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Metal Composition of Leachate and Soil in the Vicinity of Solid Waste Dumpsite in Bauchi Metropolis, Bauchi State, Nigeria

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ABSTRACT
The study examined the metal composition of leachate and soil in the vicinity of solid waste dumpsite in Bauchi metropolis, Bauchi State. Two specific objectives and two research questions were formulated to guide the conduct of this study. The study was necessitated as a result of the ever-increasing toxicity influx and the impact produced by the leachate on micro-flora and micro-fauna which has resulted in low farm produce, release of obnoxious gases into the environment and contamination of the domestic water sources. In an attempt to improve these conditions, 12 different samples of leachate and soil were collected from 12 different solid waste dumpsites in Bauchi metropolis. Inductively, Couple Plasma Emission Spectrometer was used to analyse the samples collected so as to determine the presence of heavy metals and their level of concentration in each solid waste dumpsite within the Bauchi metropolis. The results of heavy metals analysis indicate that the dumpsite soils and leachates have elevated concentration of chromium and lead. Cadmium and Copper were within the normal range in soils and leachates. The study was able to show the impact of heavy metals in some dumpsites within Bauchi metropolis. The study adopted the quasi experimental design. This is because the design does not allow the use of randomization of the population of the study. Specifically, the non-equivalent group test-posttest design was used in which intact classes were chosen for both experiment and control groups respectively. The numbered that constituted the population was 1049 and the study had a sample of 120 respondents. The simple random sampling technique was used to select the sample. The instrument used for collecting data in this study was a constructed questionnaire. The researcher administers pretest to both groups in order to verify the presence or absence of any difference between the two groups that is the experimental and control. The experimental group would use information technology based instructional teaching strategy, while the control group would use the conventional method of teaching. Thereafter, the two groups experimental and control would be subjected to pre-test and posttest to ascertain the effect of Metal Composition of Leachate and Soil in the Vicinity of Solid Waste Dumpsite in Bauchi Metropolis, Bauchi State, Nigeria. The study was able to show the impact of heavy metals in some dumpsites within

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Bauchi metropolis and strong linear relationship that exist between some physicochemical parameter and heavy metals. In view of the conclusion drawn from the study, it was recommended among others that the dumpsite which was observed to have elevated level of chromium and lead should be evacuated or moved to a safe location. Farmers who patronize these dumpsites for cheap manure should be advised on the inherent dangers associated with the waste.

INTRODUCTION

The final disposition of solid waste is a practice that still brings serious impact to the environment generating pollution by-products such as leachate, a dark-coloured, strong smelling highly toxic liquid. Leachate originates from the decomposition of organic matter, the intensity of pluvial waters and other liquids derived from waste (Bertazzoli and Pelegrini, 2002). The toxicity and impact provoked for the leachate on microflora and microfauna is very strong and they are influenced by various factors such as organic matter, heavy metals and nitrogen concentration as well as mass flux of contaminations being transported, (Isidori et al., 2003). Studies have shown that soil at refuse dumpsites contain different kinds and concentrations of heavy metals, depending on the age, contents and location (Odukoya et al., 2009). In recent times, it has been reported that heavy metals from waste dumpsites can be accumulated and persists in soils at an environmentally hazardous level (Amusan et al., 2005).

In Nigeria, leachate from refuse dumpsites constitutes a source of heavy metals pollution to both soil and aquatic environment (Ande et al., 2009). Nevertheless, most abandoned waste dumpsites in Nigeria have been used extensively as fertile ground for cultivating variety of vegetables. Identifying compounds that cause the toxicity in the leachate is not easy because the physical-chemical characteristics of leachate is highly variable and dependant on the following factors; local environmental conditions, time elapsed after waste disposal and landfill characteristics as well (Bertazzoli and Pelegrini, 2002). Toxicity tests are bioassays used in pollution control for determining the maximum permitted concentrations of a given chemical agent for the development/survival of certain living organisms (Buratini et al., 2004). Toxic compounds can have two different effects on living organisms; acute toxicity which is possible to evaluate in the short term upon the death of the organism, and chronic toxicity, whose evaluation takes longer time, in this case, sub-lethal effects must be analyzed (Buratini et al., 2004).

Heavy metals concentrations in soil are associated with biological and geochemical cycles and are influenced by anthropogenic activities such as agricultural practices, industrials activities and waste disposal method (Zauyah et al., 2004). Contamination and subsequent pollution of the environment by toxic heavy metals has become an issue of global concern due to their sources, wide spread distribution and multiple effects on the ecosystem. In Nigeria, leachates from refuses dumpsites constitute sources of heavy metal pollution to both soil and aquatic environment (Odukoya et al., 2000). Most cultivating verities of vegetable even though, research works have indicated that some common vegetables are capable of accumulating high levels of heavy metals from contaminated and polluted soil (Cobb et al., 2000). This constitutes serious health and environmental concern because of the photo toxicity of these metals to the plants and the potential health implication to humans and animals consuming such vegetables (Cobb et al., 2000).

The realization of the polluting effect of dumpsites leachate on the environment has prompted a number of studies in an attempt to mitigate the effect but the resulting effect still sufficed. Leachate is discharged into the environmental media without treatment. This has resulted in low farm produce, release of obnoxious gases into the environment, contamination of the domestic water sources. It is

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on this backdrop that the researchers investigated metal composition of leachate and soil in the vicinity of solid waste dumpsite in Bauchi metropolis of Bauchi State Nigeria.

Aim and Objectives of the Study

The main Aim of the study is to determine the metal composition of leachate and soil in the vicinity of solid waste dumpsite in Bauchi metropolis of Bauchi State Nigeria. Specifically, the objectives of the study are:

1. To determine the metal compositions of leachate and soil around solid waste dumpsite in Bauchi metropolis.
2. To find out how presence of solid waste dumpsites contribute to contamination of the environment in Bauchi metropolis.

Research Questions

Based on the aforementioned objectives, the following research questions were formulated;

1. What metal compositions are found in leachate and soil around solid waste dumpsite in Bauchi metropolis?
2. In what ways do solid waste dumpsites contribute to contamination of the environment in Bauchi metropolis?

METHODOLOGY

Leachate and soil samples were collected from vicinities of the municipal solid waste (MSW) dumpsites by digging a hole about 0-30cm deep water was poured on the solid wastes and it drained into hole. The Leachate was scooped and filter with 250 mm filter paper into one liter plastics bottle. Soil sample were randomly taken from each dumpsite and control at a depth of 0-15cm. One each of both Leachate and soil samples were obtained from the study locations makings a total of 24 samples respectively for soil and Leachate. Two replicates of each point were taken and toughly mixed together for soil samples and from which a preventative sample was obtained. For every dumpsite and its control; two preventative soil samples were collected for the study. The control soil samples were obtained at 10m radius away from the dumpsite. The soil as well as Leachate were labeled and stored in polythene bags and plastic bottles respectively and transported to the laboratory. The soil samples were air-dried between 24 - 48 hours and later sieved through a 2-mm mesh and stored for subsequent analysis. The soil and Leachate samples were collected and then labeled as SIBHE, LIBHE, CIBHE, SMHE, LMHE, CHME, STHE, LTHE, CTHE, SMM, LMM, CMM, SIQ, LIQ, CIQ, SGW, LGW, CGW, SSK, LSK, CSK, SRM, LRM, CRM, SRZ, LRZ, CRZ, SYM, LYM, CYM, SYT, LYT, CYT, SYK, LYK and CYK. The physiochemical parameters were adopted in accordance with standard procedure and guidelines by World Health Organization.

The study examined the metal composition of leachate and soil in the vicinity of solid waste dumpsite in Bauchi metropolis, Bauchi State. The study was necessitated as a result of the ever-increasing toxicity influx and the impact produced by the leachate on micro-flora and micro-fauna which has resulted in low farm produce, release of obnoxious gases into the environment and contamination of the domestic water sources. In an attempt to improve these conditions, 12 different samples of leachate and soil were collected from 12 different solid waste dumpsites in Bauchi metropolis. Inductively, Couple Plasma Emission Spectrometer was used to analyse the samples collected so as to determine the presence of heavy metals and their level of concentration in each solid waste dumpsite within the Bauchi metropolis. The results of heavy metals analysis indicate that the dumpsite soils and leachates have elevated concentration of chromium and lead. Cadmium and Copper were within the normal range in soils and leachates. The study was able to show the impact of heavy metals in some dumpsites within Bauchi metropolis. The study adopted the quasi experimental design. This is because the design does not allow the use of randomization of the population of the study. Specifically, the non-equivalent group test-posttest design was used in which intact classes were chosen for both

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experiment and control groups respectively. The researcher administers pretest to both groups in order to verify the presence or absence of any difference between the two groups that is the experimental and control. The experimental group would use information technology based instructional teaching strategy, while the control group would use the conventional method of teaching. Thereafter, the two groups experimental and control would be subjected to pre-test and posttest to ascertain the effect of Metal Composition of Leachate and Soil in the Vicinity of Solid Waste Dumpsite in Bauchi Metropolis, Bauchi State, Nigeria.

RESULTS

The results of physicochemical parameters and metal analysis of soil and leachate from the twelve dumpsites in Bauchi metropolis are presented in tables as follows:

Table 1: Mean Physicochemical Parameters and Metal Analysis of Dumpsites soil (June – July)

SITES	PH		Temp. (°c)		EC (µm/cm)		O.M (%)		Pav (mg/kg)		Sav (mg/kg)		TDS (mg/l)		O.C (%)	
	S	C	S	C	S	C	S	C	S	C	S	C	S	C	S	C
IBHE	7.26	6.74	24.70	24.40	161.50	29.50	3.35	-	20.10	14.20	23.08	16.88	1090.5	226.00	1.29	1.08
	±0.01	±0.01	±0.02	±0.80	±17.00	±1.00	±0.03		±0.08	±0.08	±0.13	±0.04	±15.00	±2.00	±0.03	±0.07
MHE	7.2	7.30	29.30	29.55	25	13	3.35	-	42.26	24.07	20.77	20.60	222.00	139.00	2.32	1.59
	±0.03	±0.02	±0.00	±0.10	±0.00	±0.00	±0.03		±0.00	±0.01	±0.01	±0.05	±2.00	±1.10	±0.04	±0.02
THE	7.47	7.22	24.70	24.80	36.50	16.00	4.45	-	55.38	13.79	29.56	10.70	273.00	135.00	1.63	1.15
	±0.02	±0.01	±0.20	±0.00	±1.00	±0.00	±0.10		±0.53	±0.75	±0.70	±0.02	±0.02	±2.60	±0.02	±0.02
MM	7.80	7.29	29.20	29.20	12.50	8.50	5.10	-	56.92	8.56	7.16	1.05	146.50	126.50	3.43	1.04
	±0.00	±0.03	±0.00	±0.00	±1.00	±1.00	±0.20		±0.32	±0.16	±0.08	±0.10	±1.00	±1.00	±0.07	±0.13
IQ	7.78	7.55	24.35	24.9	39	19	6.00	-	41.08	22.94	23.07	17.88	291.5	156.5	2.21	1.44
	±0.01	±0.01	±0.30	±0.00	±0.00	±0.00	±0.40		±0.30	±0.15	±0.14	±0.24	±0.10	±0.10	±0.02	±0.05
GW	6.9	6.47	29.3	29.3	33	11	6.5	-	55.08	15.98	35.15	8.90	275	138.5	2.00	0.82
	±0.00	±0.03	±0.00	±0.00	±0.00	±0.00	±0.20		±0.67	±0.48	±0.15	±0.41	±0.20	±0.10	±0.03	±0.13
SK	7.6	7.49	24.55	24.55	28	15.5	6.05	-	52.21	14.74	31.85	8.20	216	131	2.33	1.28
	±0.01	±0.00	±0.01	±0.10	±0.00	±0.10	±0.10		±0.14	±0.08	±0.71	±0.08	±0.03	±0.20	±0.05	±0.00
RM	6.29	5.94	21.15	20.70	20	14	7.10	-	55.94	16.80	31.9	7.91	161.5	115	3.10	1.14
	±0.01	±0.02	±0.71	±0.00	±0.00	±0.10	±0.20		±0.35	±0.43	±0.04	±0.18	±0.30	±0.20	±0.03	±0.09
RZ	6.49	6.6	22.30	21.70	21	15	7.05	-	43.74	22.26	29.40	10.60	266	116	2.28	1.42
	±0.02	±0.01	±0.00	±0.00	±0.00	±0.00	±0.10		±0.47	±0.13	±0.30	±0.08	±0.20	±0.10	±0.02	±0.00
YM	7.55	7.32	22.40	20.60	20	14	7.00	-	41.60	20.33	23.33	16.77	274	133	2.22	1.30
	±0.00	±0.00	±0.30	±0.10	±0.00	±0.10	±0.20		±0.00	±0.01	±0.13	±0.04	±1.00	±1.00	±0.03	±0.13
YT	7.22	6.97	24.50	24.30	22	19	5.45	-	46.45	14.33	20.60	20.35	147	134	2.32	1.52
	±0.03	±0.02	±0.01	±0.00	±0.00	±0.00	±0.10		±0.08	±0.08	±0.01	±0.05	±0.02	±2.42	±0.04	±0.02
YK	6.7	6.47	29.3	29.3	29	16	4.50	-	48.50	16.20	35.16	8.77	216	131	3.32	1.04
	±0.01	±0.00	±0.00	±0.00	±0.00	±0.00	±0.20		±0.14	±0.08	±0.15	±0.43	±0.03	±0.20	±0.07	±0.13

IBHE → Ibrahim Bako Housing Estate, MHE→ Makama Housing Estate, THE →Tambari Housing Estate, MM → Masakan Makafi, IQ → Igbo Quarters, GW → Gwallaga, SK → Sabon Kaura, RM → Rafin Makaranta, RZ → Rafin Zurfi, YM → Yelwan Makaranta, YT → Yelwan Tudu, YK→Yelwan Kagadama

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SITES	Cd (mg/kg)		Cr (mg/kg)		Pb (mg/kg)		Cu (mg/kg)	
	S	C	S	C	S	C	S	C
IBHE	0.85	0.06	5.04	0.31	4.13	0.08	0.79	0.29
	±0.02	±0.00	±0.02	±0.02	±0.11	±0.01	±0.03	±0.05
MHE	0.77	0.03	7.03	1.89	6.25	0.17	1.16	0.17
	±0.02	±0.03	±0.05	±0.02	±0.01	±0.02	±0.11	±0.02
THE	0.21	0.04	7.94	0.13	10.63	0.03	2.07	0.22
	±0.08	±0.00	±0.15	±0.02	±0.74	±0.00	±0.06	±0.03
MM	1.21	0.08	8.31	0.21	6.67	0.16	1.70	0.29
	±0.03	±0.02	±0.03	±0.03	±0.06	±0.04	±0.01	±0.05
IQ	0.24	0.57	3.76	0.83	3. 76	0.20	1.23	0.18
	±0.00	±0.03	±0.03	±0.09	±0.02	±0.03	±0.02	±0.01
GW	1.23	0.06	8.42	0.21	6.84	0.09	1.79	0.51
	±0.01	±0.00	±0.24	±0.01	±0.40	±0.04	±0.06	±0.02
SK	0.31	0.05	8.10	0.19	12.38	0.03	2.57	0.21
	±0.02	±0.01	±0.08	±0.06	±0.06	±0.00	±0.04	±0.01
RM	2.33	0.08	9.12	0.25	6.82	0.08	1.79	0.14
	±0.04	±0.00	±0.11	±0.02	±0.02	±0.03	±0.06	±0.01
RZ	1.22	0.04	8.12	0.19	6.45	0.16	1.64	0.18
	±0.08	±0.00	±0.03	±0.06	±0.01	±0.02	±0.04	±0.02
YM	0.72	0.08	3.72	0.82	10.25	0.04	2.04	0.20
	±0.02	±0.03	±0.10	±0.02	±0.64	±0.01	±0.06	±0.03
YT	1.15	0.08	7.90	0.13	4.12	0.08	1.73	0.18
	±0.01	±0.00	±0.15	±0.02	±0.10	±0.01	±0.01	±0.02
YK	1.23	0.06	7.03	1.83	6.52	0.13	1.16	0.18
	±0.01	±0.02	±0.05	±0.02	±0.06	±0.02	±0.10	±0.02

Temp. ⟶Temperature, EC⟶ Electrical Conductivity, TDS ⟶Total Dissolved Solid, Pav ⟶ Phosphorus Available, Sav ⟶Sulphur Available, OM⟶ Organic Matter, OC⟶ Organic Carbon, S⟶ Soil, C⟶ Control

Table 1 show that the soil analyzed was slightly alkaline with P^H ranging from 6.29 – 7.80. The EC was low with the highest value of 161.50ms/cm at Ibrahim Bako Housing Estate. The heavy metals with the highest value are Pb(12.38mg/kg) and Cr(9.12mg/kg) at SK and RM respectively.

Table 2: Mean Physicochemical Parameters and Metal Analysis of Dumpsites Leachate Samples (June – July)

SITES	P^H	Temp. (°c)	EC (µm/cm)	TS (Mg/l)	TDS (Mg/l)	TSS (Mg/l)	TA (Mg/l)	Cl^- (Mg/l)	S^2 (Mg/l)	Cd (Mg/l)	Cr (Mg/l)	Pb (Mg/l)	Cu (Mg/l)
IBHE	5.24	26	82.00	0.59	609.50	33.00	678.50	301.50	421.90	0.08	0.004	1.81	1.33
	±0.03	±0.00	±0.0	±0.02	±5.00	±2.00	±0.40	±10.60	±36.40	±0.00	±0.001	±0.61	±0.06
MHE	5.93	25.8	118.00	0.89	852.50	50.50	31.10	17.75	23.55	0.18	0.002	2.60	1.99
	±0.09	±0.00	±2.00	±0.03	±9.00	±1.00	±2.20	±0.50	±1.90	±0.04	±0.001	±0.82	±0.33
THE	5.48	27.1	26.50	0.32	233.5	21.4	82.05	73.40	259.00	0.11	0.010	2.25	1.19
	±0.01	±0.00	±1.00	±0.03	±1.00	±0.60	±0.50	±1.30	±2.30	±0.02	±0.008	±0.12	±0.05
MM	5.25	24.6	168.50	1.18	120.2	58.50	701.70	50.85	83.60	0.22	0.006	2.14	1.11
	±0.03	±0.00	±2.00	±0.04	±2.00	±3.00	±0.60	±0.03	±0.09	±0.08	±0.002	±1.10	±1.05
IQ	5.85	24.20	88.00	0.64	714.5	29.5	752.95	140.5	226.75	0.06	0.005	3.04	1
	±0.30	±0.00	±0.20	±0.05	±0.11	±0.10	±175.9	±47.00	±32.50	±0.03	±0.003	±0.06	±0.02
GW	6.17	24.20	70.00	0.79	828	45	614.15	327.5	277.95	0.11	0.003	0.87	0.98
	±0.06	±0.00	±0.40	±0.01	±0.04	±0.00	±133.3	±17.00	±34.70	±0.02	±0.002	±0.09	±0.73
SK	6.1	24.10	27.00	0.32	233.5	21.14	82.06	73.55	25.9	0.11	0.011	0.57	1.66
	±0.17	±0.00	±0.10	±0.03	±0.10	±0.60	±0.56	±1.30	±0.23	±0.06	±0.001	±0.50	±0.68
RM	6.46	24.20	109.00	1.07	1101	35	90.95	96.1	255.6	0.19	0.005	2.15	0.84
	±0.70	±0.00	±0.20	±0.06	±0.38	±0.20	±3.32	±40.00	±19.80	±0.02	±0.004	±1.12	±0.04
RZ	5.74	25.2	86.00	0.66	728	46	120.15	76.40	255.00	0.08	0.006	0.67	1.28
	±0.03	±0.00	±0.20	±0.02	±2.00	±2.00	±0.30	±0.50	±1.90	±0.15	±0.003	±0.09	±0.33
YM	5.26	26.3	108.00	0.56	642.50	34.5	608.50	136.5	96.70	0.18	0.008	0.57	0.68
	±0.30	±0.00	±2.00	±0.03	±1.00	±0.30	±0.40	±30.00	±1.80	±0.04	±0.002	±0.10	±0.05
YT	6.32	24.8	82.00	0.74	830.5	42	710.25	52.80	224.60	0.13	0.004	2.10	0.44
	±0.30	±0.00	±0.00	±0.01	±0.30	±0.10	±2.00	±0.50	±0.80	±0.06	±0.001	±0.12	±0.19
YK	5.48	24.10	110.00	0.59	648	50.5	98.2	333.2	298.00	0.15	0.006	0.79	1.40
	±0.01	±0.00	±0.30	±0.01	±0.38	±0.60	±0.38	±0.60	±3.02	±0.02	±0.002	±0.09	±0.13

Temp. ⟶ Temperature, EC ⟶Electrical Conductivity, TS ⟶ Total Solid, TDS ⟶Total Dissolved Solid, TSS ⟶Total Suspended Solid, TA ⟶Total Alkalinity, Cl^- ⟶Chloride, S^2 ⟶ Sulphate, Cd ⟶ Cadmium, Cr ⟶ Chromium, Pb ⟶Lead, Cu ⟶ Copper

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Table 2 shows that Pb (3.04mg/l) has the highest value out of the four (4) heavy metals analyzed. While P^H is within the range 5.24 – 6.46 and EC is low with the highest value at 168.50µm/cm.

CHARTS

Results of the analysis of leachates, soil and control in the different dumpsites and variation in the mean concentration of each heavy metal are presented in Figure 1 – 6 below.

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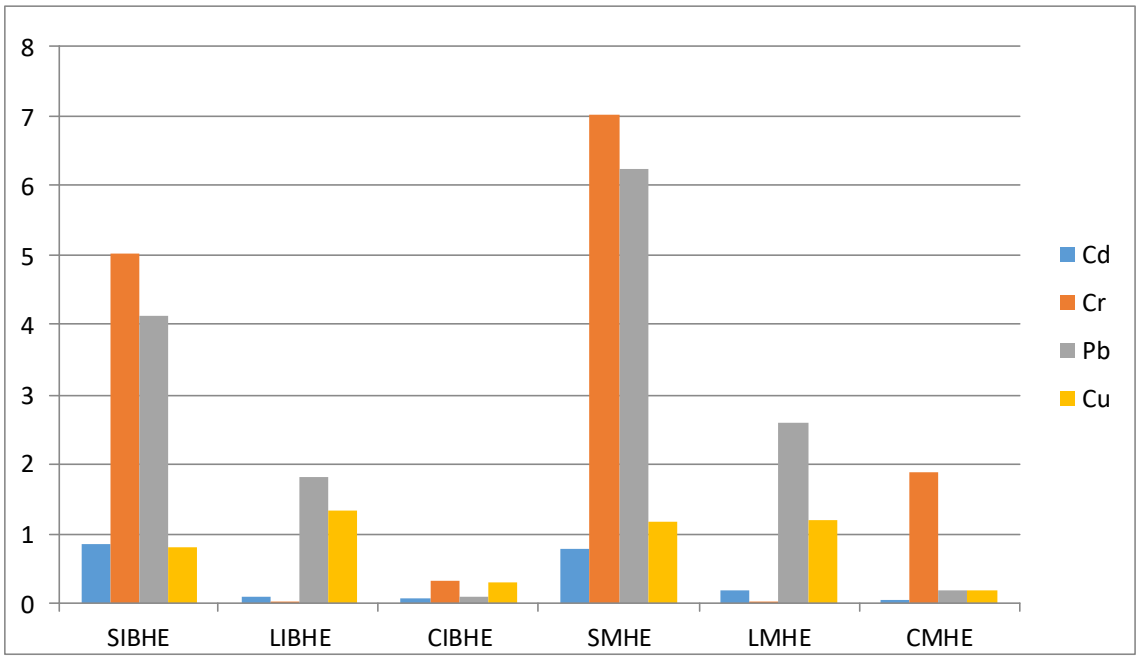

Figure 1: Variation of heavy metals in soil and leachate at Ibrahim Bako Housing Estate (IBHE) and Makama Housing Estate (MH

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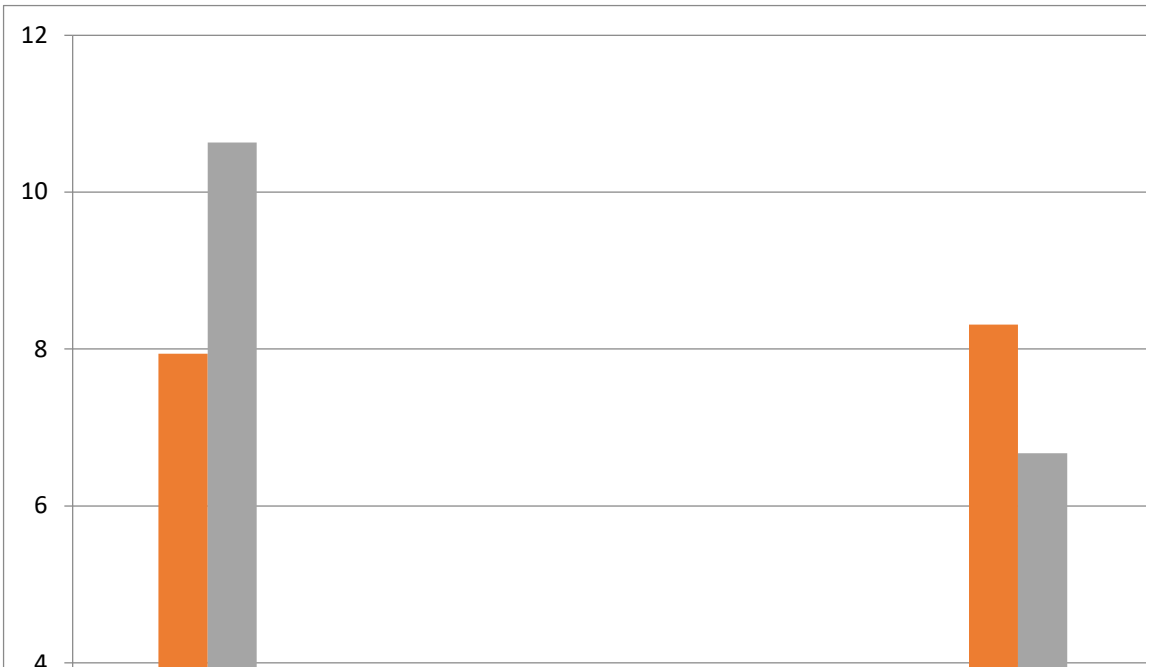

Figure 2: Variation of heavy metals in soil and leachate at Tambari Housing Estate (THE) and Masakan Makafi (MM)

Figure 3: Variation of heavy metals in soil and leachate at Igbo Quarters (IQ) and Gwallaga (GW)

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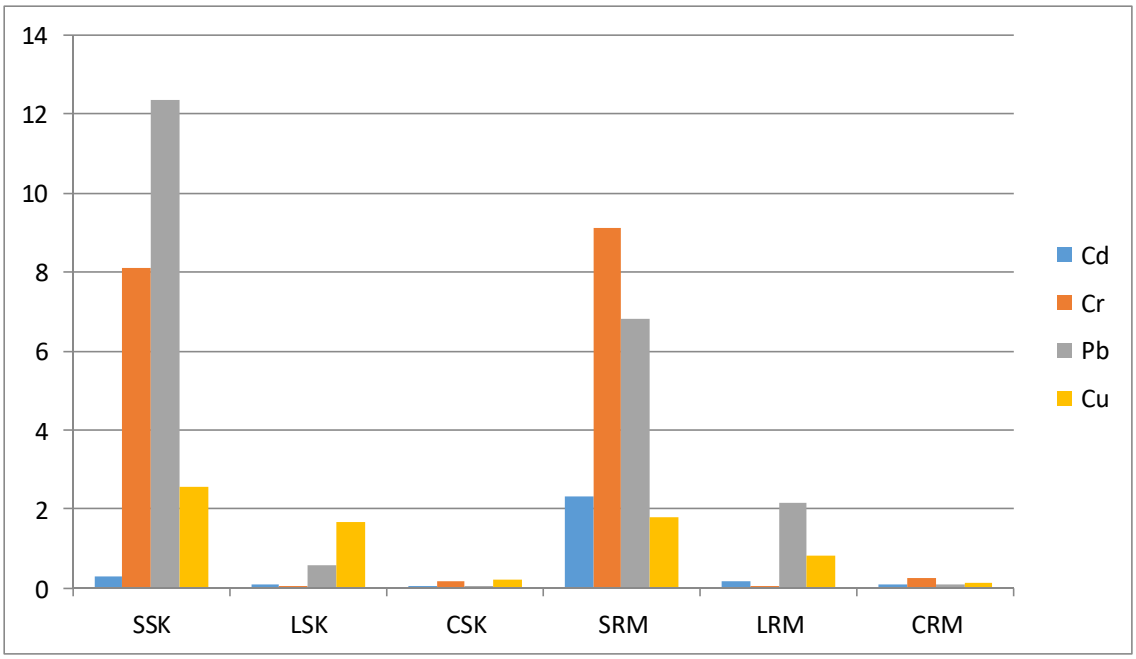

Figure 4: Variation of heavy metals in soil and leachate at Sabon Kaura (SK) and Rafin Makaranta (RM)

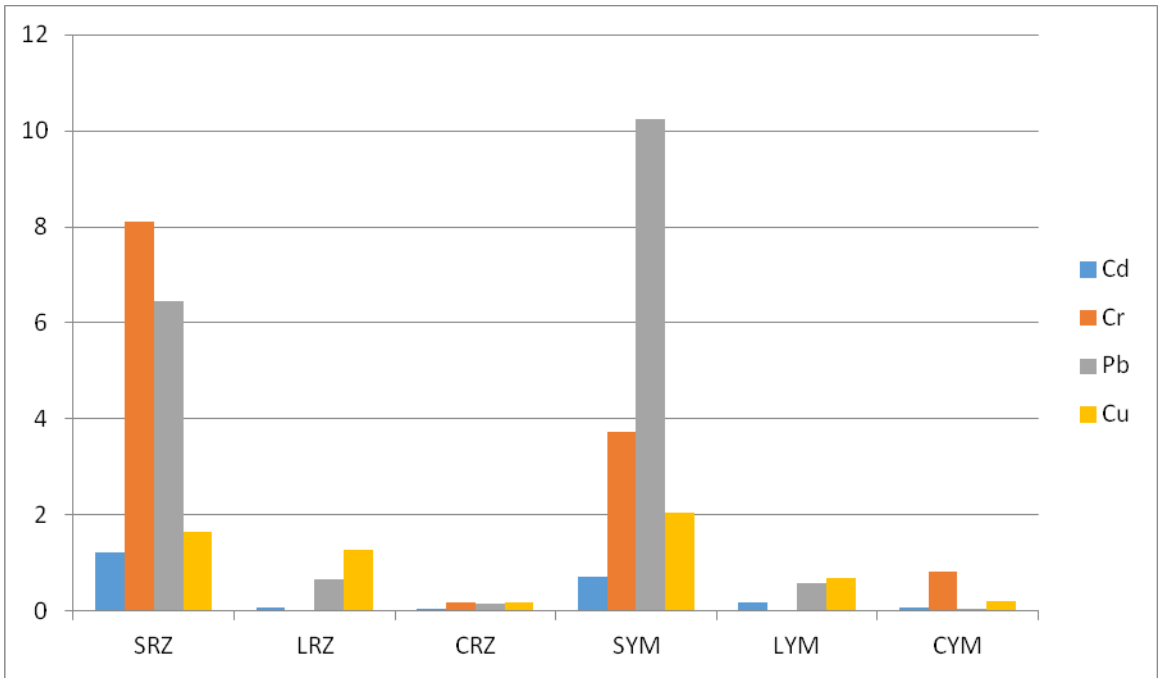

Figure 5: Variation of heavy metals in soil and leachate at Rafin Zurfi (RZ) and Yelwan Makarata

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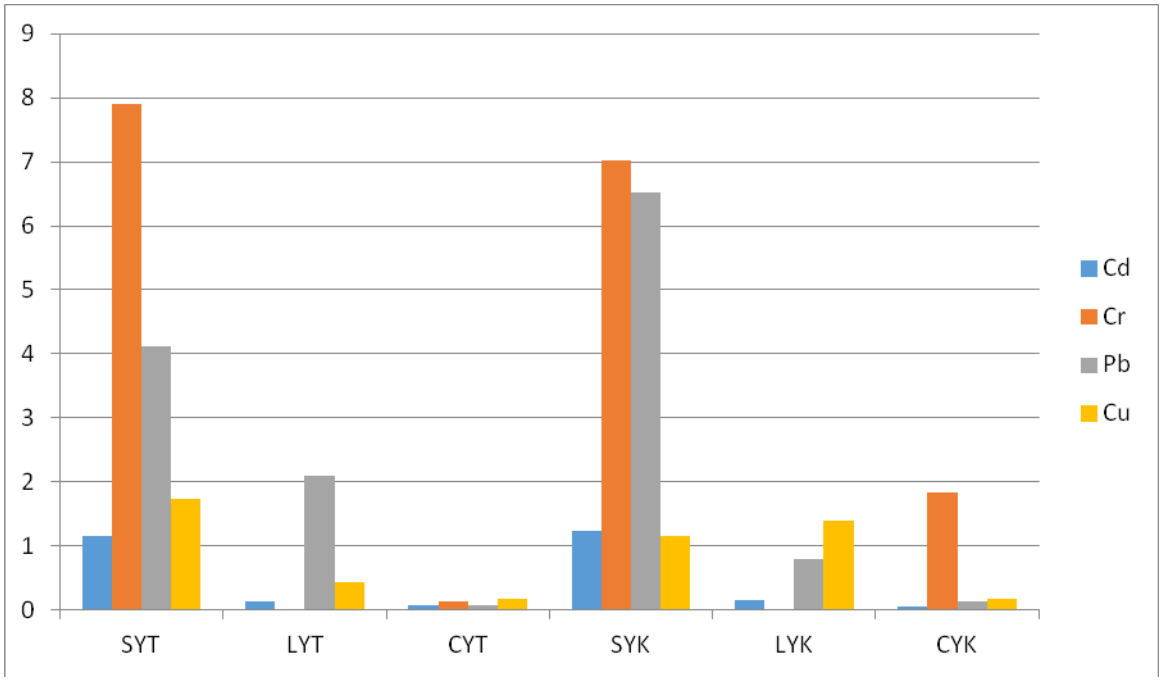

Figure 6: Variation of heavy metals in soil and leachate at Yelwan Tudu (YT) and Yelwan Kagadama (YK)

FINDINGS OF THE STUDY

Specifically, the findings of the study are made as follows:

1. The metal compositions of leachate and soil around solid waste dumpsite in Bauchi metropolis.
2. The presence of solid waste dumpsites contribute to contamination of the environment in Bauchi metropolis.

DISCUSSION OF FINDINGS

The average P^H levels in the soil and leachate sample under study was 7.19 for soil and 5.77 for leachate as shown in table 1 and 2. The soil was slightly alkaline and the leachate slightly acidic. This can affect the absorption of nutrients and also drop in crop production especially in place of dipper. Siebe (1994) determined the standard P^H range in soil and leachate to be used in agriculture to be 6.5 – 8.5 so the average and the change scope are acceptable. David *et al* (2009) opine that availability, retention and mobility of nutrients is affected by the P^H, several other physicochemical parameters and heavy metals in the soil. Soil with low P^H levels tent to increase micronutrient solubility and mobility as well as decrease heavy metal concentration in the soil, while increasing its concentration in ground water.

Electrical conductivity (EC) is considered as a measurement of the amount of dissolved salts in a solution (Motsara and Roy, 2008). The dumpsites mean EC range for soil and leachates are from 12.50 – 161.50µm/cm and 26.50 – 168.50µm/cm respectively. These were higher than those reported by Uba *et al* (2008) as 0.42 – 4.00µm/cm. This was due to the arid nature of the soil.

The concentration of the phosphorus available (Pav) in the dumpsite soil ranges from 20.10 -56.92mg/kg. The concentration of phosphorus were within the range 11.00 – 46.00mg/kg as reported by Eddy *et al* (2006) but lower than those reported by Agyarko *et al* (2010) i.e. 53.41 – 271.60mg/kg. The high phosphorus available in dumpsite soil

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encourages good plant growth. Phosphorus is among the essential element for healthy plant growth. Soil pollution by phosphorus is not a significant environmental issue except when it leached in the surrounding water (Eddy *et al, 2006).*

The organic carbon (OC) percentage obtained in this study ranges from 1.29 – 3.43%. These were lower than those reported by Uba *et al* (2008) as 3.72 – 6.10% but fall within the range reported by David *et al (*2008) as 2.90 – 3.41%. Organic matter is one of the most important parameters controlling the accumulation and availability of heavy metals in soil environment (David *et al 2009,* Myung, 2008).

Cadmium (Cd) is a toxic metal having functions neither in human body or animals or plants. It is found in materials like motor car tyres and in burning of fossil fuel such as coal or oil. This current study reveals the mean concentration range of Cadmium for soils and leachates as 0.01 – 2.33mg/l and 0.06 – 0.22mg/l respectively. These concentrations were quite lower than those reported by David *et al* (2009) as 1.28 – 21.31mg/l but higher than those ascertained by Agyarko *et al* (2010) as 0.14 – 0.90mg/l and within the range as reported by Okorokwo *et al* (2006) as 1.64 – 2.50mg/l.

Chromium (Cr) is a toxic heavy metal. It occurs naturally in soil at a normal range of 5 – 15000mg/l. It is found in the mushroom, coal and oil combustion. In this study, the mean concentration of chromium in the dumpsites soil and leachate were found to range from 3.72 – 9.12mg/l and 0.002 – 0.011mg/l respectively. These concentrations were lower than those reported by Agyarko *et al* (2010) as 13.00 – 24.20mg/l but within the range as reported by Oviasogie *et al* (2009) as 3.50 – 9.00mg/l.

Increase Lead (Pb) concentration in the soil is usually attributed to industrial activities (Eddy *et al,* 2006). Lead is found in car batteries, radiators and inks. The result of this study showed a mean lead concentration of soil and leachates in the dumpsites as 3.76 – 12.38mg/l and 0.57 – 3.04mg/l respectively. These lead concentrations were below the normal soil and leachate concentration of 15 – 25mg/l as reported by Eddy *et al* (2006) and also below the concentrations reported by Agyarko *et al* (2010) as 8.59 – 9.20mg/l.

Copper (Cu) is an essential micronutrient required by plants for their healthy growth. The normal range of copper in soil falls within 7 – 8.0ppm (Eddy *et al* (2006). The concentration of copper for the dumpsites soil and leachate range from 0.79 – 2.57mg/l and 0.44 – 1.99mg/l respectively. These concentrations were lower than those reported by Agyarko *et al* (2010) as 5.70 – 27.00mg/l and David *et al* (2009) as 16.41 – 76.18mg/l.

CONCLUSION

The results of heavy metals analysis displayed in table 1 and 2 indicate that the dumpsite soils and leachates have elevated concentration of chromium and lead. Cadmium and Copper were within the normal range in soils and leachates as reported by several authors even though the concentrations of these metals in the 12 dumpsites were significantly higher than their corresponding control sites. The study was able to show the impact of heavy metals in some dumpsites within Bauchi metropolis and strong linear relationship that exist between some physicochemical parameter and heavy metals.

RECOMMENDATIONS

The following recommendations were made in the study;

1. The dumpsite which was observed to have elevated level of chromium and lead should be evacuated or moved to a safe location.
2. Farmers who patronize these dumpsites for cheap manure should be advised on the inherent dangers associated with the waste.
3. The municipal council should create more awareness and sensitization campaign about the danger of indiscriminate solid waste disposal.

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