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Assessment of Plant Species and Physico-chemical Properties of Three Landfills in Lagos, Nigeria

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ABSTRACT
Indiscriminate disposal of municipal solid waste (MSW) poses significant environmental risks due to heavy metal accumulation in soils. This study assessed phytodiversity and physicochemical properties of soils from three dumpsites in Lagos State, Nigeria (Ajelogo, Oworonshoki, and University of Lagos), alongside a control site. Soil samples were collected at 0–10 cm depth using a calibrated auger at 40 m intervals, while plant diversity was assessed using quadrat sampling. Physicochemical parameters and heavy metals were analysed using standard procedures, including Atomic Absorption Spectrophotometry (AAS). Data were analysed using descriptive statistics and one-way ANOVA at a 0.05 significance level. Fourteen taxa across eight families were recorded, with Poaceae and Amaranthaceae dominating. Amaranthus spinosus, A. viridis, and Commelina benghalensis were widely distributed. Soil pH ranged from 7.04 to 7.89, indicating neutral to slightly alkaline conditions. Total organic carbon (0.91–2.06%) and nitrogen (0.21–0.95%) were higher in dumpsites than in the control. Heavy metals such as Cr, Fe, and Zn were elevated across sites. Although most heavy metal concentrations were within permissible limits for compost use, their accumulation suggests potential ecological risks. Dumpsite soils supported plant growth but are unsuitable for agriculture due to contamination concerns. Improved waste management practices, including sanitary landfill development and waste segregation, are recommended to reduce environmental impact.

Keywords: Leachate, Dumpsite, Physicochemical, Phytodiversity.

INTRODUCTION
The world population is currently over 8 billion and is expected to increase further by 2050. This increase in population has been directly correlated to increase in the quantity of waste generated per household (Vaverkova *et al*., 2020). Majorly because of industrialization and an improved standard of living (Vaverkova *et al*., 2020). Municipal solid waste (MSW) generation has been further enhanced by the rapid rate of urbanization, socioeconomic development and improve standard of living (Mohammad *et al*., 2019). Waste generation has been established to have a direct correlation to population composition, size and per capital income (Triassi *et al*., 2015). Solid wastes other than hazardous or radioactive wastes are often referred to as municipal waste. Municipal solid waste are useless unwanted materials discharged as a result of human activity which commonly may be solids, semi solids or liquids in containers thrown out of houses, commercials or industrial premises (Mahoun-Chouaki *et al*., 2019; Mohammed *et al*., 2019).

These MSW has continued to be a major environmental concern all over the world as indiscriminate disposal had characterized our major towns and cities. In Nigeria for instance, all major cities are faced with waste disposal issues and the management of this waste remains a humongous task (Agbeshie *et al*., 2020). The management of MSW is faced with many difficulties from the technical and economical sides as well as from the methodological and organizational sides. In seeking for a way of disposing this waste, many communities resolve to the use of open landfills (dumpsite) for the disposal and elimination of the wastes generated (Agbeshie *et al.*, 2020). The consequence of this indiscriminate waste disposal is leachates contamination of ground waters, foul smells and general environmental pollution. Hazardous substances including heavy metals are thereafter introduced into water and soil ecology leading to potential bioaccumulation of these substances (Avilara *et al.*, 2020). Improper waste management has been established to be detrimental to human health as incorrectly secured and improperly operated municipal solid waste (MSW) landfills pose a serious threat to the environment, mainly to surface and ground waters (Avilara *et al.*, 2020).

Many studies have reported the presence of heavy metals in most of the leachates and soil from dumpsites. For instance, Nwaogu *et al.* (2017) reported significant number of heavy metals that is higher than the EU and Canadian environmentally permissible limits in dumpsites near main roads linking major cities in Nigeria. A significant relationship was also observed in the number of plant species in the dumpsites in comparison with the control area. Chizuoro *et al* (2017) reported that despite the presence of heavy metals in the dumpsites in Owerri, Imo state, the area was unpolluted and safe for use based on the pollution load indices and Ecological risk models applied to the study.

In another study by Ogundiran and Afolabi (2008), Zn (0.264-0.94) was observed to be the most dominant heavy metals while Cd (0.001-0.022) was identified to be the least abundant in the dumpsite. The presence of some heavy metals such as Pb, Cd and Zn was observed to have a significant correlation with chemical oxygen demand and oil grease. In another study, Essien and Hanson (2013) while assessing the physico-chemical properties of dumpsites and around surroundings reported that the properties tested registered a strong correlation within and significant differences with the exception of K and Ea between the soils. The assessment of the physico-chemical properties and species diversity is imperative to investigate the relative amounts and distribution of heavy metals, and other properties in dump sites from different human activities.

MATERIALS AND METHODS

Study area

The leachates samples were collected from three dumpsites within Lagos metropolis in Lagos State, (Oworonsoki, Mile 12 (Owode elede) and University of Lagos dumpsites) Nigeria. The control soil samples were collected randomly at a depth of 6-8cm on a non-dumpsite located about 200m away from the dumpsites in the University of Lagos Campus, Akoka Yaba Lagos.

Soil sample collection: Samples were collected at 0–10 cm depth using an auger, composited in triplicates, and analysed.

Plant diversity: Quadrat method (50 × 50 m) was used. Ten quadrats were sampled per site. Species were identified at UNILAG Herbarium.

Determination of physicochemical characteristics of soil: The soil texture and nutrient status were determined using standard method as outlined in the International Institute of Tropical Agriculture (IITA) 'Selected Materials for Soil and Plant Analysis (1991).

Determination of soil pH: The pH of the soil sample was determined using a pH meter, model HANNA HI8314. One gram of each soil sample was weighed and mixed in distilled water. Prior to which the pH meter was standardised to pH 7 with the standardizing buffer. The measurements were taken in triplicate, and corresponding readings were recorded.

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Figure 1: Map of Lagos metropolis showing the study area

Determination of total nitrate in soil samples: Total nitrogen in soil was determined using the Macro-Kjeldahl digestion method (Black, 1965). 2g of the ground soil samples were weighed in triplicate and transferred to 500ml conical flask, and 20ml of concentrated H_2SO_4 and some Kjeldahl catalyst tablets or 1g catalyst mixture were added to each soil sample. Thereafter, 0.5g of mixture was weighed into 50ml Kjeldah flask and 10ml of conc. H_2SO_4 was added to one Kjeldahl catalyst mixture. Thereafter, the mixture in the flask was heated on the digestion stand until the solution became clear and the remaining soil residue became whitish. The mixture was heated further for a few minutes in order to ensure complete digestion. The mixture was allowed to cool, and 50 ml de-ionized water was added, mixed very well and filtered after further cooling. The mixture was thereafter transferred into a 100ml volumetric flask and made up to 100ml mark with de-ionized water. Blank digestion was carried out using all reagents and the steps, except without soil samples.

Determination of total phosphate in the soil samples: The total phosphorus (phosphate) in the soil samples was determined using colorimetric determination after a recommended digestion. 5g of soil samples which was passed through 2mm sieve was weighted and 35ml of extracting solution (containing 30ml of 1M NH_4F and 50ml of 0.5MHCL and made up to 1liter) and shook for 1min and filtered. Thereafter, the available phosphorus was determined using a spectrophotometer.

Determination of total carbon: The ammonium acetate method was used to determine the cation exchange capacity and the available potassium in soil. 5g of the ground soil samples was weighed in triplicate and transferred to 250ml conical flask, and 10ml of 0.167M$K_3Cr_2O_2$ was added. Thereafter, 20ml conc. H_2SO_4 was added rapidly, and the flask were swirled gently until the soil and reagent were mixed thoroughly. The flask was swirled more vigorously for one minute. Subsequently the flask was rotated again and allowed to stand on a sheet of asbestos for about 30mins. 10mls was added after standing for 30 min. Thereafter, 3-4 drops of ferroin indicator were added and 0.5M Iron (III) ammonium sulphate was or Iron (II) sulphate takes a greenish cast and then changes to dark green. Thereafter, ferrous phosphate was added drop by drop until the sharp colour changed from

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green to brownish red (maroon colour in reflected light against a white background) was noted. A blank titration was prepared in triplicates and step 3, 4, 5 and 6 were repeated to standardize the iron (II) solution. The average of blank was recorded and determined.

Determination of heavy metals in soil samples

Sample digestion: Wet digestion method was used for digestion of the soil samples. 0.5 g of each of the air-dried, ground, and sieved soil samples was accurately weighted into a digestion tube. 6 ml aqua regia and 1.5 ml H_2 O_2 were measured and added into the digestive tube and swirled gently to mix the sample properly. The digestion tubes were then placed on digestive furnace (Model: KDN-20C, China) and heated at a temperature of 180°C for 3 h. All the digests were cooled and filtered through Whatman No.42 filter paper and diluted to 50 ml by double distilled water. Each sample was digested in replicates of three and transferred to acid-washed stoppered glass bottle, labelled and kept for metal analysis.

Determination of heavy metals: The instrument was calibrated using calibration blank and five series of working standard solutions of each metal to be analysed. The digested samples were determined for the concentrations of heavy metals (Fe, Zn Mn, Cu, Ni, Cd, and Pb) using flame atomic absorption spectrophotometer (FAAS, Model: AA-320N, Shanghai, China). Final concentrations of the metals in the soil samples were calculated using the following formula:

$$\text{Concentration (mg/kg)} = \frac{\text{concentration}\left(\frac{mg}{L}\right)\times V}{W} \text{ -------------------- (1)}$$

Where V = Final volume (50 ml) of solution, and M = Initial weight (0.5 g) of sample measured.

Statistical analyses

One-way ANOVA ($p \leq 0.05$), Tukey HSD; diversity indices computed using PAST software.

RESULTS AND DISCUSSION

Phytodiversity

The phyto-diversity and richness are presented in Table 1. with a total of fourteen taxa distributed among eight families. The most widely represented families observed were the Poaceae and the *Amaranthaceae. Amaranthus spinosus* and *Amaranthus viridis* as well as *Commelina sp.* were observed to be present in all collection sites/ studied area in different distribution. While *Cellosia argentia* was found in the control site as well as UNILAG dumpsite. The Ajelogo dumpsite had fewest distribution of plants (Table 2). The low plant distribution of plants in this dumpsite may be attributed to the high commercial activities in the location. UNILAG dumpsite has the highest Shannon H index value (1.92) compared to the other dumpsite sites with Ajelogo dumpsite showing the lowest value (0.97). The highest Dominance D value (0.40) was observed in Ajelogo dumpsite while the lowest value (0.16) was found in UNILAG dumpsite. *A. viridis* was observed to be present across the dumpsites and the control sites in abundantly. An indication of the high resilience of the plant species to withstand different conditions prevailing in the sites. While the other plant species were found scantly in the different sites

Physico-chemical analysis

The results of the physico-chemical properties of the soil samples are presented in table 4. The pH values ranged from 7.04 to 8.2 across all the dumpsites with mean and standard deviation value of 7.8. The Ajelogo dumpsite has the highest pH value of 8.65 while UNILAG dumpsite has the lowest value of 7.04. The total organic carbon (TOC) and total organic matter (TOM) were also higher in the Ajelogo (Mile 12) dumpsite 2.06 in

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comparison to other dumpsites and the non-dumpsite. However, TOM of the soil collected from Oworonsoki dumpsite also showed a higher value (2.68) compared to the control site (Non-dumpsite). The Cation Exchanges Capacity (CEC) of the waste soils ranged from 11.04 to 11.79 C mol kg^{-1}, with dumpsite Ajelogo (Mile 12) and Oworonsoki dumpsite having the lowest and highest exchangeable cations, (11.04 and 11.79) respectively. In the present study, soil pH (in H_2O) ranged from 4.89±0.05 in the control to 7.60±0.02 in the dump indicating a moderate acidic to a neutral reaction.

Table 1: Floristic list of the collection sites

s/n	Species	Family
	Acanthospermum hispidum DC	Asteraceae
2	*Alysicarpus ovalifolius*	Fabaceae
3	*Amaranthus spinosus* L	Amaranthaceae
4	*Amaranthus viridis* L.	Amaranthaceae
5	*Celossia argetia*	Amaranthaceae
6	*Tridax procumbiens*	Rubiaceae
7	*Ellusine indica*	Rubiaceae
8	*Cassia mimosoides L*	Caesalpiniaceae
9	*Cassia occidentalis* L	Caesalpiniaceae
10	*Celosia trygina*L.	Amaranthaceae
11	*Cenchrus biflorus* Roxb	Poaceae
12	*Ceratotheca sesamoides* Endl.	Pedaliaceae
13	*Citrullus colocynthis*(L.) Schard.	Cucurbitaceae
14	*Citrullus lanatus* (thunb.)	Cucurbitaceae
15	*Cleome viscosa*	Apparidaceae
16	*Commelina benghalensis* L	Commelinaceae
17	*Pannicum maximum*	Poacea
18	*Commelina sp*	Poaceae

Table 2: Distribution of plants species and family found on the study area

Species	Ndps	Owo	UNILAG	Ajelogo
Acanthospermum hispidum	25	1	0	0
Alysicarpus ovalifolius	10	0	10	0
Amaranthus spinosus L.	60	12	16	5
Amaranthus viridis L.	64	16	24	20
Celossia argetia.	12	0	12	0
Tridax procumbiens	10	0	1	0
Ellusine indica	8	0	1	0
Cassia mimosoides L	10	0	12	0
Cassia occidentalis L	8	0	0	0
Celosia trygina L	15	12	0	0
Cenchrus biflorus	55	30	36	0
Digitaria horizontalis Wild	50	41	16	0
Commelina sp	64	25	20	16
Eleusine indica (L.) Gaertn	10	0	0	0

The high alkalinity observed in this study is an indication of accumulated organic compounds in the soil and agrees with the results obtained by Essien and Hanson (2013)

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and Isimirah (2000) and that of Adeolu *et al* (2017). This suggests that the dumpsites were mostly alkaline in nature. Similar results were reported for dumpsites by other researchers such as Gupta and Sinha, 2006 and Elaigwu *et al*., 2007 as well as Uba *et al*., 2008. The degree of acidity and/or alkalinity is considered a master variable that affects nearly all soil properties-chemical, physical and biological while some organisms are unaffected by a rather broad range of pH values, others may exhibit considerable intolerance to even minor variations in pH.The mobility of heavy metals is enhanced at pH >7 than pH<7 which is hazardous for farming as crops are take up heavy metals and subsequently leading to bioaccumulation of heavy metals across the food chain. This study agrees with the study of Fonge et al (2017) and Srivastava (2012) who also reported weak acidity of the dumpsites/landfills and suggested that the high alkalinity of the landfills is as a result of agricultural imputs such as pesticides, fungicides and fertilizers.

Table 3: Alfa diversity Indices of the studied sites

	Ndps	Oworonshoki	UNILAG	Ajelogo
Taxa_S	14	8	9	3
Individuals	401	149	136	41
Dominance_D	0.11	0.17	0.16	0.40
Simpson_1-D	0.88	0.82	0.83	0.59
Shannon_H	2.32	1.85	1.92	0.97
Evenness_e^H/S	0.73	0.80	0.75	0.88
Brillouin	2.25	1.76	1.81	0.88
Menhinick	0.69	0.65	0.77	0.46
Margalef	2.16	1.39	1.62	0.53
Equitability_J	0.88	0.89	0.87	0.88
Fisher_alpha	2.82	1.80	2.16	0.74
Berger-Parker	0.15	0.27	0.26	0.48
Chao-1	14	8	10	3

Key ndps=non dumpsite, UNILAG=University of Lagos

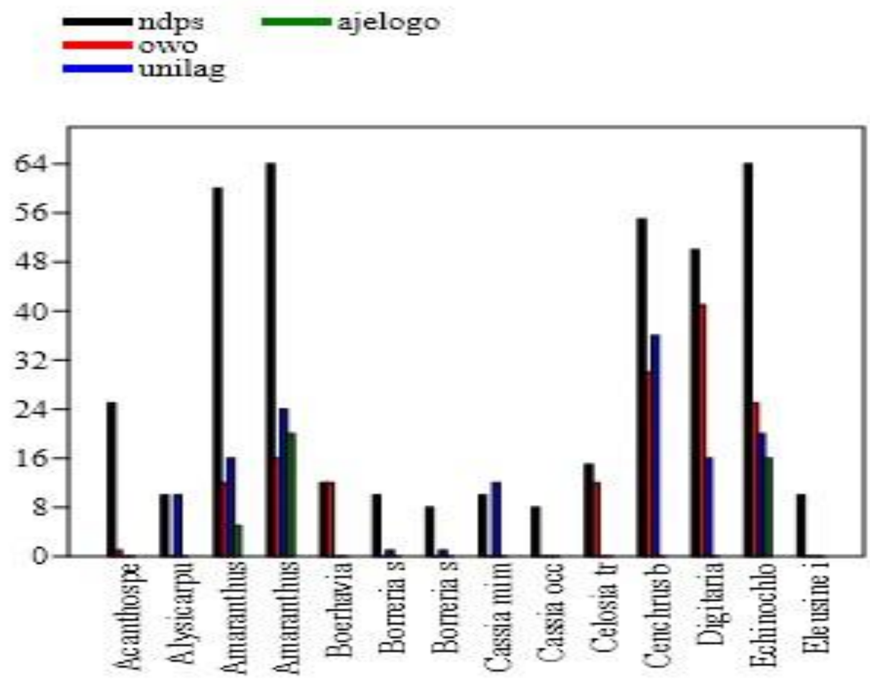

Figure 1: floristic diversity in the dumpsites and Non-dumpsites

The floristic diversity and species richness as shown by the diversity indices presented revealed that the dumpsite that supported the diversity of plants is the UNILAG dumpsite with respect to the Shannon H value obtained. This could be attributed to the sort of waste that is generated within the University campus. The dumpsite with the lowest diversity index may not be conducive for the survival of plant in the area thereby preventing the growth of different floral in and around the dumpsites.

Table 4: Physicochemical properties of soils from the dumpsites and Non-dumpsites

Sites parameters	Non dumpsite	Mile 12/Ajelogo dumpsite	Oworonshoki dumpsite	Unilag dumpsite
pH	7.47	7.58	7.89	7.04
TOC (%)	0.91	2.06	1.56	1.05
TOM (%)	1.56	3.54	0.21	1.81
Nitrogen (mg/kg)	0.21	0.95	0.48	0.42
Phosphorus (mg/g)	4.80	4.58	2.39	4.62
Potassium (mg/kg)	90.68	78.86	84.41	86.29
Sodium (mg/kg)	36.81	31.96	26.49	46.98
Calcium (mg/kg)	104.9	89.61	104.9	99.86
Magnesium (mg/kg)	29.49	37.41	29.49	30.16
CEC (mg/kg)	11.64	11.04	11.64	11.75

The total N content of soils dumpsites in this study ranged between 0.42 and 0.95% which is higher than those of the control site which was fund to be 0.21. Nitrogen and Carbon combination in form of ration has been found to enhance the general restoration of microbial flora. Generally, if the ratio is below 20, this is often adequate to satisfy the N requirements of micro flora that decompose the residues (Teglia *et al*., 2011). According to Amos-Tautua *et al*. (2014), the low values of C/N ratios showed high decomposition and efficient mineralization process of the dump area. It could also be attributed to the disposal of high organic wastes in the dumpsites. It is worthy of note that organic matter has been observed to play crucial role in soil structure, water retention capacity, cation exchange as well as in the formation of complexes (Fonge *et al*., 2017).

The UNILAG dumpsite had highest levels of 4.62±0.04 of P. However, the P level ranging from 2.39±0.89 to 4.58±1.02 mg/kg are lowers compared to the control which was 4.80±1.01 mg/kg; this could be attributed to the presence of high amount of organic matter and plants decomposition. The high concentration of phosphorous contributes to good growth of plants as was observed. All the soil samples had available P values more than 10 mg/kg considered suitable for crop production (Mohammed *et al*., 2017).

The total mean percentages of organic carbon (TOC) and Total Organic Matter (TOM) ranged from 11.04 to 11.64 and 11.75 to 11.64% respectively. These values compares favourably with those reported by Uba *et al*. (2008), and Obasi *et al* (2012). While soil organic carbon is not a requirement for plant growth, the levels of organic matter in soils influence a number of soil chemical and physical processes and it is an important indicator of the soil as a rooting environment. CEC gives the soil a buffering capacity which may slow down the leaching of nutrient cations and positively charged pollutants because they affect both soluble and exchangeable metal levels.

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Concentration of heavy metals

The results of heavy metals are presented in table 5. The highest level of Al was obtained from the soil samples collected from Oworonshoki dumpsite (0.82±0.02) while the lowest (0.15±0.01) was obtained from the soil samples collected from Ajelogo dumpsite. All of which were higher than the soils from the Non-dumpsites. The highest level of Cr (451.0±0.05) was obtained from the soils collected from UNILAG dumpsite and followed by the soils collected from Ajelogo dumpsite. The highest level of Fe (153.6±1.52) was obtained in the soil samples from Ajelogo dumpsite. The level of Zn was also highest from the Ajelogo dumpsite (1.46±0.11) but lowest in the soil collected from UNILAG dumpsite (0.6±0.42). Based on the results of this study, it is evident that some heavy metals occurred above the natural occurring values, which is an indication of pollution of the study area. Some of the metals are essential for the growth of plants; however, they can cause harmful effect when in excess.

Table 5: Heavy metal concentrations in the soil samples obtained from the different dumpsites

Heavy metals (mg/kg)	Soil sample collection site			
	NDPS	OWO	UNILAG	AJE
Al	0.12±0.02	0.82±0.02	0.80±0.05	0.15±0.01
Cr	153±2.64	231.67±1.52	451.0±1.00	281±1.00
Cu	12.4±0.20	17.16±0.15	13.70±0.10	18.60±0.20
Fe	201.67±1.52	201±1.0	116.4±0.36	153.66±1.52
Mn	0.0	20.1±0.1	20.00±0.0	20.40±0.30
Zn	0.96±0.15	1.2±0.11	0.6±0.42	1.46±0.11

The result showed that Cr and Zn were present in high amount in the soil samples across the studied area. High concentration of Cr and Cu was determined in the soil from the non-dumpsite (control). Chromium (Cr) concentration recorded in the present study (231.67±1.52 to 451.0±1.00 mg/kg) is high when compared to values recorded in other studies such as Aruleba and Ajayi, (2012) who obtained 21.51 mg kg-1 in the soil of Ado Ekiti, Southwestern Nigeria and Li *et al.* (2001) who recorded 54.88 mg kg-1 in urban soil of Hongkong. Okoronkwo *et al*, (2006) as well reported that 22.27 mg/kg was observed in abandoned dumpsite in Umuahia, Abia State, Nigeria. These essential heavy metals are known to play crucial biochemical and physiological functions in plants and animals. Among these crucial roles are redox reaction and direct participation in enzymes activities.

CONCLUSION AND RECOMMENDATIONS

Most of the parameters of the soil within the solid waste dumpsite were higher than the values recorded in the soil from control site and they varied within the solid waste dumpsites. The degree of contamination of the heavy metals was at the ranged of low to moderately contamination. The values of the soil parameters from solid waste dumpsites were within the world compost standard and rich with micro/macro nutrients Therefore, the

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compost from the solid waste dumpsites could be used as manure/ compost for soils amendment. However, the heavy metal contents were below the world soil allowable limits and FAO/WHO standard for agricultural soil. Thus, dumpsites might not be suitable for farm land for cultivation of crops.

It is recommended that solid waste disposal should be disposed in an environmentally sustainable manner. A modern sanitary and standard landfill system that will protect the soil from contamination should be designed for proper solid waste disposal in Lagos. Construction of landfill in should follow the prescribed design and the land fill site should be relocated. Solid Waste source reduction should be stimulated by the cities. It should be characterized and separated from the generation point. Recycling, recovery and composting of solid waste should be encouraged also to reduce the volume of waste as well as the negative impact on soil environment. Phytoremediation of heavy metals on dumpsite soil for cleaning up the soil environment contaminated by the toxic waste is also suggested.

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