IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

Profiling of the Physicochemical Characteristics and the Source Identification of Heavy metal in Soil from Selected Open Dumpsites in Warri, Delta State, Nigeria

Donaldson Buoro Omovfase[a*] **Wisdom Ivwurie**[a]

Department of Chemistry,

[a]Federal University of Petroleum Resources, Effurun, Delta State, Nigeria

[*]Corresponding Author: Email – donbuoro4life@gmail.com; Tel: +234 7032615840

ABSTRACT

The increase in population and urbanization has resulted in an increase in municipal waste. Waste dumped indiscriminately in the environment has potential environmental impact and risks. This study assessed three dumpsites in Delta State to evaluate heavy metal contamination, associated risks, and soil properties. Soil samples from dumpsites in London Opi, Ugborikoko, and Agbarho were collected at depths of 0-15cm and 15-30cm, along with a control sample following standard methods and procedures. The results revealed the soil particle ranged from loamy to sandy loamy in the study locations. pH for the topsoil were subsoil was 7.74 and 7.21 (Agbarho), 7.57 and 7.43 (Uvwie), 7.38 and 7.24 (London OPI); Lead for the topsoil and subsoil was 5.46 and 7.21 mg/kg (Agbarho), 5.25 and 8.18 mg/kg (Uvwie), 2.29 and 3.79 mg/kg (London OPI); Chromium for the topsoil and subsoil was 43.72 and 29.63 mg/kg (Agbarho), 113.53 and 87.49 mg/kg (Uvwie), 17.61 and 11.45 mg/kg (London OPI.Principal Component Analysis (PCA) revealed four principal components that explained 96.95% of the total variance in the data. PCA results indicated pollution may be attributed to organic waste, agricultural waste, and domestic waste such as metal scraps and plastics. Regular monitoring and proper waste recycling practices are necessary to prevent metal accumulation over time.

KEY WORDS: Soil, Landfill, dumpsites, Heavy metals.

INTRODUCTION

The global population has witnessed an unprecedented surge in recent decades, primarily fueled by rapid urbanization. As cities expand to accommodate the growing populace, the production of municipal waste has surged significantly, leading to new challenges in waste management. In developing countries, the common approach to handling municipal solid waste is through the utilization of landfills and open dumpsites (Gonzalez-Valencia *et al.* 2015; Afolagboye *et al.* 2020). The popularity of these methods stems from their simplicity, cost-effectiveness, and minimal technological requirements. Landfills and open dumpsites are prevalent in locations near residential areas, groundwater recharge zones, and areas with seasonal high-water tables The global population has witnessed an unprecedented surge in recent decades, primarily fueled by rapid urbanization. As cities expand to accommodate the growing populace, the production of municipal waste has surged significantly, leading to new challenges in waste management. In developing countries, the common approach to handling municipal solid waste is through the utilization of landfills and open dumpsites (Gonzalez-Valencia *et al.* 2015; Afolagboye *et al*. 2020).

. The popularity of these methods stems from their simplicity, cost-effectiveness, and minimal technological requirements. Landfills and open dumpsites are prevalent in locations near residential areas, groundwater recharge zones, and areas with seasonal high-water tables. However, a major concern arises due to the inadequate engineering and failure to meet recommended standards in many of these landfills and open dumpsites. The absence of proper waste management infrastructure, such as leachate collection and treatment systems, further exacerbates the issue. Consequently, the uncontrolled disposal of municipal solid waste allows leachates and toxic gases to migrate from these sites, posing potential hazards to both human health and the environment (Afolagboye *et al.* 2020). However, a major concern arises due to the inadequate engineering and failure to meet recommended standards in many of these landfills and open dumpsites. The absence of proper waste management infrastructure, such as leachate collection and treatment systems, further exacerbates the issue. Consequently, the uncontrolled disposal of municipal solid waste allows leachates and toxic gases to migrate from these sites, posing potential hazards to both human health and the environment (Afolagboye *et al.* 2020; Onwukeme *et al.* 2021). There are various hazards which are associated with the dumpsite including surface water contamination, leachate, heavy metal absorption, groundwater contamination, bad smell or odour from the wastes, and the release of greenhouse gases.

Understanding their accumulation, origin, and potential interactions with soil parameters has become a crucial aspect of environmental monitoring because of the increasing levels of heavy metals in the soil (Elaigwu *et al.* 2007; Onwukeme and Eze, 2021). To achieve these objectives, statistical techniques like principal component analysis (PCA) have been extensively employed in the investigation of heavy metal concentration, accumulation, and source identification in dumpsite soils (Afolagboye *et al.* 2020; Onwukeme *et al.* 2021). By employing PCA, it becomes possible to identify distinct groups of metals that exhibit similar behavior and likely share a common origin.

The city of Warri and its adjourning cities is rapidly growing in terms of pollution and infrastructure, this rapid growth results in an increase in waste generation. Therefore, this study aims to assess the physicochemical properties, the of heavy metals level, and to identify the likely sources of these heavy metals.; this will establish a scientific foundation for pollution control measures and ongoing monitoring of heavy metal accumulation in the selected dumpsites.

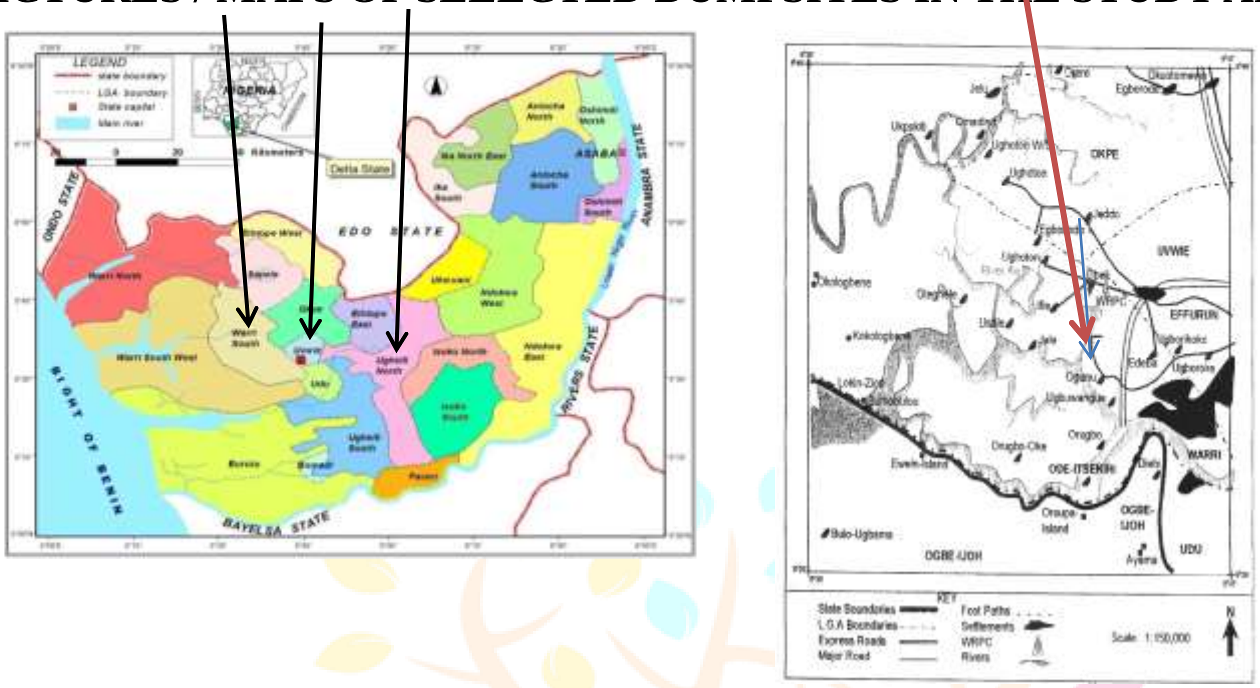
Material and methods

Study Area

Warri, situated in southern Nigeria; is a bustling commercial city located in Delta State, with a population of approximately 987,000 as of data from 1950 to 2023, sourced from the United Nations - World Population Prospects. The study areaswere selected from refuse dumpsites situated inthree distinct local government areas (LGAs), specifically Agbarho, Uvwie, and London. Figure 1 shows the Map of the various selected dumpsites.

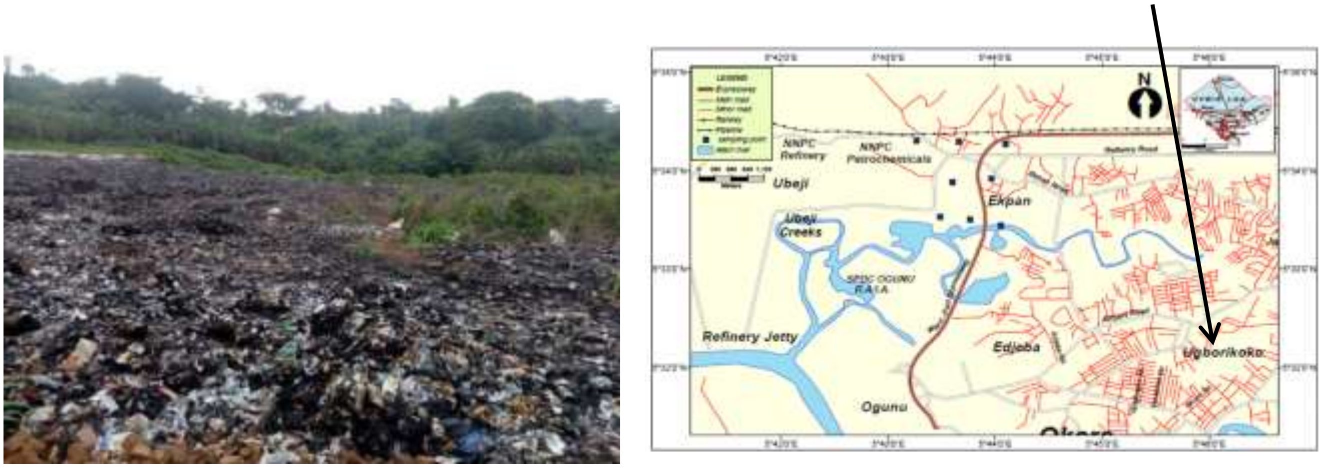
Picture 1: Showing map of Nigeria and Delta State from google.com

PICTURES / MAPS OF SELECTED DUMPSITES IN THE STUDY AREAS



Picture 2: Showing map of Delta State and sample sites in Warri South LGA, Uvwie LGA and Ughelli North LGA and sample site in London Opi street-Warri South LGA from Google.com

Picture 3: Dumpsite in London OPI Street In Warri South L.G.A



Picture 4: Picture/map of Dumpsite at Ugborikoko in Uvwie L.G.A

Picture 5: Map of Agbarho from Google.com and picture of dumpsite at Agbarho

Sample Collection

Soil samples were obtained from three dumpsites located in three different local government areas (LGAs) at two depths: 0-15cm and 15-30cm. Sampling was carried out in May 2023.The collection process involved using a stainless-steel soil auger to extract the samples after clearing away any surface debris. To ensure uniformity, the collected samples were pounded with a small mortar and pestle. Subsequently, the soil samples were filtered through filter paper in a 50ml measuring cylinder. After labeling each sample with paper tape for identification, they were promptly transported to the laboratory. In the laboratory, the soil samples underwent air-drying, during which twigs and stones were removed. Following this, the samples were sieved using stainless steel sieves with a mesh size of less than 2mm. Finally, the prepared soil samples were stored in sealed stainless-steel containers at 4°C until they were ready for analysis(Nyikaa. *et al.* 2020)

Analytical Method

pH was assessed utilizing a Consort 2000 pH meter equipped with a combined pH electrode, (Amadi *et al.* 2012), while electrical conductivity (EC) was determined using an Electrical Conductivity meter. These measurements were conducted on an aqueous suspension with a 1:5 (weight/volume) ratio of the <2 mm fraction of the soil (Amadi *et al.* 2012).The determination of organic carbon content was carried out following the Walkley and Black method (Yahaya *et al.* 2021). Particle size distribution was evaluated using the hydrometer method (Yahaya *et al.* 2021).To determine metal concentrations, soil samples were subjected to digestion using a mixture of hydrofluoric–perchloric acid and subsequently diluted with HNO_3 (Afolagboye *et al.*2020). Subsequently, the resulting aliquot was quantified using an Atomic Absorption Spectrophotometer, specifically the Buck 210 model. All concentration values were expressed in milligrams per kilogram (mg/kg) in accordance with APHA 301 AAS METHOD.

Statistical Analysis

In this study, descriptive statistics was used to determine the average and the standard deviation of the physicochemical parameters' results obtained. Principal component analysis (PCA) was used to determine source of contaminants in the study areas.All these statistical analyses were conducted using Microsoft Excel and Office 365

RESULT AND DISCUSSION

RESULT

Physico-Chemical Analysis of Soil in selected Dumpsites

pH:

In Agbarho, both the topsoil and subsoil have pH values within the slightly alkaline range, with values of 7.74 and 8.71 respectively. Uvwie shows slightly alkaline pH values for both the topsoil (7.57) and subsoil (7.43). Similarly, London OPI exhibits slightly alkaline pH values for both the topsoil (7.38) and subsoil (7.24). The Control area also displays slightly alkaline pH values for both the topsoil (8.61) and subsoil (7.43). (Smith *et al.*, 2017)

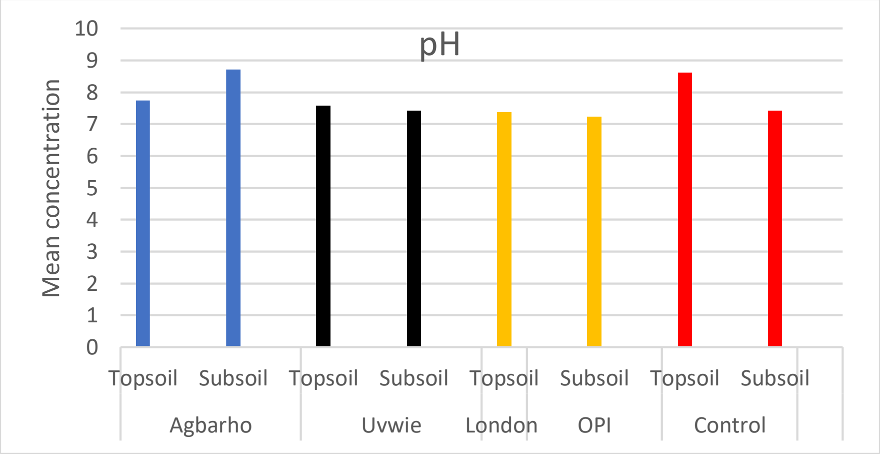


Figure 2: Result of pH analysis in the subsoil and Topsoil of selected dumpsites

EC (Electrical Conductivity):

The EC values in Agbarho are relatively higher for both the topsoil (12900µS/cm) and subsoil (7400µS/cm), indicating a higher concentration of ions in the soil. Uvwie, on the other hand, shows relatively lower EC values for both the topsoil (2800µS/cm) and subsoil (1900 µS/cm), suggesting a lower concentration of ions. In London OPI, the EC values for both the topsoil (8800 µS/cm) and subsoil (6700µS/cm) are moderate. Control exhibits relatively lower EC values for both the topsoil (700µS/cm) and subsoil (1200 µS/cm). (Afolagboye *et al.*2020)

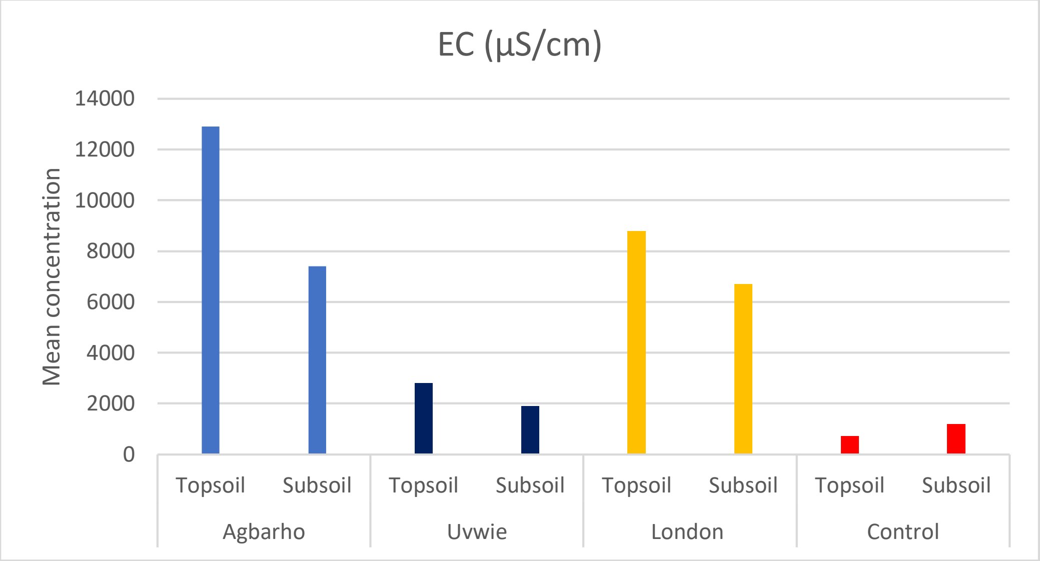


Figure 2: Result of Electrical conductivity analysis in the sub soil and Topsoil of selected dumpsite

TOC (Total Organic Carbon):

The TOC values in Agbarhofor both the topsoil (5.41%) and subsoil (4.3%), indicating a higher content of organic matter in the soil. Uvwie displays moderate TOC values for both the topsoil (4.59%) and subsoil (4.11%). Similarly, London OPI exhibits moderate TOC values for both the topsoil (4.71%) and subsoil (3.63%). In contrast, Control has relatively low TOC values for both the topsoil (1.4%) and subsoil (1.16%). (Thompson *et al.*, 2021)

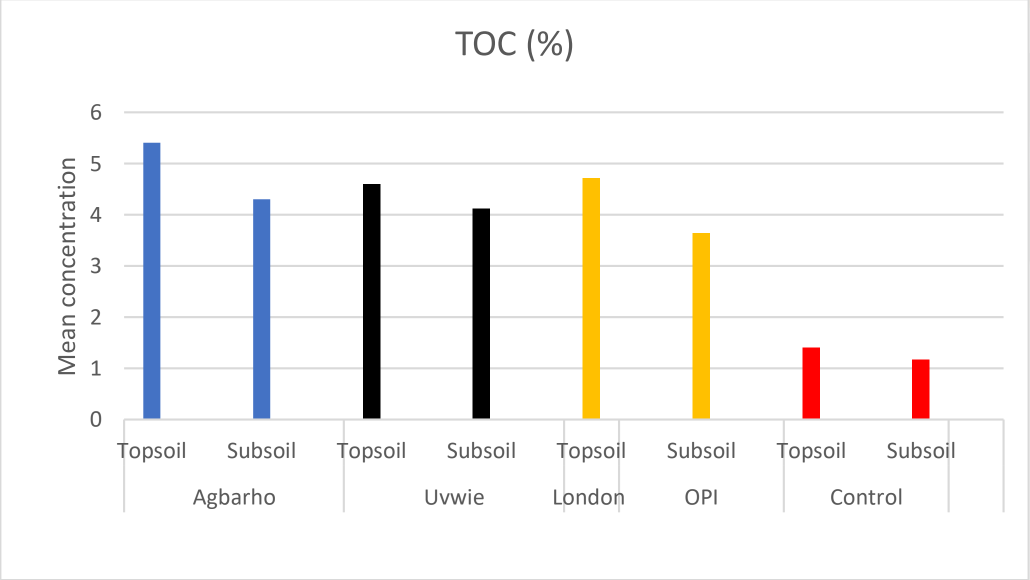


Figure 3: Result of Total Organic Carbon analysis in the sub-soil and Topsoil of selected dumpsite

Phosphate:

The phosphate levels vary across the different locations. Agbarho (Topsoil) has the highest phosphate level of 44.08 mg/kg, followed by Control (Subsoil) with the second highest level of 42.69 mg/kg. The other locations have relatively lower phosphate levels ranging from 4.49 to 26.82 mg/kg. (Johnson *et al.*, 2018)

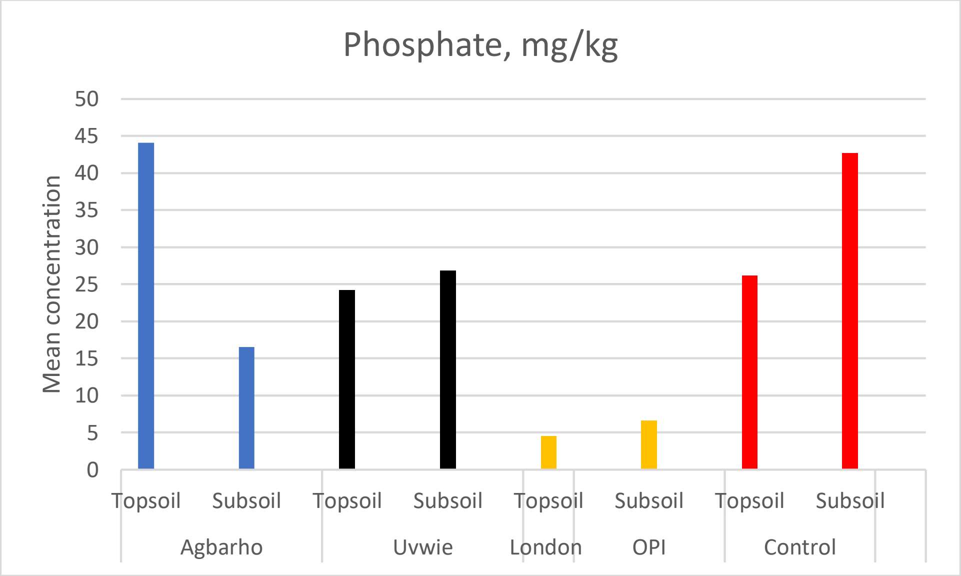


Figure 4: Result of Phosphate analysis in the sub soil and Topsoil of selected dumpsite

Sulphate:

The sulphate levels also exhibit variation across the different locations. The highest sulphate levels are observed in the subsoil of London OPI (156.33 mg/kg) and the topsoil of Uvwie (135.89 mg/kg). Agbarho and London OPI show moderately high sulphate levels, while Control has relatively lower sulphate levels. (Chinyere *et al.* 2013)

Nitrate:

The nitrate levels exhibit some variations across the locations. The highest nitrate levels are found in the topsoil of Agbarho (18.61 mg/kg) and the subsoil of Uvwie (14.18 mg/kg). London OPI and Control locations show relatively lower nitrate levels.

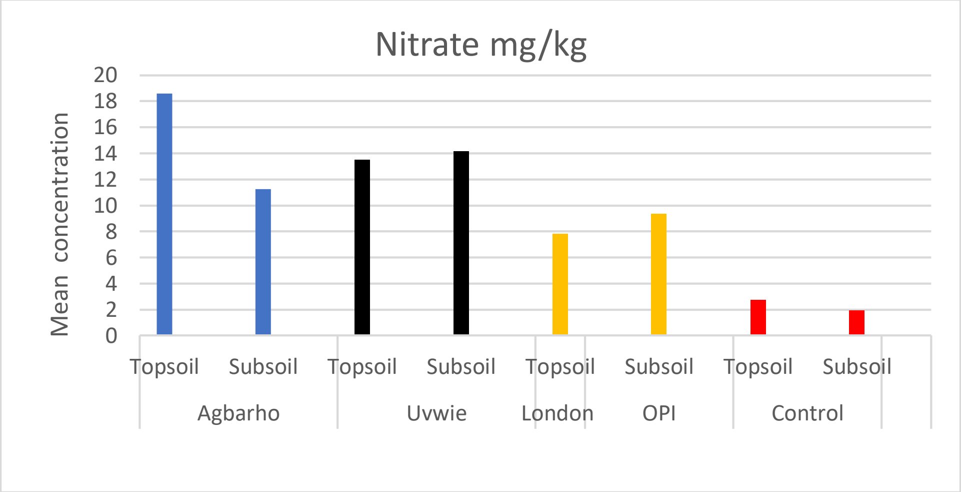


Figure 5: Result of Nitrate analysis in the sub soil and Topsoil of selected dumpsite.

Sodium:

The sodium levels vary significantly across the locations. Agbarho and Uvwie locations have relatively higher sodium levels, particularly in the topsoil. In contrast, London OPI and Control locations exhibit considerably lower sodium levels (Figure 6).

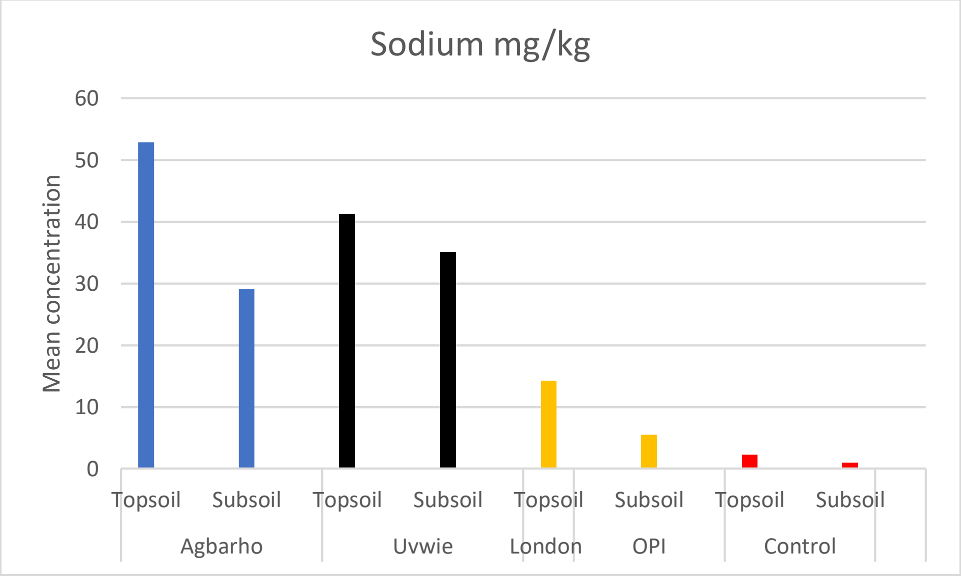


Figure6: Result of Sodium analysis in the sub soil and Topsoil of selected dumpsite.

Potassium:

The potassium levels also show variations among the locations. Uvwie (Topsoil) has the highest potassium level of 27.38 mg/kg, followed by Agbarho (Topsoil) with the second highest level of 18.19 mg/kg. London OPI and Control locations have considerably lower potassium levels.

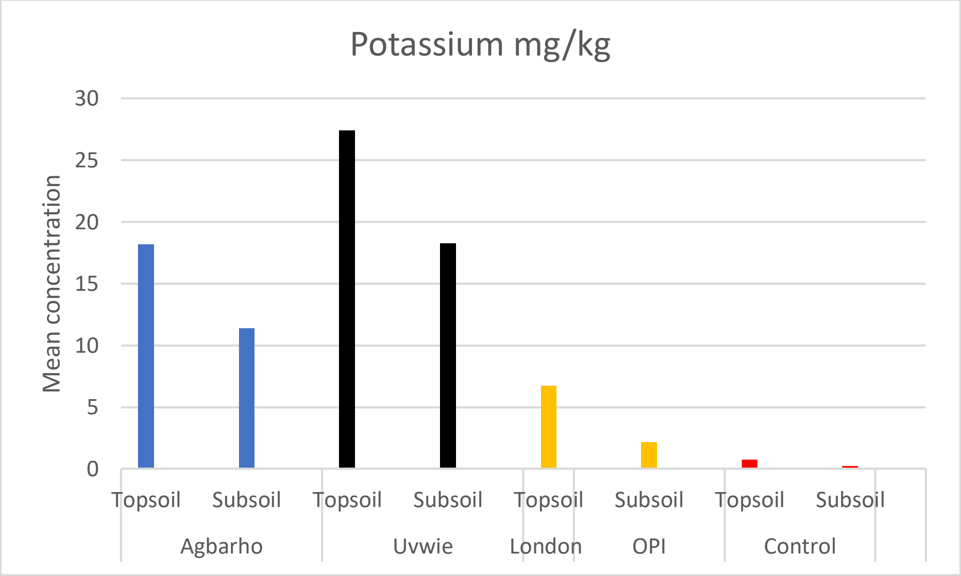


Figure 7: Result of potassium analysis in the sub soil and Topsoil of selected dumpsite.

Magnesium:

The magnesium levels vary significantly across the locations. The highest magnesium levels are observed in the subsoil of Uvwie (1,074.23 mg/kg) and the topsoil of Agbarho (936.13mg/kg). London OPI shows moderate magnesium levels, while Control has the lowest magnesium levels (Figure 8).

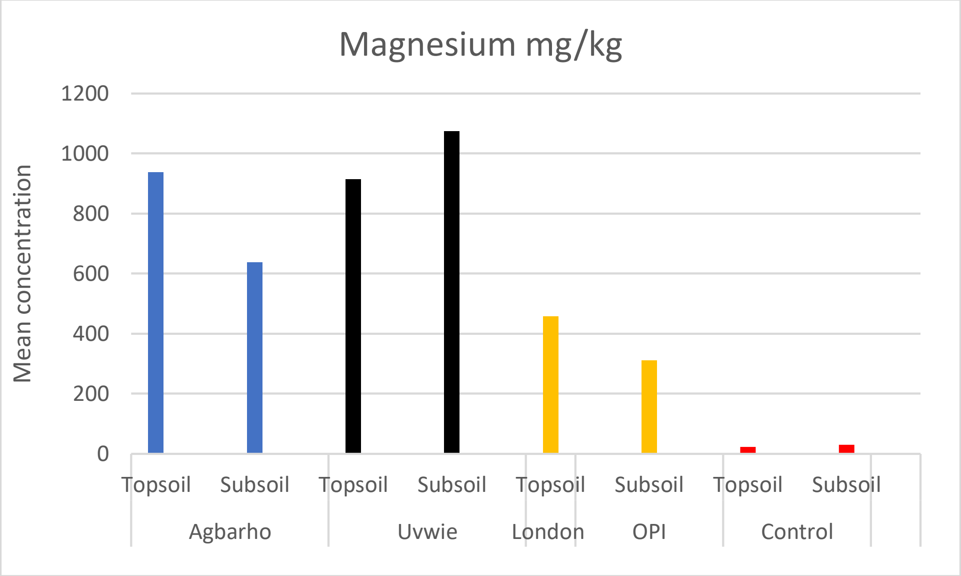


Figure 8: Result of Nitrate analysis in the subsoil and Topsoil of selected dumpsite**.**

Calcium:

The calcium levels for Agbarho (Topsoil) and Agbarho (Subsoil) were not detected. However, in other locations, calcium levels are relatively lower, with Uvwie (Topsoil) having the highest calcium level of 27.38 mg/kg.

Particle Size of the Study Areas

The particle size results are presented in Table 2. The textural class observed in the three sampling stations ranged from loamy to sandy loamy. While the textural class in the control area was sandy to sandy clay.

Table 1: Physico-chemical analysis of soil in selected dumpsite in Delta state

Location	PARAMETERS	pH	EC (µS/cm)	TOC (%)	Phosphate, mg/kg	Sulphate mg/kg	Nitrate mg/kg	Sodium mg/kg	Potassium mg/kg	Magnesium mg/kg	Calcium mg/kg
Agbarho	Topsoil 0 – 15 cm	7.74	12900	5.41	44.08	102.56	18.61	52.89	18.19	936.13	-
	Subsoil 15 – 30 cm	8.71	7400	4.3	16.52	65.39	11.25	29.12	11.37	637.46	-
Uvwie	Topsoil 0 – 15 cm	7.57	2800	4.59	24.2	135.89	13.52	41.25	27.38	913.79	-
	Subsoil 15 – 30 cm	7.43	1900	4.11	26.82	108.97	14.18	35.09	18.27	1,074.23	-
London OPI	Topsoil 0 – 15 cm	7.38	8800	4.71	4.49	128.21	7.82	14.28	6.69	457.46	1,341.27
	Subsoil 15 – 30 cm	7.24	6700	3.63	6.62	156.33	9.35	5.46	2.12	311.71	5,515.22
Control	Topsoil 0 – 15 cm	8.61	700	1.40	26.17	21.79	2.72	2.28	0.751	23.58	16.85
	Subsoil 15 – 30 cm	7.43	1200	1.16	42.69	33.45	1.94	0.97	0.23	30.73	25.21

Table 2: Particle size analysis of soil samples in sampling locations

Parameters	Agbarho		Uvwie		London		Control	
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
% Sand	54.3	47.8	38.8	32.7	41.3	37.4	86.4	54.6
% Silt	35.4	39.6	42.3	47.8	41.9	44.3	5.7	10.3
% Clay	10.3	12.6	18.9	19.5	16.8	18.3	7.9	35.1
Textural Class	Sandy Loam	Loamy	Loamy	Loamy	Loamy	Loamy	Sandy	Sandy Clay

HEAVY METAL ANALYSIS OF SOIL IN SELECTED DUMPSITE IN DELTA STATE.

This result provides information about the concentrations of different metals (manganese, iron, zinc, cadmium, lead, chromium, and nickel) in soil samples taken from different locations (Agbarho, Uvwie, London) and depths. These locations represent different areas or conditions that may affect the metal concentrations in the soil.

Manganese (Mn)

Manganese concentrations vary across the locations and depths. In Agbarho, the manganese levels are 30.22 Mg/kg in the topsoil (0-15 cm) and 19.314 Mg/kg in the subsoil (15-30 cm). In Uvwie, the concentrations are 88.858 Mg/kg (topsoil) and 104.406 Mg/kg (subsoil). In London, the levels are 23.549 Mg/kg (topsoil) and 35.193 Mg/kg (subsoil). The control samples have lower manganese concentrations (1.767 Mg/kg in topsoil and 4.582 Mg/kg in subsoil).

Iron (Fe)

Iron concentrations show a similar pattern across the locations and depths. In Agbarho, the iron levels are 4,729.18 Mg/kg (topsoil) and 3,058.48 Mg/kg (subsoil). In Uvwie, the concentrations are 7,411.39 Mg/kg (topsoil) and 5,727.52 Mg/kg (subsoil). In London, the levels are 936.032 Mg/kg (topsoil) and 588.124 Mg/kg (subsoil). The control samples have much lower iron concentrations (37.286 Mg/kg in topsoil and 24.646 Mg/kg in subsoil).

Zinc (Zn)

Zinc concentrations also exhibit variations across the locations and depths. In Agbarho, the zinc levels are 36.773 Mg/kg (topsoil) and 32.378 Mg/kg (subsoil). In Uvwie, the concentrations are 2,657.82 Mg/kg (topsoil) and 2,763.51 Mg/kg (subsoil). In London, the levels are 213.046 Mg/kg (topsoil) and 388.214 Mg/kg (subsoil). The control samples have relatively low zinc concentrations (7.623 Mg/kg in topsoil and 5.856 Mg/kg in subsoil). Zinc exceeded DPR, (2002) target values of Zinc in soil (Table 2).

Cadmium (Cd)

Cadmium concentrations differ across the locations and depths. In Agbarho, the cadmium levels are 7.748 Mg/kg (topsoil) and 5.152 Mg/kg (subsoil). In Uvwie, the concentrations are 19.291 Mg/kg (topsoil) and 10.737 Mg/kg (subsoil). In London, the levels are 4.519 Mg/kg (topsoil) and 3.352 Mg/kg (subsoil). The control samples have concentrations below the detection limit (<0.001 Mg/kg).

Lead (Pb)

Lead concentrations vary across the locations and depths. In Agbarho, the lead levels are 5.464 Mg/kg (topsoil) and 7.21Mg/kg (subsoil). In Uvwie, the concentrations are 5.249 Mg/kg (topsoil) and 8.182 Mg/kg (subsoil). In London, the levels are 2.285 Mg/kg (topsoil) and 3.794 Mg/kg (subsoil). The control samples have higher lead concentrations (29.735 Mg/kg in topsoil and 26.328 Mg/kg in subsoil

Chromium (Cr)

Chromium concentrations also show variations across the locations and depths. In Agbarho, the chromium levels are 43.728 Mg/kg (topsoil) and 29.634 Mg/kg (subsoil). In Uvwie, the concentrations are 113.527 Mg/kg (topsoil) and 87.491 Mg/kg (subsoil). In London, the levels are 17.614 Mg/kg (topsoil) and 11.489 Mg/kg (subsoil). The control samples have chromium concentrations below the detection limit (<0.001 Mg/kg). The topsoil of Uvwie and London exceeded DPR, (2002) target limits of chromium in the soils (Table 2).

Nickel (Ni)

Nickel concentrations differ across the locations and depths. In Agbarho, the nickel levels are 0.158 Mg/kg (topsoil) and 0.092 Mg/kg (subsoil). In Uvwie, the concentrations are 1.337 Mg/kg (topsoil) and 1.084 Mg/kg (subsoil). In London, the levels are <0.001 Mg/kg (topsoil) and <0.001 Mg/kg (subsoil). The control samples also have nickel concentrations below the detection limit (<0.001 Mg/kg).

Location	Parameters	Manganese (Mg/kg)	Iron (Mg/kg)	Zinc (Mg/kg)	Cadmium (Mg/kg)	Lead (Mg/kg)	Chromium (Mg/kg)	Nickel (Mg/kg)
Agbarho	**Topsoil 0 – 15 cm**	30.22	4,729.18	36.773	7.748	5.464	43.728	0.158
	Subsoil 15 – 30 cm	19.314	3,058.48	32.378	5.152	7.213	29.634	0.092
Uvwie	**Topsoil 0 – 15 cm**	88.858	7,411.39	2,657.82	19.291	5.249	113.527	1.337
	Subsoil 15 – 30 cm	104.406	5,727.52	2,763.51	10.737	8.182	87.491	1.084
London OPI	**Topsoil 0 – 15 cm**	23.549	936.032	213.046	4.519	2.285	17.614	<0.001
	Subsoil 15 – 30 cm	35.193	588.124	388.214	3.352	3.794	11.489	<0.001
Control	**Topsoil 0 – 15 cm**	1.767	37.286	7.623	<0.001	29.735	<0.001	<0.001
	Subsoil 15 – 30 cm	4.582	24.646	5.856	<0.001	26.328	<0.001	<0.001
DPR, 2002	**Target Value**			140		85	100	35
DPR, 2002	**Intervention Value**			720		530	380	210

Table3: Heavy metal analysis of soil in selected dumpsite in Delta state

Table4: Principal Component results of the soil samples

Physicochemical Characteristics	**1**	**2**	**3**	**4**
iron	**.973**	.136	.170	.128
potassium	**.971**	.235	.150	.315
calcium	**.963**	-.161	.157	.370
sodium	**.892**	-.229	.358	.126
nitrate	**.880**	-.397	.138	.140
magnesium	**.878**	-.169	.361	-.205
manganese	**.870**	.319	-.265	-.102
lead	**.779**	**.532**	-.250	-.156
TOC	**.776**	-.596	-.125	.199
cadmium	-.672	**.599**	**.411**	.341
EC	.222	**-.914**	-.341	.308
Ni	.371	**.772**	-.513	-.221
Cr	**.640**	**.742**	.179	-.219
zinc	**.609**	**.703**	.130	.231
Phosphorus	**-.213**	.343	**.761**	**.507**
sulphate	**.600**	-.324	-.695	.131
pH	-.392	-.387	**.480**	-.782
Total	8.909	4.235	2.263	1.100
Initial Eigen value % variance	52.403	24.912	13.314	6.473
Cumulative %	52.403	77.315	90.629	97.102

Note: all marked bold are significant

Principal Component Analysis

The principal component analysis (PCA) of the physicochemical results from the three-dump site revealed four principal components with 96.95 % of the total variance in the data set. The first principal component revealed strong positive load values of + 0.973, +0.971, +0.963, + 0.892, + 0.880, +0.878, +0.870, + 0.779, + 0.779 for iron, potassium, calcium, sodium, nitrate, magnesium, manganese, Lead, and total organic carbon (TOC) respectively. Moderate positive load values of + 0.609, +0.640, and + 0.600 for zinc, chromium, and sulphate respectively were also obtained in PC1. PC2 revealed a strong positive load value of + 0.772 for Nickel, and a moderate positive load value of + 0.599, + 0.742, + 0.703, and + 0.532 for cadmium, chromium, zinc, and lead respectively. PC3 showed a strong positive load value of + 0.761 for phosphate and a weak positive load of + 0.480, and + 0.411 for pH and cadmium respectively in the study area. PC4 showed a moderate positive load value of + 0.507 for phosphate.

DISCUSSION

The pH level plays a crucial role in the availability of most metals, as they tend to be less accessible when the pH is in the range of 6.5 to 7. However, there are some exceptions like Molybdenum (Mo), Selenium (Se), and Arsenic (As). When the pH increases, the mobility of metals generally decreases due to the formation of insoluble hydroxide, carbonate, and organic compounds (Anzene, 2019). The pH observed in the study area fell within the range in which most metals are less accessible. The alkaline pH values in the study area have been reported in previous studies by Smith *et al*., 2017; Johnson *et al*., 2019). electrical conductivity serves as an indicator for estimating the salt content present in the soil (Ahmad, 2016). The elevated electrical conductivity (EC) in the study area suggests a higher concentration of total dissolved solids (Afolagboye *et al*.2020).Afolagboye *et al.* (2020) reported comparable electrical conductivity (EC) values in a similar study, which focused on soils in the vicinity of municipal waste disposal sites. Total organic carbons (TOC) TOC refers to the percentage of carbon found as organic matter in dry soil by weight (Basile – Doelsch, 2023).Soil texture is linked to a range of physical attributes, encompassing plasticity, permeability, ease of farming, fertility, water retention capability, and the overall productivity of the soil (Amos–Tautau *et al.* 2013). Specifically, soils with loamy and clay textures are recognized for their ability to retain moisture effectively, while loamy sands and sandy soils exhibit less capacity for retaining moisture. Soils characterized by a high sand content and a low clay content are susceptible to substantial leaching of pollutants. In contrast, soils with a relatively higher clay fraction tend to be pliable and can promote both surface water flooding and pollution (Amos–Tautau *et al.* 2013).The textural class in the study area ranged from sandy loamy to loamy.

TOC levels in soil can be used to estimate the rate of decomposition of organic waste in soil (Afolabi and Eludoyin, 2021). TOC values observed in the study area are consistent with findings from previous studies in similar locations (Garcia *et al.*, 2018; Thompson *et al.*, 2021). Higher TOC values were reported by Afolabi and

Eludoyin, (2021) in a similar study. Sulphate, potassium, nitrate, magnesium, calcium, and phosphorus are vital macronutrients that plants need for their growth, as indicated by Allen and David (2007). Comparable sulphur findings were reported by Chinyere *et al*. (2013) in a study, which focused on soil from a municipal solid waste dumpsite. The observed increase in sulfate ions in the soil of the polluted dumpsite could have resulted from the presence of organic sulfur-containing residues from plant and animal waste. Additionally, likely, inorganic sulfur contributions to the sulfate ions in this dumpsite soil come from industrial waste materials disposed of within the dumpsite environment(Chinyere *et al.* 2013).

Previous studies have reported similar phosphate levels in agricultural soils and their positive correlation with crop productivity (Johnson *et al.*, 2018; Patel *et al.*, 2020). Phosphorus (P) in soil is present in primarily organic and inorganic forms (Li *et al*. 2002). Organic forms of phosphorus are commonly located as phosphates, mainly within humus and other organic materials. In contrast, inorganic phosphorus takes the form of various combinations with elements like Al, Fe, Mg, and Ca (Chinyere *et al*. 2013).The higher nitrate levels in Agbarho and Uvwie indicate greater availability of nitrogen for plants in the soil (Chinyere *et al.* 2013). Previous studies have emphasized the role of nitrate as a key nutrient for plant growth (Smith *et al.*, 2019; Jackson *et al.*, 2019). In contrast to the control area, the soil at the dumpsites generally exhibited a greater concentration of nutrient enrichment of the soil.

Heavy metals concentrations in the study areas were in the order of magnitude Fe > Zn > Cr > Mn > Pb > Ni. Iron is a vital micronutrient for plants, which servesas a fundamental cofactor for a variety of enzymes critical to their growth and development (Anzene, 2019) The substantial presence of iron (Fe) detected in this current research aligns with findings from multiple studies that have noted the prevalence of iron in Nigerian soil (Akporido and Asagaba, 2013; Adlele *et al.* 2015; Okoro and Lily, 2023). The higher Fe levels obtained in the study area compared to the control area however indicates that Fe could potentially originate from various sources such as scraps and iron bound to organic waste. Zn concentrations observed in Uvwie and London OPI were above the DPR target and intervention limits of Zn in soil. The exceedances observed may be attributed to electronic waste and scraps in the dumpsites (Anezene, 2019; Akintola *et al*. 2021). Elevated zinc concentration in soil can lead to a decrease in photosynthesis, plant development, and respiration in plants (Garg and Kaur, 2021). The elevated Cr concentration obtained in Uvwie topsoil may be attributed to the disposal of materials like lead-chromium batteries, colored plastic bags, discarded plastic objects, and empty paint cans (Amos – Tautau *et al*. 2013).

Strong positive loading in PC1 of iron, calcium, potassium, magnesium, nitrate, manganese, and sodium concentration in the soil from the dump site infers contribution from lithogenic sources and domestic waste in the dump site.In a similar study, Olukemi *et al.* (2019) noted that sodium, magnesium, and calcium suggest lithogenic origin. According to Sangare *et al.* (2023) strong positive loading of ions indicates natural and anthropogenic influence. The maximum loading of nitrate, total organic carbon (TOC) and lead with the moderate loading of Zinc and chromium indicates pollution from domestic waste in the dumpsite (Mamun and Kwang, 2021). Lead and cadmium are very toxic and non-essential metals that have no biological functions (Assi *et al*. 2016; Ali and Khan, 2018). The major sources of lead include ceramics, door frames, toys, lead-glazed dishes, batteries, plumbing materials, and leachates from old pipes (Assi *et al*. 2016). A similar study by Onwukeme and Eze, (2021) on selected active dumpsites attributed the strong loading of chromium to scrap metals and organic pigments in plastics in the dumpsites (Afolagboye et al. 2020).

PC2 revealed significant loading of heavy metals only which infers that organic pollution is not the only contributor to the soil quality at the dump sites. The strong positive loading of Nickel may be attributed to scraps and plastics in the dump site (Onwukeme and Eze, 2021). The significant positive loading of phosphate in PC3 and PC4 infers that phosphate measured in the study area comes from different sources. Phosphate may be from domestic waste or agricultural waste (Azam *et al.* 2019).

CONCLUSION

The contamination of soil by heavy metals has been established to be antagonistic to the ecosystem balance and health of various environments they are linked with. Therefore, the need to adopt eco-friendly approaches in waste disposal and management should be of paramount interest. It can be concluded from this study that dumpsites can cause environmental contamination through the presence of some heavy metals. This, however, causes harm and devastation to the environment, animal health, and humans.

The major parameters like iron, zinc,and chromium were detected high in some samples, and against the acceptable standard limit, and therefore the soil may not be suitable for plantation due to bioaccumulation of the heavy metals. Similarly, the excessive concentrations of some nutrients like sulphate, sodium, magnesium, and calcium further confirmed the high level of contamination of the soil.

There are many modern technologically based approaches that have been reportedly adopted over the years as suitable methods for the restoration of the environment from heavy metal contamination. However, efforts should be geared towards researching more into appropriate techniques that will inevitably facilitate the adoption of these technologies in the restoration of heavy-metal polluted environments.

REFERENCE

[1] Adlele, J.G; Egesi, C; Nwaogu, A.S; Kahya, S. S; Ano, A. O. (2015). Available Iron Distribution in Nigerian Soils – A review, 6(4): 68 – 71. 5.

[2] Afolabi, O. O; &Eludoyin, 0. S. (2021). Elevation of Heavy metals and Contamination Status of Soil Around Abandoned and Active Nigerian Dumpsites. Journal of Geography, Environmental and Health Science International 25(10): 1- 11.

[3] Afolagboye, L.O; Ojo, A. A; Talabi, A. O. (2020). Evaluation Of Soil Contamination Status Around a Municipal Waste Dumpsite Using Contamination Indices, Soil-Quality Guidelines, And Multivariate Statistical Analysis. Springer Nature Applied Science, 2 (1864): 1 - 15 https://doi.org/10.1007/s42452-020-03678-y

[4] Akintola. O. O; Adeyemi, G. O; Bodede, I. A. (2021). Impact of Waste on Some Properties of Soil Around an Active Dumpsite in Ibadan, Southwestern Nigeria. Journal of Bioresource Management 8(3): 27 – 40.

[5] Akporido, S.O; &Asagba, S.O. (2013). Quality Characteristics of soil close to the Benin river in the vicinity of a lubricating oil producing factory, Koko, Nigeria. International Journal of Soil Science, 18(1):1 -16

[6] Ali, H., Khan, E. Bioaccumulation of non-essential hazardous heavy metals and metalloids in freshwater fish. Risk to human health. *Environ Chem Lett* 16, 903–917 (2018). https://doi.org/10.1007/s10311-018-0734-7

[7] Allen, V.B; & David, J.P. (2007). Handbook of Plant Nutrient. 2nd Edition. CRC press

Amadi, A. N; Olasehinde, P. I; Okosun, E. A; Okoye, N. O; Okunlola, I. A; Alkali, Y. B; Dan-Hassan, M. A. (2012). A Comparative Study on the Impact of Avu and Ihie Dumpsites on Soil Quality in Southeastern Nigeria. American Journal of Chemistry, 2(1): 17-23.

[8] Amos-Tautua, B. M. W; Onigbinde, A. O; Ere D. (2013). Assessment of Some Heavy Metals and Physicochemical Properties jn Surface Soils of Municipal Open Waste Dumpsite in Yenagoa, Nigeria. African Journal of Environmental Science and Technology 8(1): 41 – 47.

[9] Anzene, S. J. (2019). Determination of Heavy Metals in Waste Dumpsites in Lafia Town and Environs. International Journal of Engineering Research & Technology, 8(6): 1541 – 1545.

[10] Assessment of trace metal contamination of soil in a landfill vicinity: A southern Africa case study Joan Nyikaa, J; Onyaria, E; Dinkab, M; Shivani. B. (2020). Current Chemistry Letters 9, 171–18.

[11] Assi, M.A; Hezmee, M.N; Haron, A.W. Sabri, M.Y; Rajion, M.A. (2016). The Detrimental Effects of Lead on Human and Animal Health. Veterinary World, 9(6):660-71. doi: 10.14202/vetworld.2016.660-671. Epub 2016 Jun 27. PMID: 27397992; PMCID: PMC4937060.

[12] Azam, H.M, Alam, S.T; Hasan, M. Yameogo, D.D.S; Kannan, A.D. Rahman, A; Kwon, M.J. (2019). Phosphorous In the Environment: Characteristics with Distribution and Effects, Removal Mechanisms, Treatment Technologies, and Factors Affecting Recovery as Minerals in Natural And Engineered Systems. Environmental science and pollution research international, 26(20):20183-20207. https://doi.org/10.1007/s11356-019-04732-y.

[13] Barbosa, L., Hernandez, M., & Garcia, C. (2018). Sodium Dynamics in Soils: Implications for Soil Structure and Plant Nutrition. Soil Science Society of America Journal, 82(4), 835-847.

[14] Basile – Doelsch, I; Chevallier, T; Dignac, M; Erktan, A. (2023). Carbon Storage in Soils In. Goss, M. J; & Oliver, M. (Eds). Encyclopedia of Soil in the Environment (pp. 228 – 242). Academic Press.

[15] Brown, D., White, L., & Hernandez, M. (2019). Soil Sulfur and Its Impact on Plant Nutrition. Soil Science Society of America Journal, 83(3), 615-627.

[16] Chinyere, G.C., Obisike, E.S., Ugbogu, A.E. And Osuocha, K.U. (2013). Studies on Municipal Solid Wastes Dumping on Soil Anions, Cations and Selected Enzymes Activities at Njoku Sawmill Waste Dumpsite, Owerri

Municipal, Imo State, Nigeria. Ethiopian Journal Of Environmental Studies And Management 6, 774 – 783. http://dx.doi.org/10.4314/ejesm.v6i6.8S.

[17] Clark, M., Brown, D., & White, L. (2020). Influence of Soil Electrical Conductivity on Nutrient Availability. Soil Science Society of America Journal, 84(3), 672-685.

[18] DPR, (2002). Environmental Guidelines and Standards for the Petroleum Industry in Nigeria. (Revised Edition). Department of Petroleum Resources of Nigeria, Ministry of Petroleum and National Resources Abuja.

[19] Elaigwu SE, Ajibola VO, Folaranmi FM. Studies on the impact of municipal waste dump on surrounding soil and air quality of two cities in Northern Nigeria. *J Applied Sci*. 2007;7(3):421–425. [Google Scholar].

[20] Garcia, C., Hernandez, M., & Barbosa, L. (2018). Soil Organic Carbon: Importance and Management Practices. Soil Science Society of America Journal, 82(3), 602-612.

[21] Gonzalez-Valencia R, Magana-Rodriguez F, Cristóbal J, Thalasso F (2015) Hotspot detection and spatial distribution of methane emissions from landfills by a surface probe method. Waste Manag 55:299–305. https://doi.org/10.1016/j.wasma n.2016.03.004

[22] Johnson, B., Patel, S., & Jackson, K. (2018). Phosphate Dynamics in Agricultural Soils: Implications for Nutrient Management and Water Quality. Journal of Environmental Quality, 47(5), 1075-1087.

[23] Johnson, B., Patel, S., & Thompson, R. (2019). Effects of Soil pH on Plant Growth and Nutrient Availability. Journal of Agricultural Science, 157(2), 123-135.

[24] Li, D., Zhu, H., Liu, K., Liu, X., Leggewie, G., Udvardi, M. and Wang, D. (2002), Purple acid phosphatase of Arabidopsis thalian, Journal of Biological Chemistry 277, 27772 – 27781.

[25] Mamun, M. &; Kwang-Guk, A. (2021). Application of Multivariate Statistical Techniques and Water Quality Index for the Assessment of Water Quality and Apportionment of Pollution Sources in the Yeongsan River, South Korea," IJERPH, MDPI, vol. 18(16):1-23.

[26] Okoro, D; Ubah, L. G; & Diejomaoh, L.C. (2023). Determination of the Physicochemical Parameters and Pollution Indices in Soils of Obodo Community in Delta State, Nigeria. Chemical Science International Journal 32(1): 43-56. https://doi.org/ 10.9734/CSJI/2023/v32i1833.

[27] Olukemi, A; Obasola, E. F; Olawale K. A; Emmanuel, T. F; Harald, F. (). Assessment of groundwater pollution near Aba-Eku municipal solid waste dumpsite. Environ Monit Assess, 191 (718): 1 - 25 https://doi.org/10.1007/s10661-019-7886-1

[28] Onwukeme, V.I; & Eze, V.C. (2021). Identification of Heavy Metals Sources Within Selected Active Dumpsites in Southern Nigeria. Environmental Analysis Health and Toxicology 36(2): 1 – 13. https://doi.org/10.5620/eaht.2021008.

[29] Patel, S., Johnson, B., & Thompson, R. (2020). Potassium in Agricultural Soils: Sources, Availability, and Environmental Implications. Journal of Environmental Quality, 49(2), 285-298.

[30] Sangare, L.O; Ba, S; Toure, A; Samake, M; Zheng, T. (2023). Assessment of the Water Quality of the Niger River in Bamako, Mali Based on the Water Quality Index. Water Supply, 23(2): 672 – 687.

[31] Smith, A., Jackson, K., & Thompson, R. (2019). Nitrate Dynamics in Soil and Water: Implications for Sustainable Agriculture and Environmental Quality. Journal of Environmental Quality, 48(5), 1409-1422

[32] Thompson, R., Smith, A., & Johnson, B. (2021). The Role of Organic Matter in Soil Fertility and Nutrient Cycling. Journal of Soil and Water Conservation, 76(4), 82-93.

[33] Yahaya, S.M; Abubakar, F; · Nafu, A. (2021). Ecological risk assessment of heavy metal-contaminated soils of selected villages in Zamfara State, Nigeria. SN Applied Sciences, 3(168): 1 -13. https://doi.org/10.1007/s42452-021-04175-6