Assessment of Heavy Metal Concentrations in Soils at Selected Waste Dump Sites in Abuja Municipal Area Council (Amac), Federal Capital Territory, Nigeria

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Abstract
The geographical variations in waste dissemination implies a negative consequences on the adjourning neighbourhood. Heavy metals in solid waste disposed at dumpsites can be detrimental to soil safety and its concentration may vary in season. In this study, the mean concentrations of heavy metals in soils at dumpsites were assessed in both dry and wet seasons. Seventy-two (72) soil samples were collected from three (3) waste disposal sites (Nyanya, Dutse and Karishi) and the control sites. Sampling was done using systematic random sampling technique. In each season, three top and sub-soils samples were collected at 0m, 10m, 20m and 30m way from the dumpsites. Range, mean standard deviation and coefficient of variation were used to describe the concentrations of soil physio-chemical properties in both seasons. Student't' test was use to test for seasonal variation. Result shows that the mean concentrations of soil properties in rain and dry seasons respectively differ, thus; pH (7.01 and 5.98), EC (932.20µS/Cm and 906.86µS/Cm), OM (4.60% and 4.58%), Fe (1.24 mg/Kg and 2.78 mg/Kg), Zn (0.72 mg/Kg and 0.81 mg/Kg), Pb(0.65 mg/Kg and 0.04 mg/Kg). Though, concentrations of soil properties differ between rain and dry seasons, none vary significantly at 95% confidence level. Construction of future dumpsites in the area should follow the design of a modern sanitary landfill system that guarantee protection to the soil.
Keywords: Waste, Dumpsite, Soil, Properties, Seasonal variation

1. Introduction

Pollution is the introduction of unwanted and injurious substance (solid, liquid or gas) into a geographic space. Soil pollution from heavy metals is the major concern of many studies on soil quality at dumpsites globally (Igwilo, Bello, Magaji and Ogah, 2024). The location of dumpsites has proved to be a problem to nearby residents in most parts of the world, particularly in Africa urban centres. Abuja Municipal Area Council is not an exception in the problems associated with waste disposal (Ojelade and Aregbesola, 2014). Solid waste poses complex common problem in both developing and developed countries (Igwilo *et al.*, 2024). Improper waste management can generally lead to transmission of illnesses, direct risks to those who contact with garbage, indirect risks of proliferation of animals that are carriers of microorganisms, aesthetic deterioration, degradation of the natural landscape, water, soil and air pollution (Ejaz *et al*., 2010; Sivapullaiah *et al*., 2016).

The disposal of toxic waste in June 1988 at Koko town in Delta State, Nigeria awakens Nigerian's conscience on environmental matters and promoted environmental awareness of waste dump in Nigeria (Ladapo, 2013). Consequently, several studies have been carried on solid waste and its environmental effects in Nigeria (Anikwe, 2002; Anake *et al*., 2009; Nwanta and Ezenduka, 2010; Ndukwe *et al.,* 2019; Ifeoluwa, 2019; Olumide *et al.,* 2019). Ifeoluwa (2019) assessed the harmful effects and management of indiscriminate solid waste disposal on human and its environment in Nigeria. Akinnusotu and Arawande (2016) analysed the physico-chemical characteristics and heavy metals concentration in sub surface soil at different dumpsites in Rufus Giwa Polytechnic, Owo, Ondo State, Nigeria. Angaye *et al.* (2015) analysed microbial load and heavy metals properties of leachates from solid wastes dumpsites in the Niger Delta, Nigeria. Ulakpa *et al.* (2021) carried out quantitative analysis of physical and chemical attribute of soil around power-line dumpsite at Boji-Boji Owa, Delta State, Nigeria. Amadi *et al.* (2012) carried out comparative study on the impact of Avu and Ihie dumpsites on soil quality in Southeastern Nigeria. Angaye and Abowei (2017) reviewed the environmental impacts of municipal solid waste in Nigeria. Olumide *et al*. (2019) evaluated of the impact of landfill on soil quality at Akilapa and Oleyo dumpsites in Osogbo, Nigeria. Ojekunle *et al.* (2018) assessed soil quality of Saje dumpsite at Abeokuta, Nigeria. Anikwe (2002) assessed long term effect of municipal waste disposal on soil properties and productivity of soil used for urban agriculture in Abaliki Ebonyi, Nigeria. Nwanta and Ezenduka (2010) analysed the public health implications of metropolitan abattoir solid waste in Nsukka South Eastern Nigeria. Olufunmilayo *et al*., (2015) determined the polycyclic aromatic hydrocarbons (PAHs) on selected dumpsites in Abeokuta Metropolis, South West, Nigeria. All the studies recognized the negative impact of waste pollution to man and his environment.

Furthermore, Adedosu *et al*. (2013) also assessed heavy metals in soil, leachate and underground water samples collected from the vicinity of Olusosun landfill in Ojota, Lagos, Nigeri just as Bada *et al*., (2018) analysed levels of heavy metals in soil and water leaf (*Talinum triangulare*) collected from abandoned dumpsites in Abeokuta, Nigeria. Similarly, Anake *et al*. (2009) investigated heavy metals pollution at municipal solid waste dumpsites in Kano and Kaduna States in Nigeria while Ayeni *et al*. (2017) studied heavy metal accumulation in plant, insect and soil in a public dumpsite in Ado-Ekiti, Ekiti State, Nigeria. Olarinoye *et al*.(2010) analysed heavy metal content of soil samples from two major dumpsites in Minna Niger State Nigeria while noting the harmful impact of waste. In addition, Ideriah *et al*. (2005) analysed heavy metal contamination of soils around municipal solid wastes dump in Port Harcourt, Nigeria while Amusan *et al*. (2005) studied the characteristics of soils and crop uptake of heavy metal in municipal waste dumpsite in Nigeria. On the otherhand, Ajah *et al.*(2015) studied the spatiality, seasonality and ecological risks of heavy metals in the vicinity of a degenerate municipal central dumpsite in Enugu, Nigeria.

Studies on soil quality at solid waste disposal sites also abound in Abuja. For instance, Magaji and Jenkwe (2019) assessed soil contamination in and around Mpape dumpsite, Federal Capital Territory (FCT), Nigeria. Magaji (2020) also evaluated Mpape landfill standard in FCT, Nigeria.

Olowookere *et al*., (2018) analysed heavy metals concentration in dumpsites at Gwagwalada, Abuja while Sawyerr (2017) assessed the impact of dumpsites on the quality of soil and groundwater in satellite towns of the Federal Capital Territory, Nigeria. In similar vein, Oluyori *et al.* (2019) assessed the concentration level of some heavy metals and non-metallic ions in dumpsite soils in the Federal Capital Territory, Nigeria. Ayuba *et al*. (2013) study reveals that the current status of municipal solid waste management in FCT, Nigeria is inadequate as Magaji and Jenkwe (2019) assessment of soil contamination in and around Mpape dumpsite, Federal Capital Territory (FCT), Nigeria was a thing of concerns to both the government and the local residents. This was corroborated by Magaji and Mallo (2020) as they assessed the vertical movement of heavy metals in the soils of Mpape Dumpsite, Federal Capital, Nigeria.

Most studies in Abuja paid attention on Gosa and Mpape (Magaji and Jenkwe 2019; Magaji and Mallo**,** 2020). Studies have also paid attention to a single dumpsite in the FCT notwithstanding that size, age and type of waste dump determine the impact on the soil (Mekonnen *et al*., 2020; Gupta *et al*., 2018). Moreover, despite that waste composition and volume varies in season, studies in Abuja were not seasonal in approach as they were unable to account for seasonal variation of heavy metals in soil. Thus, this study bridged this gap as it analyzed heavy metals in soils at dry and wet seasons.

2. Materials and Methods

Field survey of three purposely selected dumpsites (Nyanya, Karhi and Mpape) were embarked on sequentially in dry and rainy seasons for collection of soil samples. Soil auger was used to collect samples from top and subsurface at 0-15 cm for the top-soil, and 15-30 cm for the sub-surface soils. A total of seventy-two (72) soil samples were collected from three waste disposal sites and control sites in dry and wet seasons. Samples were stratified into two: namely top and sub-surface soils. The selections of these dumpsites were based on visible impacts and encroachment of other land uses such as residential, agricultural and transportation. The soil samples were collected at 0m, 10m, 20m and 30m away from each waste disposal sites and were Geo-referenced using Global Positioning System (GPS) coordinate data. Data for both seasons were analyzed and compared using statistical techniques such as range, mean, Standard deviation and t- test.

2. Results and Discussion

3.1 Distribution of Heavy Metals

Results of the distributions of heavy metals (Fe, Zn, Pb, Cr, Cd, Cu, As, Ni and Hg) in the study area in rainy season (Table 1)indicates that the distribution of heavy metals were generally low. Iron (Fe) ranged from 2.09-423 mg/Kg at dumpsites with mean concentration of 3.28 mg/Kg ±0.94 and coefficient of variation 0.88% for the top soils. The concentration in the sub-soils also ranged from 2.1-7.9 mg/Kg with mean concentration of 3.18 mg/Kg ± 1.59 and coefficient of variation 2.52%. The control site has values of 1.53 mg/Kg and 1.45 mg/Kg in the top and subsoil respectively. Zinc (Zn) ranged from 0.28-1.47mg/Kg at dumpsites with mean concentration of 0.78 ±0.40mg/Kg, and coefficient of variation 0.16% for the top soils. The concentration in the sub-soils also ranged from 0.34-1.38 mg/Kg with mean concentration of 0.75 mg/Kg ± 0.42 and coefficient of variation of 0.18%. The control site has values of 0.42 mg/Kg and 0.36 mg/Kg in the top and subsoil respectively. Lead (Pb) ranged from 0.02-0.71 mg/Kg at dumpsites with mean concentration of 0.22 mg/Kg ±0.26, and coefficient of variation 0.07% for the top soils. The concentration in the sub-soils also ranged from 0.02-0.37 mg/Kg with mean concentration of 0.12 mg/Kg ±0.14 and coefficient of variation 0.02%. The control site has values of 0.05 mg/Kg and 0.04mg/Kg in the top and subsoil respectively. Chromium (Cr) ranged from 0.02-0.72 mg/Kg at dumpsites with mean concentration of0.22 mg/Kg ±0.27, and coefficient of variation 0.07% for the top soils. The concentration in the sub-soils also ranged from 0.02-0.37 mg/Kg with mean concentration of 0.13 mg/Kg ±0.14 and coefficient of variation0.02%. The control site has value of 0.05 mg/Kg in both the top and sub soils.

Cadmium (Cd) ranged from 0.03-1.73mg/Kg at dumpsites with mean concentration of 1.18mg/Kg ±0.86, and coefficient of variation 0.74% for the top soils. The concentration in the sub-soils also ranged from 0.03-3.15mg/Kg with mean concentration of 1.08 mg/Kg ±0.99 and coefficient of variation 0.98%. The control site has values of 0.08 mg/Kg and 0.06 mg/Kg in the top and subsoil respectively. Copper (Cu) ranged from 1.12-2.02 mg/Kg at dumpsites with mean concentration of 1.84mg/Kg ±0.48, and coefficient of variation 0.23% for the top soils. The concentration in the sub-soils also ranged from 1.05-2.25mg/Kg with mean concentration of 1.61mg/Kg ±0.46 and coefficient of variation 0.21%. The control site has values of 1.36mg/Kg and 1.32mg/Kg in the top and subsoil respectively. Arsenic (As) ranged from 0.05-2.89mg/Kg at dumpsites with mean concentration of 0.85 mg/Kg ±0.98, and coefficient of variation 0.96% for the top soils. The concentration in the sub-soils also ranged from 0.04-2.25 mg/Kg with mean concentration of 0.63 mg/Kg 0.87± and coefficient of variation0.76%. The control site has values of 0.04 mg/Kg and 0.05mg/Kg in the top and subsoil respectively. Nickel (Ni) ranged from 0.17-0.78mg/Kg at dumpsites with mean concentration of 0.34 mg/Kg ±0.23, and coefficient of variation 0.05% for the top soils. The concentration in the sub-soils also ranged from 0.08-0.65mg/Kg with mean concentration of 0.28 mg/Kg ± 0.18and coefficient of variation 0.03%.

The control site has values of 0.07 mg/Kg and 0.06 mg/Kg in the top and subsoil respectively. Mercury (Hg) ranged from 0.01-1.01mg/Kg at dumpsites with mean concentration of 0.33mg/Kg ±0.39, and coefficient of variation 0.16% for the top soils. The concentration in the sub-soils also ranged from 0.04-0.95mg/Kg with mean concentration of 0.27mg/Kg ±0.36 and coefficient of variation0.13%. The control site has values of 0.01mg/Kg in both the top and sub soils. The study further reveals that heavy metals (Fe, Zn, Pb, Cr, Cd, Cu, As, Ni and Hg) distributions in soil were higher in the dumpsites than the control site. The concentration of heavy metals in the dumpsites samples was in the order of Fe >Cd> Cu > As>Zn> Ni> Hg >Pb. In fact, heavy metals were generally higher at dumpsites than control site. This agreed with many previous studies (Akinbile *et al*., 2016; Kanmani and Gandhimathi, 2013) that had blamed open waste dumping for soil contamination with heavy metals. Open waste dumping, industrial activities and vehicle emissions had been large contributors to the contamination of soil by metals (Akinbile *et al*., 2016). In the same vain, Monechot *et al.* (2018) posited that that chromium and cadmium could be introduced into soil through discarded rechargeable batteries, fabrics, tanned leather, stainless steel, dysfunctional electrical equipment such as alloys, and chromium and cadmium waste materials, which are used as anti-corrosive agents. The implication of heavy metal pollution of soil as documented in previous studies are numerous. For example, Ojuri and Oluwatuyi (2014) noted that pollution of soil with heavy metals will undermine its properties and finally, present a menace to the human health through the food chain. Akinbile *et al*., (2016) explained that some of these heavy metals (like iron and zinc) function as a nutrient at a certain concentration to living organisms, others have led to the contamination of groundwater over time. Thus, the presence of heavy metals in the soil should be closely monitored due to its toxicity at stipulated distributions and its bioaccumulation capacity as the presences of heavy metals can influence the concentration of other chemical properties of soil quality.

Table 1: Concentrations of Heavy Metals in the Study Area in Wet Season.

Parameters	**Unit**	**Depth**	**Mpape Dumpsite**				**Gwagwalada Dumpsite**				**Kubwa Dumpsite**								**Control**
			0m	20m	40m	60m	0m	20m	40m	60m	0m	20m	40m	60m	**Range**	**Mean**	**SD**	**COV**	
Fe	mg/Kg	0-15	2.22	4.33	2.09	3.34	4.12	2.12	4.22	4.12	4.23	3.3	3.12	2.09	2.09-4.23	3.28	0.94	0.88	1.53
		15-30	3.85	3.67	2.04	3.09	6.96	0.76	3.08	2.12	4.25	4.16	2.1	2.12	2.10-7.96	3.18	1.59	2.52	1.45
Zn		0-15	1.39	1.3	0.62	0.54	0.63	0.59	0.28	0.33	1.47	0.77	0.75	0.64	0.28-1.47	0.78	0.40	0.16	0.42
		15-30	1.28	1.38	0.55	0.57	0.69	0.47	0.04	0.34	1.37	0.89	0.77	0.61	0.34-1.38	0.75	0.42	0.18	0.36
Pb		0-15	0.36	0.71	0.02	0.02	0.35	0.69	0.32	0.04	0.03	0.06	0.02	0.02	0.02-0.71	0.22	0.26	0.07	0.05
		15-30	0.35	0.06	0.08	0.01	0.34	0.05	0.37	0.03	0.03	0.04	0.06	0.02	0.02-0.37	0.12	0.14	0.02	0.04

Cr		0-15	0.36	0.72	0.02	0.02	0.35	0.7	0.32	0.04	0.03	0.07	0.02	0.02	0.02-0.72	0.22	0.27	0.07	0.05
		15-30	0.36	0.07	0.08	0.01	0.35	0.06	0.37	0.03	0.04	0.05	0.06	0.02	0.02-0.37	0.13	0.14	0.02	0.05
Cd		0-15	1.73	2.35	1.23	0.09	2.24	1.24	0.51	0.03	1.98	1.8	0.87	0.06	0.03-1.73	1.18	0.86	0.74	0.08
		15-30	3.15	1.27	0.96	0.1	2.22	0.97	0.53	0.03	2.22	1	0.4	0.07	0.03-3.15	1.08	0.99	0.98	0.06
Cu		0-15	2.02	2.01	1.92	1.45	1.88	1.59	1.65	1.12	2.89	2.47	1.77	1.35	1.12-2.02	1.84	0.48	0.23	1.36
		15-30	2.02	2.08	1.23	1.32	1.6	1.9	1.19	1.05	2.25	2.22	1.05	1.37	1.05-2.25	1.61	0.46	0.21	1.32
As		0-15	0.09	0.09	0.07	0.05	0.78	0.43	0.26	0.19	2.89	2.22	1.77	1.37	0.05-2.89	0.85	0.98	0.96	0.04
		15-30	0.09	0.1	0.07	0.04	0.09	0.1	0.07	0.05	2.25	2.22	1.05	1.37	0.04-2.25	0.63	0.87	0.76	0.05
Ni		0-15	0.71	0.46	0.22	0.13	0.78	0.29	0.14	0.17	0.59	0.29	0.18	0.17	0.17-0.78	0.34	0.23	0.05	0.07
		15-30	0.59	0.43	0.08	0.18	0.65	0.29	0.26	0.16	0.28	0.19	0.2	0.1	0.08-0.65	0.28	0.18	0.03	0.06
Hg		0-15	1.01	0.09	0.02	0.20	1.00	0.08	0.01	0.19	0.93	0.19	0.10	0.19	0.01-	0.33	0.39	0.16	0.01

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		15-30	0.95	0.03	0.03	0.20	0.94	0.02	0.02	0.19	0.65	0.04	0.04	0.15	0.04-0.95	0.27	0.36	0.13	0.01

Result in table 2 present the concentrations of Heavy Metals in the Study Area in dry Season.

Table 2: Concentrations of Heavy Metals in the Study Area in Dry Season.

Parameter		**Depth**	**Nyanya Dumpsite**				**Karshi Dumpsite**				**Mpape Dumpsite**								
	Unit		**0m**	**10m**	**20m**	**30m**	**0m**	**10m**	**20m**	**30m**	**0m**	**10m**	**20m**	**30m**					
			0m	20m	40m	60m	0m	20m	40m	60m	0m	20m	40m	60m	**Range**	**Mean**	**SD**	**COV**	**Control**
Fe	mg/Kg	0-15	5.22	4.33	2.59	3.34	4.12	2.82	3.42	4.82	4.23	3.07	3.12	2.09	2.09-5.22	3.60	0.95	0.89	1.53
		15-30	4.85	3.97	3.04	3.39	5.06	2.76	3.08	3.32	4.25	3.16	3.01	2.12	2.12-5.06	3.55	0.87	0.75	1.45
Zn		0-15	1.69	1.73	0.62	0.59	0.69	0.79	0.58	0.63	1.37	0.79	0.95	0.68	0.58-1.73	0.93	0.43	0.18	0.42
		15-30	1.48	1.58	0.55	0.58	0.69	0.49	0.34	0.64	1.07	0.69	0.87	0.51	0.49-1.58	1.28	2.88	8.30	0.36
Pb		0-15	0.56	0.91	0.04	0.05	0.37	0.71	0.34	0.06	0.05	0.08	0.04	0.04	0.04-0.91	0.27	0.31	0.09	0.05
		15-30	0.35	0.06	0.08	0.01	0.34	0.05	0.37	0.03	0.03	0.04	0.06	0.02	0.01-0.37	0.20	0.14	0.02	0.04
Cr		0-15	0.36	0.72	0.21	0.02	0.35	0.7	0.32	0.04	0.03	0.07	0.02	0.02	0.02-0.72	0.24	0.26	0.07	0.05

		15-30	0.26	0.09	0.08	0.01	0.35	0.06	0.35	0.04	0.05	0.07	0.08	0.04	0.01-0.35	0.18	0.12	0.02	0.05
Cd		0-15	1.73	2.35	1.23	0.09	2.24	1.24	0.51	0.03	1.98	1.8	0.87	0.06	0.03-2.35	1.18	0.86	0.74	0.08
		15-30	3.15	1.27	0.96	0.1	2.22	0.97	0.53	0.03	2.22	1	0.4	0.07	0.03-3.15	1.13	0.99	0.98	0.06
Cu		0-15	2.02	2.01	1.92	1.45	1.88	1.59	1.65	1.12	2.89	2.47	1.77	1.35	1.12-2.47	1.84	0.48	0.23	1.36
		15-30	2.02	2.08	1.23	1.32	1.6	1.9	1.19	1.05	2.25	2.22	1.05	1.37	1.05-2.23	1.73	0.46	0.21	1.32
As		0-15	0.09	0.09	0.07	0.05	0.78	0.43	0.26	0.19	2.89	2.22	1.77	1.37	0.05-2.89	0.85	0.98	0.96	0.04
		15-30	0.09	0.1	0.07	0.04	0.09	0.1	0.07	0.05	2.25	2.22	1.05	1.37	0.04-2.25	0.74	0.87	0.76	0.05
Ni		0-15	0.71	0.46	0.22	0.13	0.78	0.29	0.14	0.17	0.59	0.29	0.18	0.17	0.13-0.59	0.34	0.23	0.05	0.07
		15-30	0.59	0.43	0.08	0.18	0.65	0.29	0.26	0.16	0.28	0.19	0.2	0.1	0.08-0.65	0.31	0.18	0.03	0.06
Hg		0-15	1.01	0.09	0.02	0.20	1.00	0.08	0.01	0.19	0.93	0.19	0.10	0.19	0.01-1.01	0.33	0.39	0.16	0.01
		15-30	0.95	0.03	0.03	0.20	0.94	0.02	0.02	0.19	0.65	0.04	0.04	0.15	0.03-0.95	0.30	0.36	0.13	0.01

Table 2 present the concentrations of heavy metals (Fe, Zn, Pb, Cr, Cd, Cu, As, Ni and Hg) in the study area in dry Season as follows:

The concentrations of heavy metals were generally low. Iron (Fe) ranged from 2.09-5.22 mg/Kg at dumpsites with mean value of 3.60mg/Kg ±0.94, and coefficient of variation 0.89% for the top soils. The concentration in the sub soils also ranged from 2.12-5.06mg/Kg 6 with mean value of 3.55 mg/Kg ± 0.87 and coefficient of variation 0.75%. The control site has values of 1.53 mg/Kg and 1.45 mg/Kg in the top and subsoil respectively. Zinc (Zn) ranged from 0.58-1.73mg/Kg at dumpsites with mean value of 0.93mg/Kg ±0.43, and coefficient of variation 0.18% for the top soils. The concentration in the sub soils also ranged from 0.49-1.58mg/Kg with mean value of 1.28mg/Kg ± 2.88 and coefficient of variation 8.30%. The control site has values of 0.42mg/Kg and 0.36mg/Kg in the top and subsoil respectively. Lead (Pb) ranged from 0.04-0.91mg/Kg at dumpsites with mean value of 0.27mg/Kg ±0.31 and coefficient of variation0.09 % for the top soils. The concentration in the sub soils also ranged from 0.01-0.37mg/Kg with mean value of 0.20mg/Kg ± 0.14 and coefficient of variation 0.02%. The control site has values of 0.05mg/Kg and 0.04mg/Kg in the top and subsoil respectively. Chromium (Cr) ranged from 0.02-0.72mg/Kg at dumpsites with mean value of0.24 mg/Kg ±0.26, and coefficient of variation 0.07% for the top soils. The concentration in the sub soils also ranged from 0.01-0.35mg/Kg with mean value of 0.18mg/Kg ± 0.12and coefficient of variation 0.02%. The control site has values of 0.05mg/Kg in both the top and subsoil. Cadmium (Cd) ranged from 0.03-2.35mg/Kg at dumpsites with mean value of 1.18mg/Kg ±0.86, and coefficient of variation 0.74% for the top soils.

Furthermore, the concentration in the sub soils also ranged from 0.03-3.15mg/Kg with mean value of1.13 mg/Kg ±0.99 and coefficient of variation0.98%. The control site has values of 0.08mg/Kg and0.06 mg/Kg in the top and subsoil respectively. Copper (Cu) ranged from 1.12-2.47mg/Kg at dumpsites with mean value of 1.84mg/Kg ±0.48, and coefficient of variation 0.23% for the top soils. The concentration in the sub soils also ranged from 1.05-2.23mg/Kg with mean value of 1.73mg/Kg ±0.46 and coefficient of variation0.21%. The control site has values of 1.36mg/Kg and 1.32mg/Kg in the top and subsoil respectively. Arsenic (As) ranged from 0.05-2.89mg/Kg at dumpsites with mean value of 0.85mg/Kg ±0.98, and coefficient of variation 0.96% for the top soils. The concentration in the sub soils also ranged from 0.04-2.25mg/Kg with mean value of 0.74mg/Kg ± 0.87and coefficient of variation0.76%. The control site has values of 0.04 mg/Kg and 0.05mg/Kg in the top and subsoil respectively. Nickel (Ni) ranged from 0.13-0.59mg/Kg at dumpsites with mean value of 0.34mg/Kg ±0.23, and coefficient of variation % for the top soils. The concentration in the sub soils also ranged from 0.08-0.65mg/Kg with mean value of 0.31mg/Kg ± 0.18 and coefficient of variation 0.03%. The control site has values of 0.07mg/Kg and 0.06mg/Kg in the top and subsoil respectively. Likewise, Mercury (Hg) ranged from 0.01-1.01mg/Kg at dumpsites with mean value of 0.33mg/Kg ±0.39, and coefficient of variation 0.16% for the top soils. The concentration in the sub soils also ranged from 0.03-0.95mg/Kg with mean value of 0.30mg/Kg ± 0.36 and coefficient of variation0.13%. The control site has values of 0.01mg/Kg in both top and subsoil respectively.

3.2 The Seasonal Distribution of Physical and Chemical Properties of Soils at Dumpsites in the Study Area

Represented in Table 3 is the result of the Seasonal Distribution of Physical and Chemical Properties of Soils at Dumpsites in the Study Area.

Table 3: Seasonal Distribution of Physical and Chemical Properties of Soil at Dumpsites in the Study Area

Parameter	RAINY	DRY	Calculated t Value	Table t value value
pH	7.01	5.98	1.12	2.13
EC (µS/Cm)	932.20	906.86	0.03	2.13
OM (%)	4.60	4.58	0.00	2.13
N%	0.35	0.38	0.01	2.13
$NO3^{-}$(mg/Kg)	10.96	1.34	0.00	2.13
P (mg/Kg)	3.20	3.58	0.00	2.13
K(mg/Kg)	12.96	14.26	0.93	2.13
Ca(mg/Kg)	14.00	14.38	0.02	2.13
Mg(mg/Kg)	3.81	4.19	0.04	2.13
Na(mg/Kg)	18.18	18.53	0.00	2.13
CEC(%)	5.99	5.39	0.01	2.13
Fe(mg/Kg)	1.24	2.78	0	2.13
Zn(mg/Kg)	0.72	0.81	0.001	2.13
Pb(mg/Kg)	0.65	0.04	0.002	2.13
Cr(mg/Kg)	1.34	0.04	0.12	2.13
Cd(mg/Kg)	0.85	0.88	0.00	2.13
Cu(mg/Kg)	0.75	1.79	0.00	2.13
As(mg/Kg)	0.71	1.53	0.00	2.13
Ni(mg/Kg)	1.56	0.21	0.00	2.13
Hg(mg/Kg)	1.15	0.23	0.01	2.13

Comparisons between rainy and dry seasons are illustrated in figure 1 and discussed further.

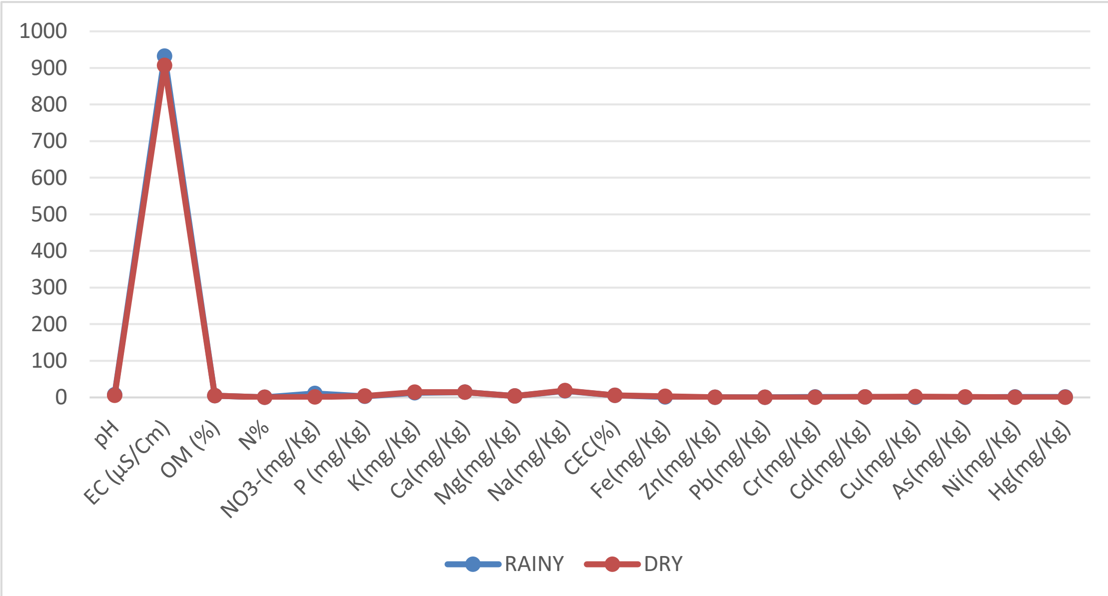

Figure 1. Comparison between rainy and dry seasons

PH: The mean concentration of soil pH in rainy season is 7.01 but 5.98 in dry season which suggest that pH is higher in rainy season. However, the calculated t vale of 1.12 is less than table t value of 2.13. Since the calculated 't' is less than table t value, the Ho, there is no significant difference in soil properties between dry and rainy season samples at 95% significant level is accepted for pH. Thus, pH concentration soil at dumpsites in the study area did not differ significantly between dry and rainy seasons.

EC: The mean concentration of soil EC in rainy season was 932.20µS/Cm but 906.86µS/Cm in dry season which suggest that EC is higher in rainy season. However, the calculated t value of 0.03is less than table t value of 2.13. Since the calculated 't' is less than table t, the Ho, there is no significant difference in soil properties between dry and rainy season samples at 95% significant level is accepted for EC. Thus, EC concentration soil at dumpsites in the study area did not differ significantly between dry and rainy seasons.

OM: The mean concentration of soil OM in rainy season is 4.60% but 4.58% in dry season which suggest that OM is higher in wet season. However, the calculated t value of 0.00 is less than table t value of2.13. Since the calculated't' is less than table t value, the HO, there is no significant different in soil properties between raining and dry season samples at 95% significant level is accepted for OM. Thus, OM concentration in soil at dumpsites in the study area did no differ significantly between dry and wet seasons.

N%: The mean concentration of soil N% in rainy season is 0.35% but 0.38% in dry season which suggest that N% is higher in dry season. However, the calculated t vale of 0.01 is less than table t value of2.13. Since the calculated 't' is less than table t value, the Ho, there is no significant difference in soil properties between dry and rainy season samples at 95% significant level is accepted for N%. Thus, N% concentration soil at dumpsites in the study area did not differ significantly between dry and rainy seasons.

$NO3^-$: The mean concentration of soil $NO3^-$ in rainy season is 10.96 mg/Kg but 1.34 mg/Kg in dry season which suggest that $NO3^-$ is higher in dry season. However, the calculated t vale of 0.00 is less than table t value of 2.13. Since the calculated 't' is less than table t, the Ho, there is no significant difference in soil properties between dry and rainy season samples at 95% significant level is accepted for $NO3^-$. Thus, $NO3^-$ concentration soil at dumpsites in the study area did not differ significantly between dry and rainy seasons.

P: The mean concentration of soil P in rainy season is 3.20 mg/Kg but 3.58 mg/Kg in dry season which suggest that P is higher in dry season. However, the calculated t vale of 0.00 is less than table t value of2.13. Since the calculated 't' is less than table t, the Ho, there is no significant difference in soil properties between dry and rainy season samples at 95% significant level is accepted for P. Thus, P concentration soil at dumpsites in the study area did not differ significantly between dry and rainy seasons.

K: The mean concentration of soil P in rainy season is 12.96 mg/Kg but 14.26 mg/Kg in dry season which suggest that K is higher in dry season. However, the calculated t vale of 0.93 is less than table t value of2.13. Since the calculated 't' is less than table t, the Ho, there is no significant difference in soil properties between dry and rainy season samples at 95% significant level is accepted for K. Thus, K concentration soil at dumpsites in the study area did not differ significantly between dry and rainy seasons.

Ca: The mean concentration of soil P in rainy season is 14.00 mg/Kg but 14.38 mg/Kg in dry season which suggest that Ca is higher in dry season. However, the calculated t vale of 0.02 is less than table t value of2.13. Since the calculated 't' is less than table t, the Ho, there is no significant difference in soil properties between dry and rainy season samples at 95% significant level is accepted for Ca. Thus, Ca concentration soil at dumpsites in the study area did not differ significantly between dry and rainy seasons.

Mg: The mean concentration of soil pH in rainy season is 3.81 mg/Kg but 4.19 mg/Kg in dry season which suggest that Mg is higher in dry season. However, the calculated t vale of 0.04 is less than table t value of2.13. Since the calculated 't' is less than table t, the Ho, there is no significant difference in soil properties between dry and rainy season samples at 95% significant level is accepted for Mg. Thus, Mg concentration soil at dumpsites in the study area did not differ significantly between dry and rainy seasons.

Na: The mean concentration of soil Na in rainy season is 18.18 mg/Kg but 18.53 mg/Kg in dry season which suggest that Na is higher in dry season. However, the calculated t vale of 0.00 is less than table t value of 2.13. Since the calculated 't' is less than table t, the Ho, there is no significant difference in soil properties between dry and rainy season samples at 95% significant level is accepted for Na. Thus, Na concentration soil at dumpsites in the study area did not differ significantly between dry and rainy seasons.

CEC: The mean concentration of soil CEC in rainy season is 5.99% but 5.39% in dry season which suggest that CEC is higher in rainy season. However, the calculated t vale of 0.01 is less than table t value of 2.13. Since the calculated 't' is less than table t, the Ho, there is no significant difference in soil properties between dry and rainy season samples at 95% significant level is accepted for CEC. Thus, CEC concentration soil at dumpsites in the study area did not differ significantly between dry and rainy seasons.

Fe: The mean concentration of soil Fe in rainy season is 1.24 mg/Kg but 2.78 mg/Kg in dry season which suggest that Fe is higher in dry than wet season. However, the calculated t vale of 0.00 is less than table t value of2.13. Since the calculated 't' is less than table t, the Ho, there is no significant difference in soil properties between dry and rainy season samples at 95% significant level is accepted for Fe. Thus, Fe concentration soil at dumpsites in the study area did not differ significantly between dry and rainy seasons.

Zn: The mean concentration of soil Zn in rainy season is 0.72 mg/Kg but 0.81 mg/Kg in dry season which suggest that Zn is higher in dry season. However, the calculated t vale of 0.001 is less than table t value of2.13. Since the calculated 't' is less than table t, the Ho, there is no significant difference in soil properties between dry and rainy season samples at 95% significant level is accepted for Zn. Thus, Zn concentration soil at dumpsites in the study area did not differ significantly between dry and rainy seasons.

Pb: The mean concentration of soil Pb in rainy season was 0.65 mg/Kg but 0.04 mg/Kg in dry season which suggest that Pb is higher in dry season. However, the calculated t vale of 0.002 is less than table t value of2.13. Since the calculated 't' is less than table t, the Ho, there is no significant difference in soil properties between dry and rainy season samples at 95% significant level is accepted for Pb. Thus, Pb concentration soil at dumpsites in the study area did not differ significantly between dry and rainy seasons.

Cr: The mean concentration of soil Cr in rainy season is 1.34 mg/Kg but 0.04 mg/Kg in dry season which suggest that Cr is higher in dry season. However, the calculated t vale of 0.12 is less than table t value of2.13. Since the calculated 't' is less than table t, the Ho, there is no significant difference in soil properties between dry and rainy season samples at 95% significant level is accepted for Cr. Thus, Cr concentration soil at dumpsites in the study area did not differ significantly between dry and rainy seasons.

Cd: The mean concentration of soil Cd in rainy season is 0.85 mg/Kg but 0.88 mg/Kg in dry season which suggest that Cd is higher in dry season. However, the calculated t vale of 0.00 is less than table t value of2.13. Since the calculated 't' is less than table t, the Ho, there is no significant difference in soil properties between dry and rainy season samples at 95% significant level is accepted for Cd. Thus, Cd concentration soil at dumpsites in the study area did not differ significantly between dry and rainy seasons.

Cu: The mean concentration of soil Cu in rainy season is 0.75 mg/Kg but 1.79 mg/Kg in dry season which suggest that Cu is higher in dry season. However, the calculated t vale of 0.00 is less than table t value of2.13. Since the calculated ‘t’ is less than table t, the Ho, there is no significant difference in soil properties between dry and rainy season samples at 95% significant level is accepted for Cu. Thus, Cu concentration soil at dumpsites in the study area did not differ significantly between dry and rainy seasons.

As: The mean concentration of soil As in rainy season is 0.71 mg/Kg but 1.53 mg/Kg in dry season which suggest that As is higher in rainy season. However, the calculated t vale of 0.00 is less than table t value of2.13. Since the calculated ‘t’ is less than table t, the Ho, there is no significant difference in soil properties between dry and rainy season samples at 95% significant level is accepted for As. Thus, As concentration soil at dumpsites in the study area did not differ significantly between dry and rainy seasons.

Ni: The mean concentration of soil Ni in rainy season is 1.56 mg/Kg but 0.21 mg/Kg in dry season which suggest that Ni is higher in rainy season. However, the calculated t vale of 0.00 is less than table t value of2.13. Since the calculated ‘t’ is less than table t, the Ho, there is no significant difference in soil properties between dry and rainy season samples at 95% significant level is accepted for Ni. Thus, Ni concentration soil at dumpsites in the study area did not differ significantly between dry and rainy seasons.

Hg: The mean concentration of soil Hg in rainy season is 1.15 mg/Kg but 0.23 mg/Kg in dry season which suggest that Hg is higher in rainy season. However, the calculated t vale of 0.01 is less than table t value of2.13. Since the calculated ‘t’ is less than table t, the Ho, there is no significant difference in soil properties between dry and rainy season samples at 95% significant level is accepted for Hg. Thus, Hg concentration soil at dumpsites in the study area did not differ significantly between dry and rainy seasons.

4. Conclusion and Recommendations

The adverse effect attendant upon the indiscriminate and improper disposal of municipal solid waste is a challenge that requires urgent and collective measures to abate. Solid waste are considered injurious to man and the society; hence this study. The finding in this research shows concentrations of heavy metal in soils in the study area differ between rain and dry seasons but none vary significantly at 95% confidence level. Illegal disposal of toxic wastes in dumpsites should be discouraged so that dumpsites can be used for farming. Construction of future dumpsites in the area should follow the design of a modern sanitary landfill system that guarantee protection to the soil. Future dumpsites should be located in clay soil to reduce infiltration of leachate. Residents should sort their waste to avoid dumping toxic substance alongside with organic matter that act as manure in the dump site.

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