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Pollution Assessment of Heavy Metals in Soil and Leachate Around Ungwan Doki Dumpsite, Plateau State Nigeria

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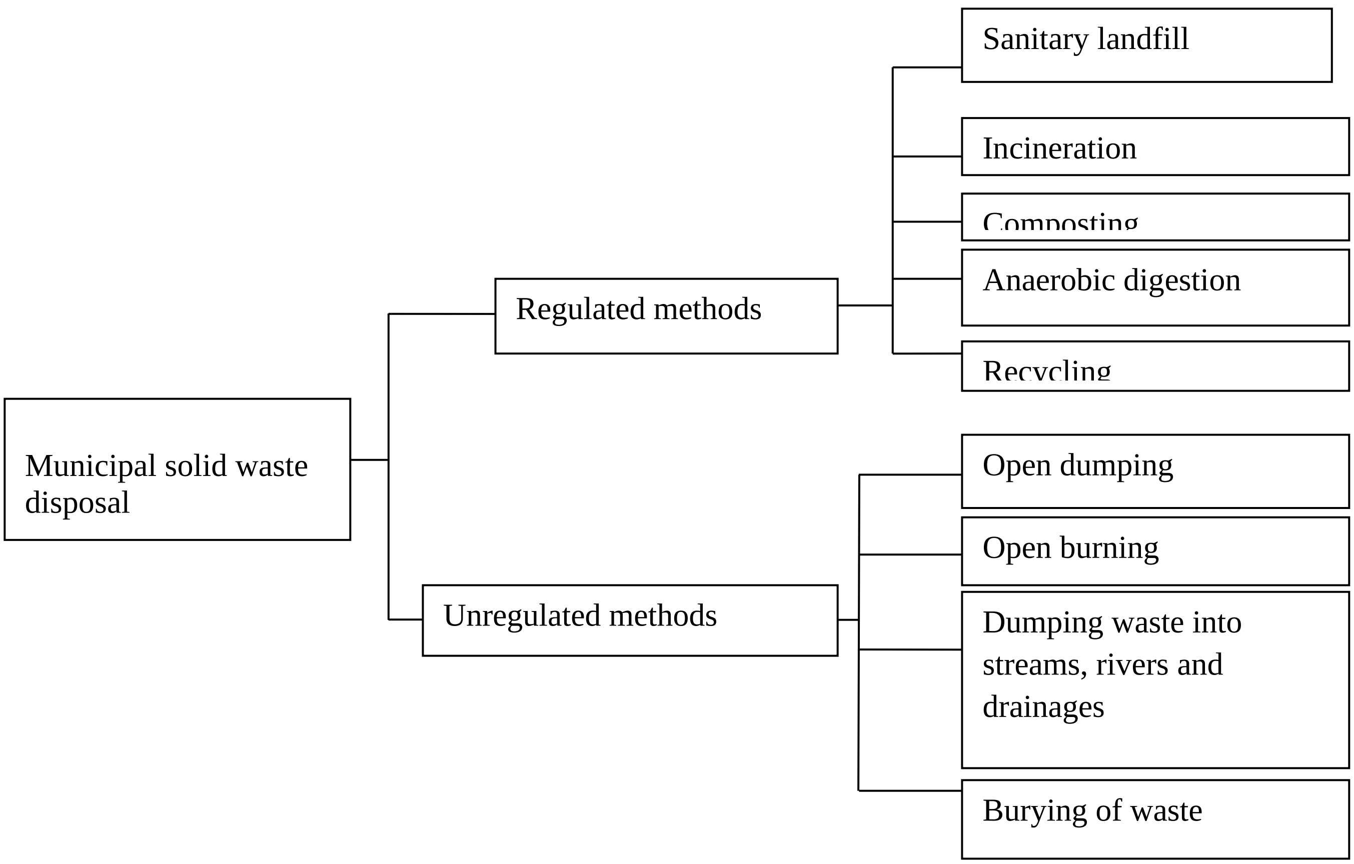
Abstract
Pollution assessment of some heavy metals in Ungwan Doki dumpsite of Plateau State Nigeria was investigated. Six (6) soils samples were collected from the sampling points and were homogenized, digested and analyzed for Mn, Cu, Cd, Fe and Pb using Atomic Absorption Spectrophotometry (AAS) and X-ray Fluorescence (XRF) for oxides elemental composition. The results revealed the pH range of (6.20 - 6.40) for dumpsite soils and control samples, bulk densities of (1.53 and1.58 g/cm^3) and electrical conductivities of the soil samples were found to be (0.01 and 0.10 µs/cm). XRF results for elemental composition in soil around the dumpsite and control site (1.0-20940 ppm) and (1.0-28730 ppm); this also unveiled the presence of radionuclides such as, K-40, Cobalt and rubidium in the soil and plant sample (root, stem and leave). AAS result revealed the concentrations of heavy metals for leachates and control sample as (0.01±0.004 - 2.20±0.004 ppm) and (2.24±0.00 ppm) and that of analytical soil and control sample as (0.37±0.005 - 12.90±0.006 ppm) and (0.02±0.001-10.40±0.003 ppm). Contamination factor, geo-accumulation index was employed to assess the level of contamination. The values were found to range between (0.049 - 41.20) and (-0.661 - 2.107) respectively. This study also examines the potentials of sorghum-bicolor for phytoremediation of some heavy metals in the Ungwan Doki dumpsite Plateau State Nigeria. Bioconcentration factor (BCF >1) indicates metal accumulation by the plant and thus, the plant can be used for phytoremediation studies.
Keywords: Waste, Dump site, Leachate, Heavy metals and pollution

Introduction

Environmental pollution has emerged as a global challenge, presenting renewed health threats from the emergence of pollution linked diseases, threat to aquatic life, agriculture and the environment in general [1]. Pollution is orchestrated by the rising demand for energy, food, and other human essentials, engineered by growing population and industrialization [2]. These demands have propelled the continuous discharge of waste on a daily basis from medical centers, food stores, feeding centers, food distribution points, slaughter areas, warehouses, agency premises, markets domestic homes, energy generation stations, among others [3]. Waste from the aforementioned sources has been the sole source of environmental pollution. Pollution of environment is the presence of contaminants to the degree that it posse danger to the existence of man, and life generally. Solid wastes from the aforementioned are confirmed to harbour a variety of microbial pathogens and allied harmful chemical substances like cyanides, heavy metals, volatile organic compounds, among others [3]. These hazardous chemicals upon leaching contaminate soil, water, air, food and animals. This in turn affects human health particularly; residents around dumpsite and vulnerable class like; young children, waste workers and immunocompromised persons [3]. Consequentially, environmental pollution and climate change has together synergistically threatened the peaceful existence of man on earth with evidential catastrophic events. Solid waste aside environmental pollution is implicated in climate change, as a source of greenhouse gases, contributing as much as 4 % of the global emission [4]. Majorly among the greenhouse gases are Methane (CH_4) and carbon dioxide (CO_2). Methane has even more global warming potential (21 times) than carbon dioxide, increasing the annual atmospheric concentration of the greenhouse gases by 2 % [4]. Climate change due in part to the reckless waste disposal causes global warming (rising air and water temperatures), short and erratic rainfalls, cyclones, storms and tidal waves, flooding, landslides, drought and desertification, among others [5]. Pollution due to waste disposal has been under serious investigations recently even in Nigeria [6]. Ulakpaet *al,* [7] analyzed the soil around power line dump site at Boji-Boji Owa, Delta State [7], it was found that the soil differs significantly from the control in physicochemical parameters and had potential of polluting nearby waters. Furthermore, the increased sand relative to clay fractions in the study area is a demonstration of desertification potential. In another research, it was found that waste deposit polluted the air quality in Makurdi; carbon monoxide, hydrogen sulfide and methane were recorded to be above the recommended limits [4]. Waste is an inherent and inevitable part of human activities hence; its generation cannot be avoided. However, with proper handling, the impact of waste will be reduced to the minimum. Unfortunately, poor waste management as evidenced by open dumping has characterized developing countries to which Nigeria is not an exception [7]. This is due to lack of proper enforcement of environmental protection laws which are supposed to deter violators, and a lack of awareness of the general public about the impactful implication of their reckless attitudes toward the environment [8]. In many parts of Nigeria; including Ungwan Doki in plateau state, the reckless, illegal and indiscriminate dumping of solid waste is a common experience and the major challenge [9]. Wastes are not collected directly from households, but at open deposit sites where residents dump the waste. A mild exception to this fact is the case with Lagos, Calabar and Abuja, where private sector relied upon the collection of waste directly from households [10]. Although, in these states the system is not universal; rural and low-income people do not engage these services.

Even though, waste discharged in small quantities are said to improve agricultural soil by increasing the content of nitrogen, organic matter and cation exchange capacity [7]. These nutrients are pertinently essential to plants growth. However, the accompanying of heavy metals and the excessive discharge and dumping rather poses pollution challenges [6]. Therefore, the method of handling remains the most profound tool in addressing the pollution resultant of the wastes generated from these varying sources [7]. In a related research Bemgba and Akaahan recommended that recycling and proper dumping facilities should be provided by the regulatory authorities instead of indiscriminate and reckless dumping on soil in order to protect the environment and human health [6]. The two basic approaches of waste management are regulated and unregulated pathways show in scheme 1.



Scheme 1: Waste management approaches

The best approach of waste management which is recycling is not common among the residents around the dump site. The residents of Ungwan Doki are known to sort the wastes at the dump site before final dumping as shown in Plate 1. Even though, this approach is not entirely regulated, it is better than the just dumping wastes. The soil and leachate around Ungwan Doki dumpsite were selected for this researched simply because the dumpsite seem to impact a lot on the source of drinking water by the nearby community in terms of contamination.

In recent times, various soil metal pollution indices have been in used which include among others such as, enrichment factor (EF), metal enrichment index (MEI), contamination factor (CF), pollution load index and geo-accumulation index (Igeo) [25]. Reference values of these parameters are used as a tool to evaluate the potential for contaminants within the soil matrix.

Contamination factor (CF) is used to determine the enrichment of metals based on the concentrations of each metal in the soil. Pollution load index (PLI) this described the level of heavy metal pollution in soil. Also, Geo-accumulation Index (Igeo) is a regularly used index to evaluate the degree of metals geogenic pollution load and anthropogenic [26]. This study aimed to evaluate the degree of pollution of Ungwan Doki dumpsites soil.

Plate 1: Sorting of Metals from Waste at Ungwandoki Dumpsite

Materials and Methods

Materials

Reagents: All the reagents used in this research study were of analytical grade. They include; n-hexane, dichloromethane, iso-octane, nitric acid, sulphuric acid, hydrochloric acid and sodium tetraoxosulphate(vi) acid.

Sample material: Other materials include the soil sample from the dumpsite and the leachates thereof.

Equipment/Apparatus: Denver sieve shaking machine, Analytical weighing balance, crusher, pH meter and conductivity meter, Atomic Absorption Spectroscopy (MY14470001), Energy dispersive X-ray fluorescence spectrometer (Genius IF Xenometrix Ltd Isreal) and Scanning Electron Microscopy (Phenom ProX world Eindhoven the Netherlands).

Methods

Sampling: Soil samples were collected from dumpsites of Ungwan Doki in Jos-South local government area of Plateau state Nigeria. Plateau state is located in Nigeria's middle belt, with an area of 30,913 km^2 (11,936sq mi). It is located between latitudes 9° 51'30'N to 10°02'00"N and longitudes 8°48'00"E to 9°59'00"E. The State has an estimated population of about three million people. Figure 1 shows the sample area. Six replicate soil samples were collected at depth of 0 - 15 cm with steel augar, within a tract section of 2 m by 2 m grid and were thoroughly mixed to obtain homogenous sample. The sample was then transported to the laboratory in an ice cooler at temperature of 40c and was analyzed. Controlled sample was also collected 300 - 500 m away from the dumpsite at different points within the Ungwan Doki neighboring village.

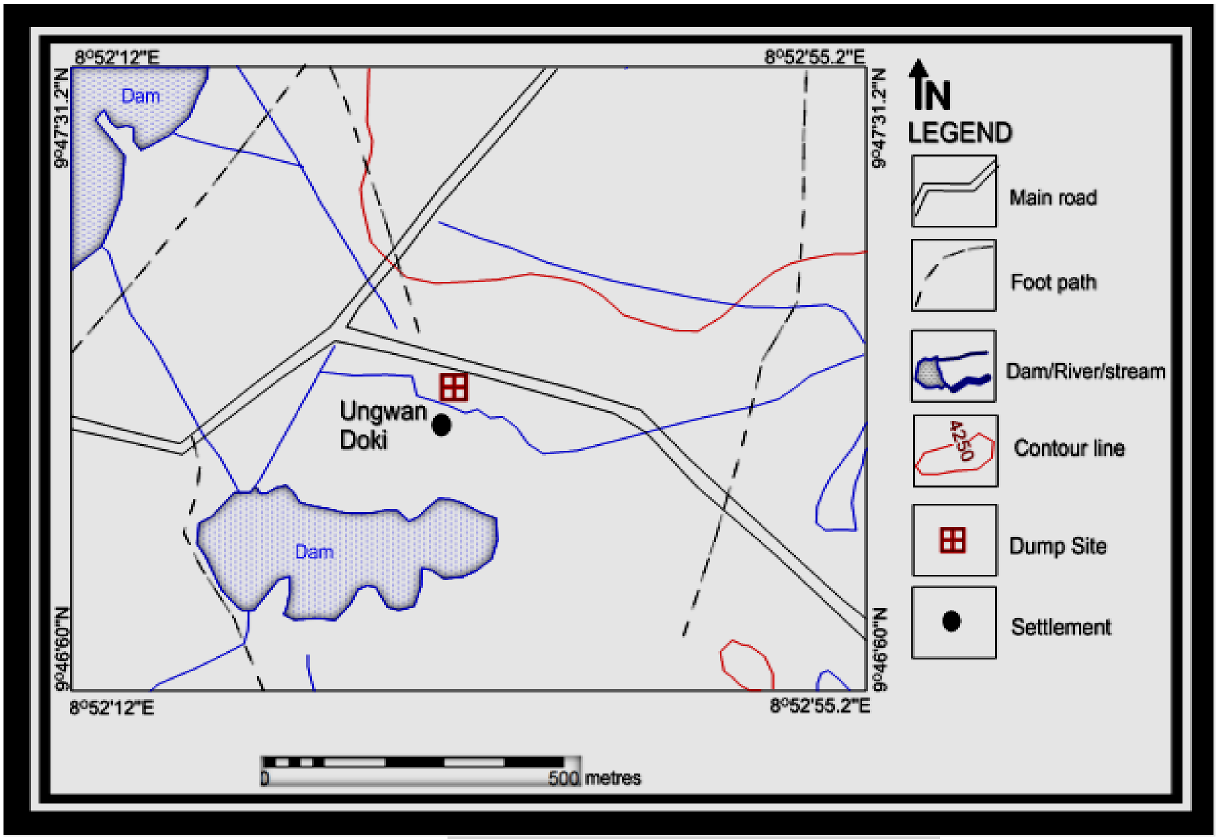


Figure 1: Map of the sample collection point

Plate 1: UngwanDoki dump site and dump site soil sampling respectively

Sample pretreatment and preparation

The soil sample was air-dried over several days, crushed with mortar then sieved through a 0.5 mm nylon mesh to obtain a homogenous sample matrix and stored in polyethylene containers for analysis of soil properties and heavy metal concentration [11].

Physicochemical Parameters of Soil around the Dumpsite

Physiochemical parameters of the soil samples which include; pH [12], conductivity [12], bulk density [12] and grain size distribution [13], were determined following the procedure documented by the corresponding references. The morphology of the dump site soil was analyzed using a JEOL JSM-6400 scanning electron microscope at accelerating voltage of 20 KAV, real time of 21-36 and life time of 60 seconds.

Soil pollution indices

a) Contamination Factor (CF) gives an indication of degree of contamination of heavy metals in the soil.

Expressed as $CF = \frac{C\text{-Sample}}{C\text{-Background}}$

Where C-Sample is the given metal in the soil, C-Background is the background value f the metal

b) Geo- accumulation index (Igeo) determines the concentration of the metal accumulation in soil above the baseline concentration. It is expressed as

$Igeo = \log_2[Cn/Bn.1.5]$. where Cn is the measure concentration of element n and Bn is the geochemical background value.

Results and Discussion

Table 1: Physicochemical properties of the dump site soil Ungwandoki

Parameters	Mean values	
	Dump site	**Control**
pH	6.36±0.002	6.20±0.002
Conductivity (µS/cm)	0.10±0.001	0.01±0.001
Bulk density (g/cm³)	1.58±0.001	1.53±0.001
CEC (meq/100g)	4.12±0.001	3.28±0.002
Clay (%)	14.72	12.72
Silt (%)	16.00	16.00
Sandy (%)	69.28	71.28
Textural class	Sandy loam	Sandy loam

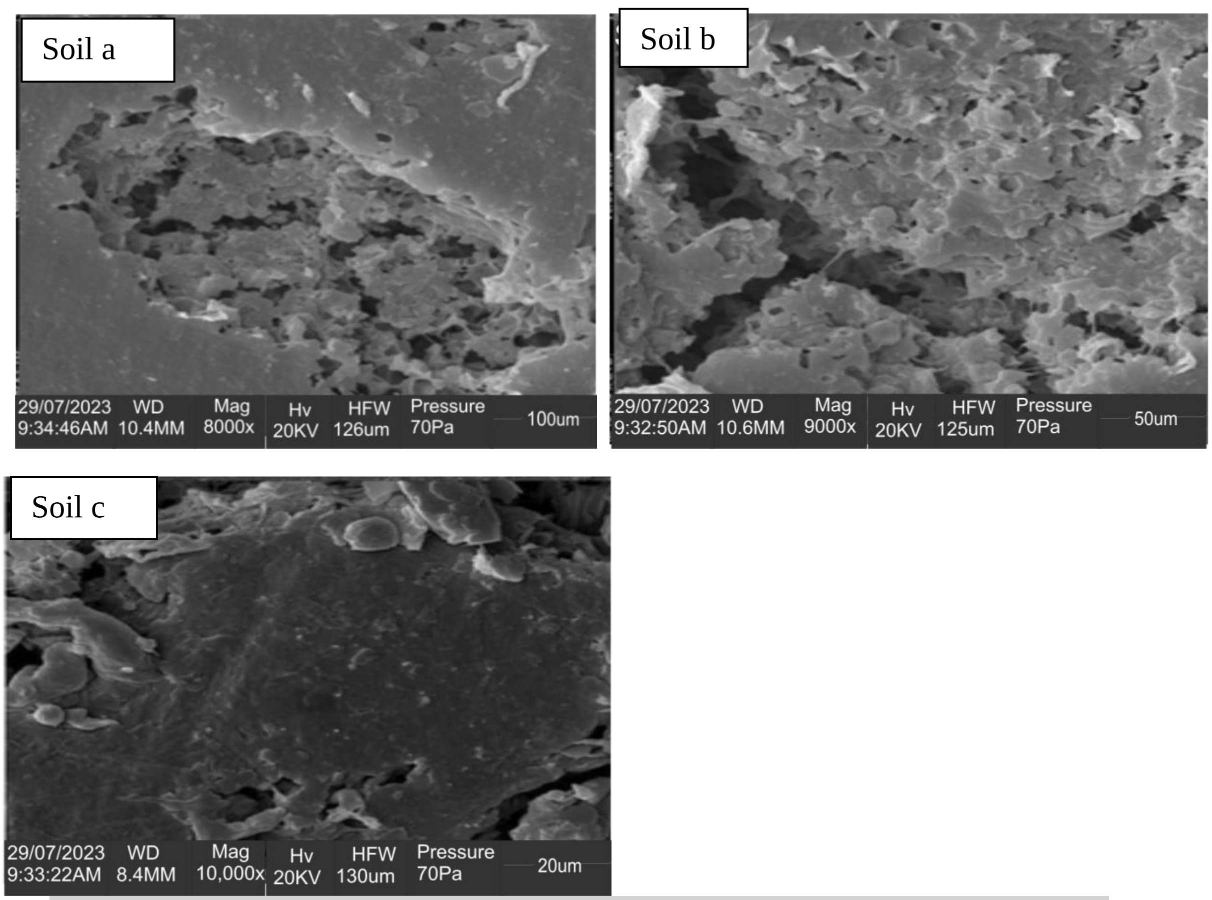


Plate 2: SEM Images of the Dump Site Soils at (A) 8000, (B) 9000 and (C) 10000 Magnifications

Table 2: Heavy Metal Content of the Dumpsite Soil and the Leachate

		Concentrations in ppm	
S/No.	**Heavy metals**	**Sample**	**Control**
		Dumpsite soil	
1	Mn	1.45±0.001	0.02±0.001
2	Cu	0.37±0.005	0.11±0.001
3	Cd	BDL	BDL
4	Fe	12.9±0.006	10.4±0.003
5	Pb	0.81±0.002	BDL
		Dumpsite leachate	
1	Mn	BDL	BDL
2	Cu	0.01±0.004	BDL
3	Cd	BDL	BDL
4	Fe	2.20±0.004	2.42±0.001
5	Pb	BDL	BDL

BDL= Below detection limit

Table 3: XRF Result Showing Concentrations of Oxide and Elemental Composition in Soils around Ungwan Doki Dumpsite

		Concentrations in (ppm)		
S/N	Oxide	Oxides in soil	Elements	Elements in oxides
1	Al_2O_3	15970	Aluminum	8454
2	SiO_2	44800	Silicon	20940
3	P_2O_5	388.0	Phosphorus	169.0
4	K_2O	1726	Potassium	1433
5	CaO	20740	Calcium	14820
6	SO_3	1999	Sulphur	801.0
7	TiO_2	2500	Titanium	1499
8	V_2O_5	97.00	Vanadium	54.00
9	Cr_2O_3	52.00	Chromium	35.00
10	MnO	139.0	Manganese	108.0
11	Fe_2O_3	10230	Iron	7154
12	NiO	1.000	Nickel	1.000
13	CuO	64.00	Copper	51.00
14	ZnO	132.0	Zinc	106.0
15	MgO	BDL	BDL	BDL
16	Ta_2O_5	20.00	Tantalum	17.00
17	SnO_2	2412	Tin	2040
18	WO_3	BDL	BDL	BDL
19	Ag_2O	23.00	Silver	21.00
20	Co_3O_4	41.00	Cobalt	30.00
21	PbO	BDL	BDL	BDL
22	BaO	81.00	Barium	73.00
23	ZrO_2	278.0	Zirconium	206.0
24	Nb_2O_3	65.00	Niobum	52.00

BDL = Below detection limit

Table 4: XRF Results Showing Concentrations of Oxide and Elemental Composition in Control Soil around UngwanDoki Dumpsite

		Concentrations in (ppm)		
S/N	Oxides	Oxides in soil	Elements	Elements in oxide
1	Al_2O_3	6556	Aluminum	3470
2	SiO_2	17120	Silicon	8006
3	P_2O_5	1804	Phosphorus	787.0
4	K_2O	34610	potassium	28730
5	CaO	16960	Calcium	12120
6	SO_3	3136	Sulphur	1256
7	TiO_2	374.0	Titanium	224.0
8	V_2O_5	54.00	Vanadium	30.00
9	Cr_2O_3	24.00	Chromium	17.00
10	MnO	255.0	Manganese	198.0
11	Fe_2O_3	1590	Iron	1112
12	NiO	1.000	Nickel	1.000
13	CuO	182.0	Copper	145.0
14	ZnO	162.0	Zinc	130.0
15	MgO	3448	Magnesium	2079
16	Ta_2O_5	BDL	Tantalum	BDL
17	SnO_2	833.0	Tin	657.0
18	WO_3	18.00	Wolfram	14.00
19	Ag_2O	59.00	Silver	55.00
20	Co_3O_4	BDL	Cobalt	BDL
21	PbO	BDL	Lead	BDL
22	BaO	66.00	Ba	59.00
23	ZrO_2	7.000	Zirconium	5.000
24	Nb_2O_3	BDL	Niobium	24.00

BDL = Below detection limit

Table 5: Comparative Elemental Composition of Soil Samples from Dumpsite and Control Site and their Contamination Factor C_f

		Composition (ppm)		
Class	Elements	Dumpsites	Control	*Cf*
Heavy metals	Manganese	1080	1980	0.545
	Chromium	350.0	170.0	2.058
	Copper	510.0	1450	0.351
	Zinc	1060	1300	0.815
	Titanium	14990	2240	6.691
	Vanadium	540.0	300.0	1.800
Non essential	Zircon	2060	50.0	41.20
	Niobium	520.0	240.0	2.166
	Aluminum	84540	34700	2.436
Non metals	Phosphorus	1690	7870	0.214
	Sulphur	8010	12560	0.637
	Silicon	20940	12560	16.67
Other metals	Calcium	14820	12120	1.222
Radionuclides	Potassium	14330	28730	0.049
	Rubidium	BDL	BDL	BDL
	Cobalt	300.0	BDL	BDL

BDL = below detection limit

Cf= contamination factor

Table 6: Total Pollution Load Index Showing the Geo Accumulation Index (I_{geo}) of the Metals in Dumpsite Soils

Elements	Bn	Cm	Igeo	Pollution status
Manganese	0.900	BDL	BDL	BDL
Nickel	0.012	BDL	BDL	BDL
Chromium	0.797	350.0	-0.321	Uncontaminated
Zinc	0.168	1060	-0.881	Uncontaminated
Niobium	1.496	520.0	-0.421	Uncontaminated
Vanadium	0.805	540.0	-0.637	Uncontaminated
Titanium	22.56	11990	2.107	Contaminated
Tin	36.33	BDL	BDL	BDL
Tantalum	0.182	BDL	BDL	BDL
Silver	0.255	BDL	BDL	BDL
Cobalt	0.323	300.0	-3.321	Uncontaminated
Lead	0.043	BDL	BDL	BDL
Bismuth	1.932	BDL	BDL	BDL
Zircon	7.536	2060	-0.432	Uncontaminated
Phosphorus	2.024	1690	-0.123	Uncontaminated
Silicon	21.33	20940	-0.612	Uncontaminated
Aluminum	3.470	84540	-0.661	Uncontaminated

BDL = Below detection limit
Bn = Geochemical background values of metals.
Cm = Measured total concentration of metals in soil.
I_{geo} = Geoaccumulation index.

Table 7: Mean Concentrations of Heavy Metals in Root, Stem and Leave of Guinea Corn Plant

		Concentrations in (ppm)		
S/N	Metals	Root	Stem	Leave
1	Aluminum	5190±4.123	2588±8.011	1581±3.70
2	Silicon	9831±2.201	7203±10.22	12240±6.80
3	Phosphorus	671.0±1.10	7005±7.041	570.0±4.00
4	Potassium	18420±6.22	35540±11.1	27490±10.1
5	Calcium	18960±4.02	14270±6.44	15880±8.02
6	Sulphur	1647±2.20	973.0±3.10	678.0±5.23
7	Titanium	1367±5.03	141.0±1.24	145.0±1.29
8	Vanadium	36.00±0.23	BDL	BDL
9	Chromium	13.00±0.08	4.000±0.33	29.00±0.60
10	Manganese	141.0±1.24	70.00±0.51	130.0±1.00
11	Iron	4859±3.31	714.0±2.20	927.0±3.00
12	Nickel	1.000±0.00	4.000±0.31	4.000±0.39
13	Copper	214.0±1.00	176.0±2.10	161.0±2.08
14	Zinc	243.0±1.02	168.0±1.90	132.0±0.67
15	Niobium	32.00±0.12	23.00±0.03	21.00±0.04
16	Tantalum	24.00±0.01	BDL	50.00±0.90
17	Tin	329.0±3.00	1012±5.02	679.0±4.90
18	Wolfram	37.00±0.31	13.00±0.41	7.000±0.07
19	Silver	14.00±0.01	15.00±0.31	35.00±0.08
20	Cobalt	19.00±1.00	20.00±0.55	BDL
21	Lead	BDL	BDL	BDL
22	Bismuth	BDL	BDL	27.00±0.02
23	Rubidium	24.00±0.01	59.00±0.70	27.00±0.02
24	Zirconium	24.00±0.01	2.000±0.001	9.000±0.01

BDL = Below detection limit

Table 8: Bioconcentration Factor in *Sorghum bicolor* (Guinea Corn Plant)

S/N	Metals	Plant	Soil	BCF	Pollution Status
1	Al	9350	8454	1.105	Accumulation
2	Cr	46.00	35.00	1.314	Accumulation
3	Mn	211.0	108.0	1.953	Accumulation
4	Fe	6500	7154	0.908	Absorption
5	Cu	551.0	51.00	10.80	Accumulation
6	Zn	432.0	106.0	4.075	Accumulation
7	S	3298	801.0	4.117	Accumulation
8	Ti	1653	1499	1.102	Accumulation
9	Ta	29.00	17.00	1.705	Accumulation
10	Ag	64.00	21.00	3.047	Accumulation
11	Zr	35.00	206.0	0.169	Absorption

BCF = Bioconcentration factor, BCF ≤ 0, indicate absorption, BCF ≥ 1, indicate accumulation

Table 9: Translocation Factor in *Sorghum bicolor* (Guinea Corn) Plant

S/N	Metals	$Plant_{shoot}$	$Plant_{root}$	TF	Pollution Status
1	Al	2588	5190	0.498	absorption
2	Cr	4.000	13.00	0.307	absorption
3	Mn	70.00	141.0	0.496	absorption
4	Fe	714.0	4859	0.146	absorption
5	Cu	176.0	214.0	0.822	absorption
6	Zn	168.0	243.0	0.691	absorption
7	S	973.0	1647	0.590	absorption
8	Ti	141.0	1367	0.103	absorption
9	Ni	4.000	1.000	4.000	accumulation
10	Ag	15.00	14.00	1.071	accumulation
11	Zr	2.000	2.000	1.000	Accumulation

TF = Translocation factor, TF ≤ 0, indicate absorption, TF ≥ 0, indicate accumulation

The physicochemical properties of the dump site soil show that the soil is slightly acidic as shown in Table 1. This pH value is typical of dumpsite which is in the second phase of anaerobic decomposition and in transition to third phase which is the methane fermentation stage. However, following the suitability of this kind of soil for farming, it is regarded as being normal [14]. Electrical conductivity is the measure of soil salinity, texture and cation exchange capacity [7]. For the dump site soil, the value correlates with the result of the parameters as presented in Table 1 and was slightly above the control soil sample. This is likely due to the presence of metals discharged from electronic waste and metal scraps. Bulk density of the dump site soil was observed to be slight higher than the bulk density of productive natural soil which is 1.1 g/cm^3. High bulk density greater than (>1.5) reduces water infiltration and plant root penetration resulting in increase in surface water pollution. The observed bulk density can partly be explained by the traffic of heavy duties in and out of the site packing the residue after burning. Cation exchange capacity (CEC) is the measure of the number of exchangeable cations presence in the sampled soil. This parameter entails metals like Calcium (Ca), Sodium (Na), Magnesium (Mg) and Potassium (K). Soil fertility to a great extend depend on the cation exchange capacity, as it defers from presence of the metals, in which some may not be exchangeable. The CEC for the dump site soil studied is similar to that obtained by [7]. The low clay content of this soil implies that the metals though present may be absorbed hence, not exchangeable. Furthermore, the high sand content partly also explain the low CEC content observed as presented in Table 1. Textural quality of the soil shown in Table 1 depicted that the soil in general is sandy loamy [15]. In both the dump site and the control, the trend is an increasing content from clay, silt to sandy fractions. The higher sandy content and low clay content of the soil is due to low CEC [15].

Leachate modification of waste dump site soil mainly takes place due to the physicochemical interactions between contaminant and soil [16]. It can also be observed from the SEM image in Plate 2, that the sand has fine particles with aggregation less dispersed small pore sizes. However, big pore sizes exist between the aggregations dissolved calcite possibly from the contamination. This characteristic nature of the soil will lead to decreased friction angle and permeability. The SEM magnification at 8000x and 9000x clearly shows the distortion in the sand particles distribution with less pore sizes. In SEM image at 10000x, the sand particles are show to be interlocked by the silt and clay fractions and the dissolved calcite. Soil with poor percolation has high tendency to be affected by erosion. The heavy metal content of the soil and the leachate were examined and the results were as presented in Table 2. All the heavy metals detected from the dump site soil, the leachate and the controls were all considerably lower than their respective guideline values set by WHO [17]. The presence and absence of lead in the dump site and the control respectively, implies that it emerges from the waste dumped at the site. This result also agrees with that of Musa *et al*. [18]. In the leachate however, manganese, cadmium and lead were all absent both at the site and the control. This is an indication of early discharge, in which the metals are yet to leach out in to the water system. Copper was also found present in the site leachate but absent at the control implying that the waste contained copper substance which is yet to migrate to nearby places. The result of heavy metals content of the dump site as discussed in above implies that the site is not polluted. Proper waste management is however encouraged to prevent eventual contamination and pollution of the dump site and the nearby soil and water bodies. Base on the information obtained from Table 3, using XRF SiO_2 was found to be relatively high in concentration than any other elemental oxides and this is in agreement to the one reported by Ikusemoran*et al*, [20]. The high concentration could be due to the fact that silicon and oxygen are the most abundant element in the earth crust; they are strongly bonded to each other which make their compound stable as reported by Alexander *et al*, [21]. Al_2O_3 was observed to be relatively high in concentration which is in tandem with the result reported by Alexander *et al*. [21]. The high concentration could be due to the fact that Al_2O_3 are less mobile elements in the soil in which they are lock up especially alumino-silicate minerals as reported by Magili and Maina, [22]. CaO was observed to be high in concentration which could be due to the soil pH balance, calcium oxide helps in neutralizing acidic nature of the soil by increasing the pH value, creating more favourable environment for plant growth. Another reason could be due to the fact that CaO helps in flocculating soil particles which in turn improve soil structure, aeration and water infiltration. The result in Table 3, revealed the concentration of Fe_2O_3 to be relatively high as reported by Alexander *et al*. [21]. The high concentration of Fe_2O_3 could be due to the fact that Fe is relatively abundant in the earth crust. TiO_2, SnO_2, SO_3, K_2O. P_2O_5, ZrO_2, MnO, ZnO, V_2O_5, BaO, Nb_2O_3, CuO, Cr_2O_3, Co_3O_4, Ag_2O, Ta_2O_5 and NiO were observed to be in relatively low concentration and this could be due to leaching or due to ionic exchange, reaction that took place in the soil. [21]. PbO, WO_3 and MgO were below the detection limit. Table 4, revealed the result of the oxides in the control soil to be lower compared to the samples of the soil around Ungwan Doki dumpsite. In the aquatic environment, these oxides get into the streams through run-off of soils around the dumpsite existing in different chemical forms (species), distributed between sediments and solutions [19].

The recorded contamination factor values for manganese, copper, zinc, phosphorus, sulphur and potassium, all fall within the low contamination range [16], while zircon, silicon and titanium fall within the range of high contamination; aluminum, niobium, chromium, vanadium and calcium fall within the range of moderate contamination as presented in Table 5.

The geo-accumulation index values of less than zero imply practical uncontamination [17]. This simply indicate that the availability of chromium, zinc, niobium, vanadium, cobalt, zircon, phosphorus, silicon and aluminum may likely be natural and less of anthropogenic source, whereas manganese, nickel, tin, tantalum, silver, lead and bismuth were not available as presented in Table 6.

XRF analysis was used to determine the heavy metal concentration in the root, stem and leave of guinea corn plant as presented in Table 7. From this analysis, calcium, potassium, silicon aluminum and iron appear to be the most predominant elements in the root stem and leaves. However, the concentration is much higher in the root than the stem and leaves except for potassium which has higher concentration in the stem and leaves than the root Wu *et al*, [23] reported that the roots of plants tend to have higher concentration of metals compared to stems and leaves. Roots acts as a barrier for metal translocation and protect stem and other plant parts from metal contamination. Roots have more ability to absorbed potassium from the soil than other plant parts since it has higher concentration in all the three compartments of the plant samples (root, stem and leave) [23]. Cobalt, vanadium, barium and lead were not detected in the three compartments of the plant except for cobalt that is detected the root and stem of the plant (190 ppm and 200 ppm) respectively. This could be attributed to the inability of the plant root to absorb the heavy metals from the soil. While the concentration of Zn, Cu, Zr, W, Ta, Nb, Ag, Sn, Ni,Ti, S, P,and Cr appears to be very low in the root, stem and leaves of the plant, ranging from (10-16470 ppm).

The results of bioconcentration factor in guinea corn plant as presented in Table 8 revealed the value for Al, Cr, Mn, Fe, Cu, Zn, S, Ti, Ni, Ag and Zr in the plant. BCF value for all the metals in root, stem and leave of the plant exceed value 1.00 except for Fe and Zr which the values were below 1.00 (<1). This indicates that the root, stem and leave can accumulate these metals; thus, Al, Cr, Mn, Cu, Zn, S, Ti, Ni and Ag. These results suggested that Fe and Zr bioavailability were low and the plant can only absorb but do not accumulate them [24].

Translocation ratios from root to stem and from stem to leave were calculated for each metal as presented in Table 9, which revealed the translocation ratios of Al, Cr, Mn, Fe, Cu, Zn, S, Ti, Ni, Ag and Zr below 1.00 from root to stem except for Ti and Ni which were slightly higher than 1.00 from root to stem. All metals translocated from stem to leaves more than from root to stem. This indicates that these metals in the root zone transported weakly to the stem but somehow easily mobilized to leaves when they are available in the stems [24].

Conclusion

The dump site waste at Ungwan Doki seems to have not significantly impacted the soil and the leachate as the locale in terms of physicochemical properties and heavy metals. The attitude of metals sorting at the dump site is possibly the reason for less metal content impact noticed within the site and its environs. Although the soil is not polluted at the moment, literature on the waste disposal still present convincing and compelling reasons to agree that waste recycling is the best. Hence, Ungwan Doki residents are still encouraged to maintain the good practice of waste sorting to remove potential pollutants source wastes and adoption of incineration of the rest rather than open dumping. It can be agreed that the dumpsite soil at Ungwan Doki area of Plateau State is not polluted yet base on the results of the quality indices obtained.

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