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Research Article

Monitoring and Evaluation of Microbial Load and Physicochemical Characterization of Soil from Selected Dumpsites in Port-Harcourt

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Abstract
The high incidence of heavy metals in the environment originating from innumerable anthropogenic activities has recently gained attention. The indiscriminate and untreated waste disposal system in a landfill seems like a major pathway in which these metals are found predominantly in the biosphere. This study examined the soil's physical, chemical, and biological characteristics from solid waste dumpsites in Port Harcourt. This research was conducted at dumpsites located on Latitude 4.9046ºN, Longitude 6.9630ºE and 4.9046ºN and Longitude 6.9630ºE for dormant and active dumpsites respectively, while the control site was sampled 200m away from the various dumpsites on Latitude: 4.9044ºN and Longitude: 6.9628ºE. The systematic sampling technique was adopted. The soil sample was collected at a depth of 0-15m using a soil auger and analysis was done using standard methods. The highest increment in mean soil Mg^{2+}, Ca^{2+} and P was found in control site soils. Mean soil K, N and S was high in the active site soils and the concentration of N was low in the dormant site soils while pH and conductivity were highest in the active dumpsite soils. Concentration of 28.9kg/mg and 9.89 mg/kg of Pb and Cd respectively were reported at active dumpsite soils while 18mg/kg of Pb and 2.8 mg/kg of Cd were found at the dormant (inactive) dumpsite soils. Soil physical properties showed a remarkable variation among the sampled areas. The highest bulk and particle density was reported at active dumpsite soils while soil texture was loamy sandy soil for both dumpsites. Microbial growth and diversity were predisposed; THBC, TFC, HUBC and HUFC were reported highest in dormant (inactive) soil. Therefore indiscriminate waste disposal system modifies soil physicochemical properties and microbial activity. In conclusion, monitoring and evaluation system should be put in place to ensure proper segregation of waste from collection points, this will help decrease the amount of metal-prone materials from reaching the dumpsite while liquid waste should be properly treated before being discharged to avoid polluting ground and surface water through leaching and erosion.
Keywords: Microbial load, heavy metal, segregation and isolation, environmental degradation.

Introduction

Most developing nations of the world are faced with major environmental pollution problems associated with indiscriminate waste disposal systems. In these countries, inadequate waste management infrastructure, population growth and urbanization often contribute to the prevalence of indiscriminate waste disposal practices (Kimani, 2007). In Nigeria, the traditional way of disposing of waste in a landfill and around abandoned construction sites indiscriminately is now predominately practiced (Ferré-Huguet *et al.,* 2009). This incorrect waste disposal system practice poses significant challenges to the urban and rural dwellers, impacting various aspects of the environment, health, and socio-economic well-being and could lead to adverse consequences that affect both the present and future generations (Igwe *et al.*, 2002). Ferré-Huguet *et al.,* (2009) reported that the traditional pattern of waste disposal system contributes immensely to the increase in the concentration of heavy metals in the environment. Indiscriminate waste disposal systems have severe environmental implications such as water pollution and degradation of aquatic ecosystems (Igwe *et al.*, 2002; Amadi and Chuku, 2023). Waste disposed into a landfill does not experience primary waste treatment geared towards reducing the presence of heavy metals and metallic materials from reaching the dumpsite and underground water bodies through leaching (Igwe *et al.*, 2002). Understanding the effects of such practices is crucial for the development of sustainable waste management strategies suitable for adequate solid and liquid waste management. This environmental pollution emanating from indiscriminate waste disposal systems affects the availability of clean water for drinking, agriculture, and industrial use. In addition, open dumping and burning of waste also release harmful gases into the atmosphere leading to air pollution and climate change. The emission of greenhouse gases such as methane from decomposing organic waste aggravates global warming and climate-related challenges (Rajaram *et al*., 2020). Land pollution originating from refuse is alarming in recent times due to an increase in heavy metal occurrences which appears recalcitrant in the environment and heavy metal has been reported as a major dumpsite pollutant (Fifield and Haina, 1997). Heavy metals such as cadmium and lead are predominant among other metals in the dumpsite with no essential benefit to plants and animals human (Fifield and Haina, 1997).

Rajaram *et al*., (2020) attribute the increase in heavy metal levels in dumpsites to various points of waste generation and collection. The waste segregation process is often omitted from the point of collection this lead to different combination of hazardous waste (industrial effluent and clinical waste) with high levels of heavy metal (Rajaram *et al*., 2020). Heavy metals are detrimental at high concentrations; these metals interfere with the physiological and biological processes of living organisms and result in excess expression of reactive oxygen species which is capable of causing death (Olaniran *et al*., 2013). Heavy metals are recalcitrant in the environment and this nature makes them non-degradable waste hence they accumulate along the food chain could be detrimental (Budianta, 2021). Plant species through its root system is able to accumulate a reasonable concentrations of heavy metals in their biomass. The presence of these metals in plant parts bio-magnify along the feeding process (food chain) and as such, has gained global attention. The negative environmental and health effects place a burden on healthcare systems, diverting resources that could be allocated to other critical sectors Tourism, a significant source of revenue for many developing countries, can be adversely affected by the unsightly and polluted environments associated with poor waste management (Rajaram *et al*., 2020).

Statement of the problem

Most edible plants especially vegetables are predominantly in the dumpsites, these plants growing around these areas are likely to absorb high concentrations of these heavy metals in their harvestable tissues. Metals are mobile ions predominantly in the solution phase and as such could accumulate in plants through their root system (Fifield and Haina, 1997; Amadi and Chuku, 2023). The consumption of plants grown in heavy metal-prone environments is dangerous for human consumption (Rajaram *et al*., 2020). Heavy metals are non-biodegradable, which makes them persist in the environment and also increase in concentration overtime (Amadi and Tanee, 2016; Amadi *et al*., 2023).

Objective of the Study

The objectives of this study include the following:

1) Determine the physicochemical characteristic of soil from the selected dumpsite.
2) Estimate the microbial community of the soil from the selected dump site.
3) Ascertain the effects of indiscriminate waste disposal system practices on the soil.

Materials and Methods

Study Locations

This study was conducted at the solid waste dumpsite along the popular new airport road, close to a major community farm land in Obio/Akpor Local Government Area, Rivers State, Nigeria.

Figure 1. Active Dumpsite.

Figure 2. Dormant (inactive) Dumpsite.

The two solid waste dumpsites are found almost adjacent around the selected environment was sampled. The size of the dumpsite and dumping frequency made it a suitable choice. The sampled dumpsites were located on Latitude 4.9046°N, Longitude 6.9630°E and 4.9046°N and Longitude 6.9630°E for dormant and active dump sites respectively while Latitude 4.9044°N and Longitude 6.9628°E 200m away from both dumpsites served as control site.

Samples Collection/Preparation of Soil

Systematic sampling method was adopted. A transect line was laid across a mapped-out area of 20m by 20m while a quadrant of 1m by 1m was placed on the marked points along the line. The marked areas were sampled at 5m intervals all the way down the line given a total of four sample plots at each site. Soil samples were obtained at 0-15m using a soil auger. This sampling technique was also adopted for both sites (active and dormant dumpsite) while the control site was sampled 200m away from both dumpsites. The soil collected from 3 locations was placed in an ice pack and transported to the research laboratory for physicochemical analysis and microbial load determination. The soil samples were air dried using a bulb for one month to get constant weight and further processed into powdered form, sieved using a 2mm wire mesh to obtain a fine dust-like substance devoid of coarse particles. The powdered form was then stored for digestion and subsequently analyzed for soil physical and chemical characteristics.

Determination of soil chemical, microbial and plant growth properties

The determination of soil organic matter was done by calculation method using the formula cited by Osuji *et al.,* (2005). Soil cadmium (Cd), lead (Pb), potassium (K+), calcium (Ca^{2+}), magnesium (Mg^{2+}), nitrate (N), and sulfate (S) contents were determined using atomic absorption spectrometer (AAS) through the digestion method. Soil Phosphate was determined by ascorbic and oxidation methods. The pH and conductivity values were determined using Equip-tronics (Model EQ-610) pH and conductivity meter. Soil chloride (Cl) was determined by electrometric method as described by Itano and Matsuura (1931) while moisture content was determined by crucible method described by Blake (1965) and bulk density and particle density were determined by oven-dry and pycnometer method respectively as determined by Blake and Hartage (1986). Porosity was obtained mathematically by percentage determination of total pore spaces and was extrapolated from bulk and particle density according to the method of Blake and Hartage (1986).

Microbial Load Determination

The medium nutrient agar was used for the analysis of total heterotrophic bacteria count (THBC). In the preparation of nutrient agar, 28g of the powder was added to 1 L of distilled water and characterized by autoclaving at 121^{0}C for 15 minutes and allowed to stand for about 45 minutes. It was poured into sterilized Petri dishes and allowed to solidify, excess moisture found was eradicated from the agar using a hot air oven set at 60^{0}C. One (1g) of the soil sample was weighed into 9 mL sterile diluent for serial dilution. Aliquot inoculum of 0.l ml was aseptically inoculated on duplicated agar surface using a sterile pipette and flame sterilized. Glass rod was used to spread the inoculum uniformly and incubate at 37^{0}C for 24 hours followed by a colony to obtain colony forming unit (CFU/g) calculation.

Data Analysis

The data generated were subjected to statistical analysis of variance (ANOVA) using Statistical Analysis System (SAS, 2002) to test the significance of bio-stimulant on soil characteristics and plant growth. Least Significant Difference (LSD) was used to analyze the data obtained.

Results

Results showed that the highest increment in magnesium, calcium and phosphorus were recorded at the control site (Table 1). Slight increments in soil magnesium, calcium and phosphorus were found in the dormant waste soil as compared with the active solid waste soil. The least in soil magnesium, calcium and phosphorus concentration was reported at active solid waste dumpsite. There was a significant difference between and within the sample area at ($p=0.05$). An increase in the concentration of soil potassium and sulphur was found highest in active solid waste dumpsite soil while control soil showed the least. A decrease in the concentration of nitrate was also reported at the dormant waste soil while active waste sampled soils showed the least decrease. The highest increase in nitrate was recorded in the control sampled soil. There was a significant difference between the sampled locations (Table 1). The highest increment in soil pH and conductivity were also reported at active and dormant solid waste sampled soils while control soil showed an optimal range of pH and conductivity levels. The highest lead and cadmium concentrations were reported at the dumpsites soils while active dumpsite soils showed the highest concentration while the least decrease was found at the control site.

Soil moisture content was high in control soil while the least moisture content was reported in dormant solid waste dumpsite soil. The highest soil bulk and particle density were found in active solid waste sampled soil while control soil showed the least in bulk and particle density and the proportion of sand was high in active dumpsite soil (Table 2).

High soil organic matter (SOM) was reported in the dumpsites soils. The highest increment was SOM content was found in dormant dumpsite soil while the controlled sampled soil showed the least in SOM. Microbial population such as total heterotrophic bacteria count (THBC), total fungi count (TFC), hydrocarbon utilizing bacteria count (HUBC) and hydrocarbon utilizing fungi count (HUFC) were reported highest at the dormant (inactive) soil while the least in microbial estimation was found at the active sample soil (Table 3).

Table 1. Chemical properties and heavy metal concentration of soil in the sampled locations.

Sample Locations	Mg^{2+} Mg/kg	Ca^{2+} Mg/kg	P Mg/kg	K Mg/kg	S Mg/kg	N Mg/kg	pH	Cond (us/cm)	Pb Mg/kg	Cd Mg/kg
Active	9.8± 0.03c	104± 0.3c	3± 1.3b	1.48± 0.001a	122± 8.1b	0.8± 0.001a	8.7± 0.023a	994± 14.0a	28.9± 0.3a	9.89± 0.3a
Dormant (inactive)	18.6± 0.23b	118.4± 5.2b	8.4± 1.3a	1.2± 0.02b	135± 112a	0.3± 0.001a	8.2± 0.013a	893± 11.3a	18± 0.32b	2.8± 0.002b
Control	236± 2.0a	134± 3.6a	1.87 ±1.3c	0.4± 0.001c	89± 11.6c	1.3± 0.01ab	6.7± 0.001b	89± 1.3a	3.6± 0.003c	0.1± 0.0001c
LSD	0.23	1.07	1.02	2.04	0.43	0.02	0.1	2.9	3.01	0.12

Table 2. Soil physical properties from sampled locations.

Sample Locations	Moisture %	Bulk density %	Particle density %	Porosity	SOM %	Sand %	Silt %	Clay %
Active	43± 0.04b	1.9± 0.002a	5.1± 0.004a	0.38± 0.002a	16± 0.1b	93± 13a	0.7± 0.003a	5.7± 0.01a
Dormant (inactive)	38± 3.9c	1.7± 0.001a	4.8± 0.02a	0.3± 0.001a	24± 1.3a	91± 5.4a	0.71± 0.01a	5.32± 0.05a
Control	46± 2.3a	1.2± 0.002a	2.1± 0.001a	1.8± 0.001a	12± 1.32c	95.6± 1.2a	0.10± 0.002a	3.2± 0.001b
LSD	0.2	0.14	1.4	0.6	2.9	3.0	0.01	1.32

Table 3. Soil microbial population from sampled locations.

Sample Locations	THBC (Cfu/g)	TFC (Cfu/g)	HUBC (Cfu/g)	HIFC
Active	1.1×10^5	1.0×10^4	1.2×10^4	1.32×10^4
Dormant (inactive)	6.4×10^4	4.0×10^4	5.6×10^4	2.8×10^4
Control	1.2×10^5	3.8×10^4	2.32×10^4	1.3×10^4

Discussion

The edaphic component of the environment is a good determinant of the overall performance of plant, microbial diversity, growth and the physicochemical and biological properties of soil are at the mercy of human actions on the environment (Amadi *et al.*, 2023). This study showed that changes in the physiochemical and biological properties of soil are attributed to man activities ranging from indiscriminate dumping of unsegregated and untreated solid waste into a landfill. The highest increase in soil magnesium, calcium and phosphorus reported in control soils could be attributed to run off water from a cattle farmstead found close to the collection site. Runoff of water from the ranches to the point of soil collection might have altered the soil nutrient levels and elevation in nutrients emanating from the microbial degradation process of cow dung waste. Similar results were reported by Amadi and Chuku (2023).

Highest increase in soil potassium and sulphur found at the active waste dumpsite could be attributed to the nature of waste disposed at the dumpsite; most of the waste is biodegradable in nature and rich in organic matter which is the source of most nitrogen, potassium and other essential nutrients when acted upon by microorganisms. These findings corroborated with Ideriah *et al.*, (2010) who attributed the increase in soil nutrient at the dumpsite to the type of waste discharged by man, majority of this waste are biodegradable and the nutrients are made available in dumpsite soils during the microbial mineralization process. Sootahar *et al.,* (2019) also reported that the presence of biodegradable materials is capable of improving soil fertility significantly thereby maintaining nutrient balance and availability. The least decrease in the concentration of soil nitrate in dormant (inactive) soil is understandable, the presence of biodegradable waste served as biostimulants initiating an increase in microbial diversity and growth, during the mineralization process certain amounts of nitrate substances are been used by microorganisms. This finding is in line with Amos-Tautua *et al.,* (2014) who reported an increase in soil nutrient content during microbial decomposition. Higher pH and conductivity levels in the dumpsites soils could be attributed to the nature of waste materials discharged at the dumpsites and on the account of mineralization process might have altered the soil pH and conductivity levels. These findings corroborated with Ideriah *et al*., (2005), who linked liming materials found in domestic waste and the activities of microorganisms as factors responsible for an increase in pH and conductivity levels.

The variation in soil texture content could be attributed to the influence of waste disposed at the dump site. This is in line with Ideriah *et al.,* (2005) who reported that the decomposition of domestic and industrial wastes influences texture characterization. Highest in SOM recorded at dormant sampled soil dumpsite suggests that the influx of biodegradable substance deposited at the dumpsite overtime increased the level of SOM. This explanation was not in agreement with Amadi *et al*. (2023b) reported that increase in soil organic matter content is not proportional to the concentration or quantity of biodegradable material added. This also disagrees with Bago (2000) who reported that increase in SOM is not a function of the biodegradable amendment present. This result corroborated with Wang *et al*., (2014) who observed a remarkable increase in SOM with different levels of biodegradable addiction. Microbial growth recorded highest at the dormant soil suggests that the type and nature of waste found at the dumpsite is responsible. Similar findings had also been reported by Amadi *et al.,* (2023), Amadi and Chuku (2023) that the biodegradable substance incorporated dumpsites soils stimulate microbial activity and diversity since it contains required nutrients in the form of protein and amino acids and during mineralization process. Microorganisms breakdown and convert nitrogen into nitrate and ammonium which further undergo nitrification by nitrifying bacteria resulting in increased soil nitrate which could also influence microbial growth and diversity. This finding also agreed with Yuan *et al.,* (2017) who reported that changes in soil microbial community are usually on the increase in areas with highly biodegradable materials.

High levels of Pb and Cd concentration reported at the active dumpsite could be attributed to the number of metallic materials found in solid and liquid waste discharge at the dumpsites. The metallic substance at the dumpsite is made available in the environment during corrosion. This result agreed with Amadi and Chuku (2023) who also reported an increase in heavy metal levels at the active dumpsite and attributed it to the concentration of metals present in industrial effluent discharged into landfill and corrosion process of metallic materials found at the dumpsite.

Conclusion and Recommendations

This study has shown that indiscriminate waste disposal system is capable of influencing soil physicochemical and biological properties. The result of this investigation showed that the presence of heavy metal concentration is directly proportional to the nature and volume of waste disposed at the dumpsites. However, it is necessary to develop a function and standard waste monitoring and evaluation system at the various dumpsites to ensure proper segregation, treatment and isolation of metallic substances this will help decrease elevated toxicity levels of metals and microbial diversity in the environment.

Declarations

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References

1. Amadi, N, Tanee, F.B.G. and Okogbule F.N.C. 2023b. Biostimulating effect of plantain peels (waste) on soil chemical properties, microbial loads and growth of *Cyperus iria* (Linn) in a heavy metal polluted soil. International Journal of Advanced Research in Biological Sciences, 10(5): 157-167.

2. Amadi, N. and Chuku, O.S. 2023. Assessment of dominant heavy metals in selected solid waste dumpsites in Port Harcourt metropolis, Nigeria. International Journal of Advanced Research in Biological Sciences, 10(5): 177-187.

3. Amadi, N. and Tanee, F.B.G. 2016. Comparative study of three ornamental plant species for their phytoextraction potentials of cadmium polluted soil. Journal of Advances in Biology, 9(1): 1-8.

4. Amadi, N., Okogbule, F.N.C. and Chikere, L.C. 2023. Soil enhancer: A vital tool for plant stress Management in heavy metal polluted environment. International Journal of Advanced Research in Biological Sciences, 10(4): 168-182.

5. Amos-Tautua, B.M.W., Onigbinde, A.O. and Ere, D. 2014. Assessment of some heavy metals and physicochemical properties in surface soils of municipal open waste dumpsite in Yenagoa, Nigeria. Africa Journal of Environmental Science and Technology, 8(1): 87-94.

6. Bago, B. 2000. Putative sites for nutrient uptake in arbuscular mycorrhizal fungi. Plant Soil, 226: 263–274.

7. Blake, G.R. 1965. Bulk Density in Methods of Soil Analysis. Agronomy, No. 9, Part 1, C. A. Black, 374-390.

8. Blake, G.R. and Hartge, K.H. 1986. Bulk density. In: Klute, A., (Ed.,), Methods of Soil Analysis, Part 1—Physical and Mineralogical Methods, 2nd Edition, Agronomy Monograph 9, American Society of Agronomy—Soil Science Society of America, Madison, 363-382.

9. Budianta, W. 2021. The influence of mineralogical composition on the adsorption capacity of heavy metals solution by java natural clay, Indonesia. ASEAN Engineering Journal, 11(2): 64-76.

10. Ferré-Huguet, N., Bosch, C., Lourencetti, C., Nadal, M., Schuhmacher, M., Grimalt, J.O. and Domingo, J.L. 2009. Human health risk assessment of environmental exposure to organochlorine compounds in the Catalan stretch of the Ebro River, Spain. Bulletin of Environmental Contamination and Toxicology, 83: 662-667.

11. Fifield, W. and Haina, I. 1997. Environmental Analytical Chemistry. Blackie Academic and Professional: Chapman and Hall, Boundary Row, London. 56p.

12. Ideriah, J.K.T., Harry, F.O., Stanley, H.O. and Igbara, J.K. 2010. Heavy metal contamination of soils and vegetation around solid waste dumps in Port Harcourt, Nigeria. Journal of Applied Sciences and Environmental Management, 14(1): 101-109.

13. Ideriah, J.K.T., Omuaru, O.T.V. and Adiukwu, U.P. 2005. Heavy metal contamination of soils around municipal solid wastes dump in Port Harcourt, Nigeria. Global Journal of Environmental Sciences, 4(1): 1-4.

14. Igwe, C., Isirimah, N.O. and Teme, S.C. 2002. Distribution and characteristics of solid wastes and waste disposal sites in Port Harcourt municipality, Rivers State, Nigeria. African Journal of Environmental Pollution and Health, 1(2): 51-60.

15. Itano, A. and Matstuura, A. 1931. Determination of Chloride in Soils. Journal of the Agricultural Chemical Society of Japan, 7(4-8): 43.

16. Kimani, N.G. 2007. Implications of the Dandora Municipal Dumping Site in Nairobi, Kenya. Environmental Pollution and Impacts on Public Health, Kenya: United Nations Environment Programme.

17. Olaniran, A.O., Balgobind, A. and Pillay, B. 2013. Bioavailability of heavy metals in soil: impact on microbial biodegradation of organic compounds and possible improvement strategies. International Journal of Molecular Sciences, 14(5): 10197-10228.

18. Osuji, L.C., Egbuson, E.J.G and Ojinaka, C.M. 2005. Chemical reclamation of crude oil in undated soils from Niger Delta, Nigeria. Chemistry and Ecology, 2(1): 1-10.

19. Rajaram, R., Rameshkumar, S. and Anandkumar, A. 2020. Health risk assessment and potentiality of green seaweeds on bioaccumulation of trace elements along the Palk Bay coast, Southeastern India. Marine Pollution Bulletin, 154: 111069.

20. SAS Institute Inc. 2002. SAS for Windows Release 9.1, Canny, United States of America, Statistical Analysis Systems Institute Incorporated, 2002.

21. Sootahar, M.K., Zeng, X., Su, S., Wang, Y., Bai, L., Zhang, Y., Li, T. and Zhang, X. 2019. The Effect of Fulvic Acids Derived from Different Materials on Changing Properties of Albic Black Soil in the Northeast Plain of China. Molecules, 24: 1535.

22. Wang, L., Sun, X., Li, S., Zhang, T., Zhang, W. and Zhai, P. 2014. Application of organic amendments to a coastal saline soil in North China: Effects on soil physical and chemical properties and tree growth. PloS One, 9(2): e89185.

23. Yuan, J., Zhao, M., Li, R., Huang, Q., Rensing, C. and Shen, Q. 2017. Lipopeptides produced by B. amyloliquefaciens NJN-6 altered the soil fungal community and non-ribosomal peptides genes harboring microbial community. Applied Soil Ecology, 117-118: 96-105.

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