase heavy metal concentration (Smith et al., 1996). The amounts of metals increased with haphazard disposal of municipal waste in soils. Soils are usually regarded as the ultimate sink for heavy metals discharged into the environment

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(Banat et al., 2005). Heavy metals are of considerable environmental concern due to their toxicity, wide sources, non-biodegradable properties and accumulative behaviors (Yu et al., 2008). There need for continued and effective monitoring of these heavy metals to source and distribution in the environment is highly necessary.

Dumpsites have been identified as one of the major threats to groundwater resources receiving a mixture of municipal, commercial and mixed industrial wastes. The depressions into which solid wastes are often dumped include valleys and excavations. Studies on the effects of unlined waste dumps on the host soil and underlying shallow aquifers have shown that soil and groundwater system can be polluted due to poorly designed waste disposal facilities (Amadi et al., 2012). Uncontrolled dumpsite and waste dumpsites threaten the groundwater supply as movement of leachates from dumpsites through the soil and the aquifers pose a risk to the environment and human health. Waste placed in dumpsites or open dumps are subjected to either groundwater underflow or infiltration from precipitation (Mor et al., 2006). In recent times, the impact of leachate on groundwater and other water resources has attracted a lot of attention because of its overwhelming environmental significance. Leachate migration from wastes sites or landfills and the release of pollutants from sediments (under certain condition) pose a high risk to groundwater resource if not adequately managed (Ikem et al., 2002). It is essential to protect soil, surface and groundwater contamination due to leachates percolation in and around the dumpsite (Alkalay et al., 1998). Protection of groundwater is a major environmental issue since the importance of water quality on human health has attracted a great deal of interest lately (Longe et al., 2010 and Mackey, 1990).

2.0 Materials and methods

2.1 Study Area

The study area is Gombe, the capital of Gombe state, situated in the North-Eastern part of Nigeria. It is located between latitude 10°17′05.88"N and 11°10′36.78"E. The LGA has an area of 52km^2 and a population of 266,844 persons according to 2006 population census; today the population is projected to be 399,531 persons using 3.2% growth rate (FRN, 2007). It is characterized by a tropical climate with two distinct seasons; a rainy season (May-October) and a dry/harmattan season (November-April). Based on the vegetation classification of Nigeria, the study area falls into Sudan savanna climate. The monthly mean temperature records show a range from 18 ^{o}C to 39 ^{o}C, with an average annual rainfall of 850 - 954mm (Ileoje, 2001). The relative humidity ranged from 70% to 80% in August and decrease to 15 to 20% in December. The geology Gombe is part of the central highland with flat landscape. The open dumpsite was originally an abandoned. The dumpsite has been in existence since 1998.

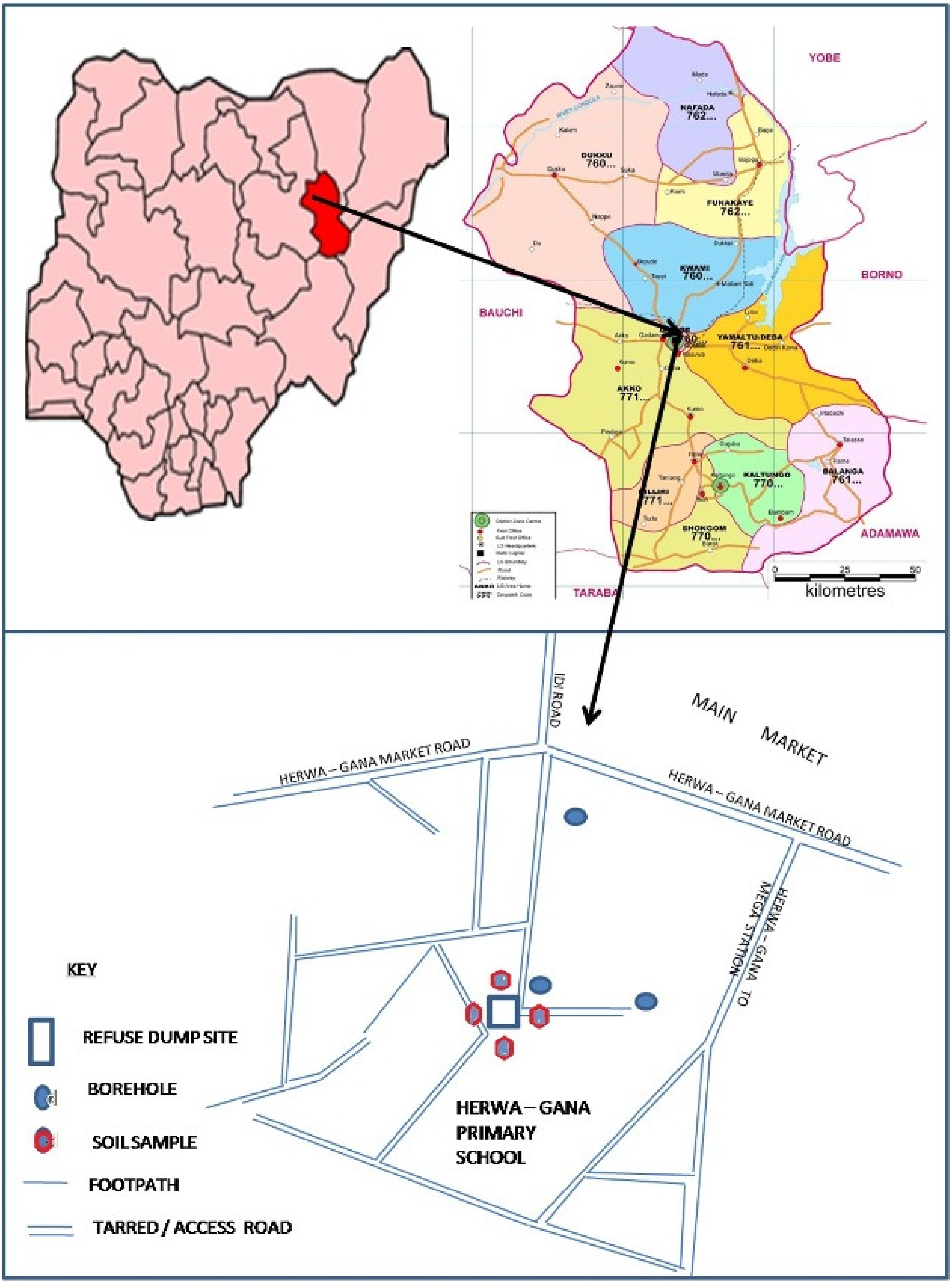

Fig 1: Map extract of Gombe showing sample locations

2.2 Sample collection

Soil Samples were collected from five different locations: at the dumpsite, 20m north, south, east and west; after extraneous materials and stones were removed from the soil sampling sites, samples were collected from 5-15 cm below the surface in order to avoid collection of decayed waste materials. At each sampling location, five subsamples were randomly collected to make a composite sample. Ten composite samples were collected at each sampling location in both dry and rainy season in 2015. A total of fifty different composite samples were collected for the study. Each soil sample (500 g) were placed inside polyethylene bag and covered with aluminum foil.

Water samples were collected from three different boreholes whose depth varied from 20-35m, around the dumpsite twice a month for period of three months in the wet season and another period of three months in the dry season into 500 ml sterile bottles, and a few drops of concentrated nitric acid was added to all the samples used for heavy metal analysis. A total of thirty six different samples were collected for the study as shown in fig 1. The water samples are chemically analyzed. The analysis of water sample was done using procedure of standard methods. All the samples were taken to the laboratory and stored under room temperature until analysis.

2.3 Sample preparation and digestion of soil

The soil samples were air dried and then passed through a 1 mm stainless steel sieve. 1g of each prepared soil sample was put into 150 ml conical flask, a mixture of concentrated HNO_3:$HClO_4$:HF in the ratio 3:1:3 was added. The mixture was placed on a hot plate for three hours at 80 ^{o}C. The digest was filtered into 100 ml standard flask and made to mark with distilled water (Nwajei and Gegophien 2000). Cu, Zn, Ni, Cu, Mn, Fe, Cd and Cr were all determined using atomic absorption spectrophotometer (AAS, Unicam 969, United Kingdom).

2.4 Data analysis

The data obtained from this study were analysed using SPSS software version 20. The mean values were used to compare with the FEPA, NSDWQ and WHO (2006) standards whereas the independent t-test values were used to compare the mean values obtained during the wet season with values obtained during the dry season at $P<0.05$.

3. Result and Discussion

Study of pollution of soil and groundwater at a functional dumpsite was carried out to at different proximate distances from both sites.

Soil analysis

The result of the analysis of the surrounding soil is shown in Table 1. The highest mean concentrations of cadmium (12.22 mg/kg), copper (2.15 mg/kg), manganese (92.05 mg/kg), iron (2440.00 mg/kg), lead (8.8 mg/kg), zinc (151.0 mg/kg), nickel (11.85 mg/kg) and chromium (4.55 mg/kg) were recorded in the soil from dumpsite in both seasons. Low concentration of cadmium was recorded from soil sample 20m north of the dumpsite (4.55 mg/kg) during the wet season, while the lowest concentration of copper (0.23 mg/kg) was recorded from the soil sample 20m east outside the dumpsite. The high iron concentrations in all soil samples may not be from the waste. It has been reported that natural soils contain significant concentration of iron which suggest that pollution of the environment by iron cannot be completely linked to waste materials alone but other natural sources of iron must be taken into consideration (Eddy et al. 2006). Besides, iron has earlier been reported to be the most abundant element in Nigeria soil (Amusan et al. 2005). The low content of iron was recorded from the soil sample 20 m west while low zinc content was recorded from the soil sample 20 m north. There is increase in zinc content in soil sample from west this may be due to surface run off from the dumpsite. The increase in heavy metal levels of soil sample from the dumpsite and 20 m south of the dumpsite reflects the composition of waste dumped in study area. South of the dumpsite is sloppy could have contributed to the appreciable levels of most of the metals in the location compared to the other locations due to surface run off from the dumpsite. The general trend for the heavy metals in the soil samples is Fe> Zn> Mn> Pb> Ni> Cd> Cr> Cu. The mean metal concentrations (Cu, Mn, Fe, Pb, Zn, Ni, Cr) in all the soil samples were lower than the limit set by FEPA and WHO. However, the mean Cd content in all the soil samples from dumpsite, 20m north, south, east and west of the dump were above 3 mg/kg limit set by FEPA. Similar trend of metal levels above the DPR limit has been reported by Ihedioha et al (2016) in soils around a dumpsite in Uyo, Nigeria. Cadmium is mostly released from anthropogenic sources. Cadmium is mainly used as an anticorrosion coating in electroplating, as an alloying metal in solders, as a stabilizer in plastics, as a pigment, and as a component of nickel-cadmium batteries and phosphate fertilizers. The Cd levels in this study was higher than 9.05mg/kg reported by Ihedioha et al (2016) in dumpsite soil from Uyo, Nigeria and also higher than 0.73mg/kg reported in dumpsite soil in Ghana (Jafaru et al. 2015). However, the Pb levels in this study were lower than 9.90mg/kg and 41.82mg/kg reported in dumpsite soils in Uyo and Ghana respectively (Ihedioha et al. 2016; Jafaru et al. 2015). Most of the other metals like Mn, Fe, Zn and Cr levels in this study were higher than values reported by Ihedioha et al (2016) and Jafaru et al. (2015). It was observed that in the rainy season, the metal concentrations decreased. This could be attributed to heavy rainfall, dilution and runoff during the rainy season; metals from the soil in the various sites may have been washed out to some extent (Mondol et al., 2011). There was a significant increase ($p<0.05$) in levels of iron, lead, cadmium, nickel, copper, chromium and zinc in soils from the dumpsite and 20 m south of the dump compared to soil from the control site in both seasons. However, soil samples from the dumpsite and from 20m east, and north of the dumpsite recorded significant increase ($p<0.05$) in manganese concentrations compared with samples from the control site in both seasons.

Table 1: Concentration of heavy metals in dumps and surroundings soil during wet and dry season

				Wet season					
S/N	**Distance**	**Cd**	**Cu**	**Fe**	**Mn**	**Pb**	**Zn**	**Ni**	**Cr**
1	Center of dumps	10.03 ±0.15	1.34 ±0.60	1998.80 ±0.53	91.03 ±1.0	8.80 ±0.2	148.0 ±0.5	11.63 ±0.59	4.20 ±0.25
2	20m north	1.60 ±0.05	0.25 ±0.09	1946.00 ±3.0	55.50 ±0.5	4.00 ±0.1	60.33 ±0.5	3.10 ±0.11	1.60 ±0.10
3	20m west	1.80 ±0.09	0.52 ±0.41	1797.60 ±2.0	49.45 ±0.65	5.30 ±0.2	137.0 ±3.0	2.50 ±0.10	1.72 ±0.14
4	20m south	6.73 ±0.10	0.82 ±0.28	1845.00 ±3.0	62.80 ±0.5	6.90 ±0.5	50.90 ±2.0	7.50 ±0.40	2.90 ±0.10
5	20m east	1.61 ±0.05	0.23 ±0.09	1865.00 ±2.0	44.27 ±0.5	6.35 ±0.25	70.05 ±1.15	2.00 ±0.10	1.74 ±0.15
				Dry season					
S/N	**Distance**	**Cd**	**Cu**	**Mn**	**Fe**	**Pb**	**Zn**	**Ni**	**Cr**
1	Center of dumps	12.22 ±0.19	2.15 ±0.61	92.05 ±1.92	2440.00 ±3.0	8.78 ±0.5	151.0 ±1.0	11.8 ±1.0	4.55 ±0.05
2	20m north	1.75 ±0.01	0.25 ±0.20	61.75 ±0.46	1989.50 ±3.0	4.10 ±0.1	66.55 ±0.45	3.75 ±0.05	1.65 ±0.03
3	20m west	1.92 ±0.10	0.68 ±0.38	54.50 ±0.50	1814.00 ±4.0	5.63 ±0.33	147.0 ±2.0	2.85 ±0.05	1.7 ±0.02
4	20m south	6.60± 010	1.34 ±0.60	81.20 ±0.80	1865.00 ±4.0	7.83 ±0.4	61.57 ±0.27	9.55 ±0.65	3.25 ±0.14
5	20m east	1.70 ±0.10	0.83 ±0.25	46.60 ±0.50	1899.50 ±4.0	6.90 ±0.2	72.25 ±1.05	2.50 ±0.30	1.95 ±0.12

All the parameters expressed in mg/L.

Groundwater analysis

The result of the analysis of the ground is shown in Table 2. The concentrations of iron obtained in this study ranged from 0.01 - 0.04 mg/L during wet and dry seasons. These findings are lower than the previous research reported by Ahmed et al. (2013). There was no significant increase at (p>0.05) in iron concentrations in water samples during the dry season. Lead, cadmium and nickel were below the detected level in the water samples in both seasons. The concentration of zinc obtained in this study in both seasons, ranging between 0.01 - 0.05 mg/L during wet and dry seasons. The concentration of zinc in the study area was within the recommended standard NSDWQ and (WHO, 2006). This result conforms to the findings of a similar study carried out by (Temilola et al., 2014). The chromium concentrations in this study ranged from of 0.01 - 0.33 mg/L during wet season and 0.01 - 1.2 mg/L during dry season. The copper concentrations recorded in the water samples with values of 0.01 - 0.04 mg/L during wet and dry season. These findings are lower than thus reported by (Ornguga, 2014). The manganese concentrations recorded in this study was 0.01 mg/L during wet season and ranged from 0.01 - 0.03 mg/L during dry season. The results recorded in this study were lower than that reported by (Ahmed et al., 2013). There no significant increase at (p>0.05) in the concentration of manganese in water samples during the dry season. There was no clear trend in the way the values varied from well to well. However it was observed that Cu, Mn, Fe, Pb, Zn, Ni and Cd were within the specified NSDWQ and WHO limit standards for drinking water with exception of chromium which found to exceed the regulatory limit for some boreholes. These might be due to other environmental factors like soil type or due to leachate from the dumpsite.

Table 2: Heavy metals content in groundwater samples during wet and dry season

Seasons			Wet season			dry season	
S/No	Parameters	BH1	BH2	BH3	BH1	BH2	BH3
1	Cd	ND	ND	ND	ND	ND	ND
2	Cu	ND	ND	ND	0.04± 0.02	0.01 ± 0.01	ND
3	Mn	0.01 ± 0.01	ND	ND	0.03 ± 0.01	0.02 ± 0.01	0.01 ± 0.01
4	Fe	0.02 ± 0.01	0.01 ± 0.01	ND	0.04 ± 0.01	0.04 ± 0.03	0.03 ± 0.01
5	Pd	ND	ND	ND	ND	ND	ND
6	Zn	0.03 ± 0.01	ND	ND	0.05 ± 0.01	0.02 ± 0.01	0.01 ± 0.01
7	Ni	ND	ND	ND	ND	ND	ND
8	Cr	0.33 ± 0.07	0.05 ± 0.01	ND	1.20 ± 0.02	0.13 ± 0.03	ND

All the parameters expressed in mg/L. BH = Borehole. ND = No detection

4. Conclusion

The study carried out on groundwater and soil samples at various distances to both a seasons around dumpsite to find out the possible impact of solid waste effect on soil and groundwater quality. The values show that the boreholes studied had values of many parameters within limit of WHO and NSDWQ. However the values of chromium exceeded the regulatory limit in borehole 1. The soil samples in both season show a considerable level of pollution as all the metal determined but within the specified FEPA and WHO limit with the exception Cd which is above FEPA and WHO standard.

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