Evaluation of Two Major Dumpsites as Potential Sources of environmental Pollution in Owerri, Imo State, Southeast Nigeria

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Abstract*: Environmental contamination emanating from indiscriminate disposal of municipal solid waste is a trending issue in most developing countries of the world today. The aim of this was to evaluate physicochemical, selected heavy metal contents and organic compounds at Nekede and Naze dumpsites. Soil samples were randomly collected at 0 -15cm and 15 - 30cm depths with the aid of a soil auger. Standard analytical methods were used for the determination of physicochemical parameters, AAS was employed for selected heavy metal determination while high Pressure Liquid Chromatography was used to analyze organic compounds. Results showed that at Nekede dumpsite vicinity, pH, TOC and TPH measured ranged as follows: 4.45 – 5.11, 1.50-2.40%, N.D – 0.153 mg/kg respectively, with corresponding lowest and highest values at NKSS2 and NKSSC; NKSS1 and NKSS2; NKSSC and NKSS2, while at the Naze area, comparative values of 4.73 – 5.17, 0.70–1.92% for pH and TOC was obtained. Lowest and highest values were at NZSS2 and NZSSC for pH, NZSSC and NZSS2 for TOC, but TPH was below equipment detection level. At Nekede dump site; the phosphate value varied 44.00 – 90.01mg/kg, Nitrate, 10.80 – 20.00mg/kg and Sulphate, 17.00 – 40.55mg/kg, compared to Naze dump site with Phosphate 33.10 – 46.50mg/kg, Nitrate, 8.30 – 10.70mg/kg and Sulphate, 12.10 - 20.00mg/kg. The exchangeable cations: calcium, sodium, magnesium and potassium varied 40.800 – 44.560mg/kg; 10.500 – 13.018mg/kg; 32.60- 43.640mg/kg and 12.140 –17.380mg/kg for Nekede while in the same vein, Naze recorded 35.16– 37.620mg/kg; 8.72 –12.770mg/kg; 0.660 – 1.940mg/kg and 10.340 – 17.860mg/kg. While Nekede dumpsite vicinity has moresandy soil with a mean value of about 53%, clay formed foremost part of soil structure at the Naze axis with 58.50%. In both sites silt was lowest with about 10.6% and 7% recorded at Nekede and Naze respectively. These dumpsite soils are constitutean environmental risk to local population hence there is exigent need for urgent remediation action plan by the regulatory agencies concerned.

***Keywords*: Dumpsite, Physicochemical, Heavy metals, Soil, Imo State.**

I. INTRODUCTION

In most developing countries, lack of proper disposal and management of municipal solid waste represents a serious environmental challenge [1-2]. This is due to the tendency of such dumpsites to contaminate the soil, ground and surface water sources which ultimately becomes toxic to flora and fauna in the ecosystem [3]. According to [4], lack of proper waste management and disposal system is an unavoidable problem in Nigeria as a result increasing population, rapid urbanization, industrialization, and lax environmental laws. This assertion is apt given the prevalent method of municipal solid waste in most developing countries such as Nigeria. For instance, In Imo state, the commonest method of waste management practices are simply based on the collection and dumping out of the city boundaries in an open excavated waste dumps [5-6]. This consequently results in flagrant disposal of wastes thereby creating major waste dumpsites in many parts of the city [7]. These dumpsites have been implicated to contain hazardous substances with potentials to alter ecosystem integrity and the services they render [8]. In particular, heavy metals and organic compounds have been detected in municipal solid waste dumpsites soil with a myriad environmental implications. According to [5], solid waste dumps through leachate seeps to the groundwater, thereby causing abnormalities, such as cancer of the body and heart diseases. Soil and ground water acidification and nitrification have been linked to waste dumps as well as microbial contamination of soil and ground water system [9-11]. There have been numerous journals and texts published in the past which explain the harmful effects of disposal of municipal solid waste on natural water bodies and soil [1]. Exposure to multiple chemical combination in occupational exposed populations and those residing near dumpsites has been implicated in series of human health disorders such as organic dysfunction, reproductive, neurobehavioral and genetic disorders [12]. Heavy metals are released into the environment from metal smelting and refining industries, scrap metals, plastic and rubber industries, various consumer products and from burning of waste containing these elements. The metals volatilize on burning and is released into the air. These volatilized metals becomes mobile and travels for large distances and are deposited on the soil, vegetation and water depending on their density[10]. Once deposited, the metals are not degradable, they persist in the environment for many years poisoning humans through inhalation, ingestion and skin absorption. Acute exposure to these toxic metals leads to nausea, anorexia, vomiting,

gastrointestinal abnormalities, dermatitis and many fatalities. The contamination of the ecosystem by harmful waste indicators such as heavy metals and is a serious problem in the society because the environment is a direct receptacle for waste products generated in the space within the environment [13-16]. [17] noted that waste from municipal dumpsites bear soils that are satisfactorily rich in organic matter that would be acceptable for surface feeder plants. Subsequently, [10] and [6] reported concurrently, that an open dump sites perform a twofold purposes of a safe disposal of waste and simultaneously approved chemical properties of soils that constitute productive agricultural fields. Nigeria a Western African country has a comparatively very poor waste management approach. Thus, the inadequate waste management approach has the potential of increasing soil metal concentration in and around the Nekede and Naze open dumpsites. Soil metal contamination increases health risks and deteriorates agricultural lands. In Imo state, the Ministry of Environment is saddled with the responsibility of checkmating solid waste and other waste disposal. In his assessment of heavy metals pollution in dumpsites in Ilorin Metropolis, [18] observed that about 70 % of Mn, Fe, Zn, Cd and Pb were found in the exchangeable bound to carbonate and bound to iron/manganese oxide fractions. These fractions represent the mobile and lethal portion of the total metals to the ecosystem. The metal enrichment factor revealed that Zn, Cd and Pb were of anthropogenic source while Fe is of natural and anthropogenic sources. The author concluded that the dumpsites pose negative consequences on the soil and groundwater environment. [19] postulated that disposal of municipal waste on soils may cause an increment in heavy metals composition in the soil and shallow water that would be amicable to deep feeding crops. The mobility of heavy metals, bioavailability and related bio-toxicity to organisms depend on their specific chemical forms or ways of binding rather than the total metal concentration obtained after strong acid digestion. The mobility and bioavailability of metals in water and soil is a self-motivated process that depends on unambiguous combination of biochemical and environmental parameters. These include parameters such as pH, organic matter content, redox potential, cation exchange capacity (CEC) [20], sulfate, carbonate, hydroxide, soil texture and clay content. Presently, there is paucity of information regarding the assessment of inorganic and organic compounds of municipal solid wastes in the study areas. It is hoped that the present study will produce a new framework for assessment of environmental risks associated with municipal waste. Therefore, this study seeks to access the physicochemical properties, selected heavy metals and organic compounds in the vicinity of open waste dumpsite in Nekede and Naze Areas, Imo State of Nigeria. Assessing the environmental implications of waste disposal on ecosystem health requires a thorough soil chemistry as well as laboratory and filed studies to fully comprehend the extent of contamination of the environment and potential risk to the ecosystem. This study was therefore undertaken to evaluate the physicochemical, selected heavy metal concentration and organic compounds at two dumpsites in Owerri, Imo State Nigeria.

II. MATERIALS AND METHODS

Study location

The study carried out at Nekede and Naze dumpsites located at Owerri West L.G.A., Imo State. It was characterized by a main annual rainfall ranging from 2000-2500 mm, a mean temperature ranging from 26-28 ^{0}C and humidity ranging from 70-80% [21].

Sample collection

Soil was sampled at a total of 6 sampling locations, made up of 3 each, around Nekede (Nekede soil sample 1, 2 and 3 coded NKSS1, NKSS2, NKSSC respectively) and Naze (Naze soil sample 1, 2 and 3 coded NZSS1, NZSS2 and NZSSC respectively) dumpsite under stringent controls. A hand augur was employed to take the soil samples after decontamination using distilled water at each point of sampling. Five sampling points in a quadrant were selected per sampling location. Sampling depth was at 0-15cm and 15-30cm per point with 2m space between sampling points, making a total of 10 and then all combined for homogeneity, to make a composite sample per location/site (ISO, 11074-2, 1998). As done in varying European Union soil studies, 500g from composite is recommended for laboratory analysis[22]. A plastic spoon was used to transfer into polythene bags, labeled, packed and kept in an ice packed cooler and taken to the laboratory for analysis [23].

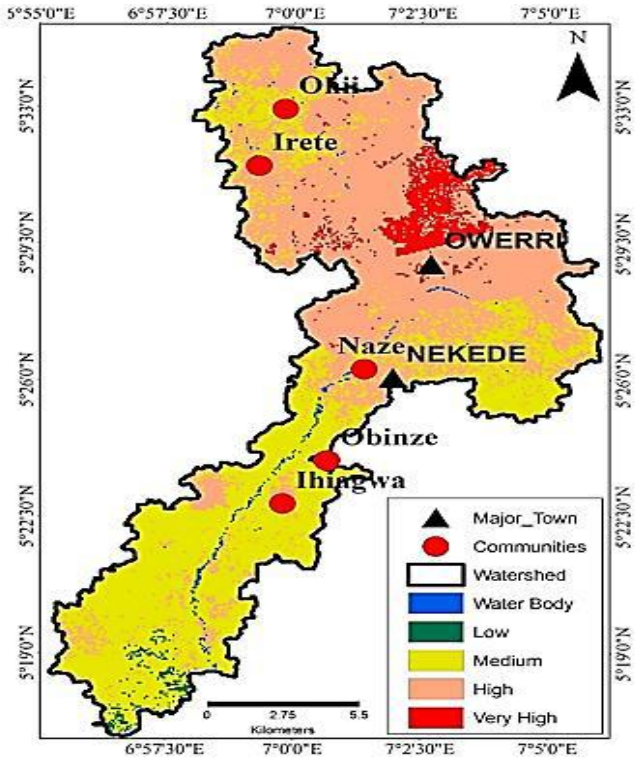


Fig. 1. Map of the study areas

Laboratory analysis of sample

In the laboratory, soil samples were stored in cardboard boxes and then dried with a fan at 36–40°C until constant weight was reached[22]. Then they were disaggregated using a wood pestle, sieved at 2 mm, the volume was reduced by quartering and rifling to obtain the test sample from the laboratory samples[24].About 1.0g weight of the air dried soil sample was weighed and digested using Aqua Regia. This method which is consistent with USEPA 3050 and ISO standard 11466 as reported by [25] involves treating a soil sample with a 3:1 mixture ratio of hydrochloric (HCl) and nitric (HNO_3) [25]. The nitric acid destroys organic matters and oxidizes sulphide material. It reacts with concentrated hydrochloric acid to generate aqua regia: $3HCl+HNO_3 \rightarrow 2H_2O+NOCl+Cl_2$. Aqua regia is considered adequate for dissolving most base element sulphates, sulphides, oxides and carbonates[25]. Quantitatively, the digested samples were transferred into a 125ml plastic container, filtrated with 50ml de-ionized water and metal analysis performed with Buck scientific Atomic Absorption Spectrophotometer (Model GFA-EX7i, Shimadzu Corporation, Japan) using air acetylene flame with a digitalized read out system [26]. This involves direct light source emitting a narrow spectral line of characteristic energy. A hallow cathode lamp is used to excite the free atoms of trace metal of concern in the flame. Concentration of representative metal standard solution is run along the wavelength and its absorbance reading recorded. The concentration of the excited metal atom is calculated by comparison with a standard curve of the metal. To ascertain the reproducibility of the measurements, the analyses was replicated thrice. Furthermore, to ascertain the accuracy of analysis, it was verified by analyzing the certified reference material from International Atomic Energy Agency (IAEA) [26]. Moreover employing similar methods, standard calibrated solutions and blanks were analysed. All results are expressed in mg/kg.

Physicochemical analysis of samples

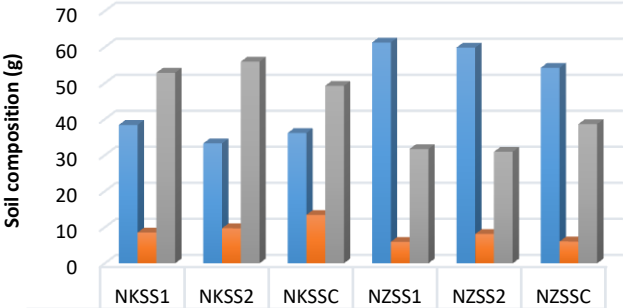
To determine pH and Total Organic Carbon (TOC), Mettler Toledo Seven Easy pH meter and Walkley-Black Titrimetric method respectively were used [23].

III. RESULTS

Table 1displays soil test result of measured parameters around an active dumpsite at Nekede and a non-active dumpsite at Naze. At Nekede dumpsite vicinity, pH, TOC and TPH measured ranged as follows: 4.45 – 5.11, 1.50-2.40%, N.D – 0.153 mg/kg respectively, with corresponding lowest and highest values at NKSS2 and NKSSC; NKSS1 and NKSS2; NKSSC and NKSS2, while at the Naze area, comparative values of 4.73 – 5.17, 0.70–1.92% for pH and TOC was obtained. Lowest and highest values were at NZSS2 and NZSSC for pH, NZSSC and NZSS2 for TOC, but TPH was below equipment detection level. The three (3) main nutrients are nitrogen (N), Phosphate (P) and Potassium (K), these form the NPK value. Most anions analyzed in the samples tend to be relatively abundant which increase the microbial load associated with the dump site. At Nekede dump site; the phosphate value varied 44.00 – 90.01mg/kg, Nitrate, 10.80 – 20.00mg/kg and Sulphate, 17.00 – 40.55mg/kg, compared to Naze dump site with Phosphate 33.10 – 46.50mg/kg, Nitrate, 8.30 – 10.70mg/kg and Sulphate, 12.10 - 20.00mg/kg. The exchangeable cations: calcium, sodium, magnesium and potassium varied 40.800 – 44.560mg/kg; 10.500 – 13.018mg/kg; 32.60- 43.640mg/kg and 12.140 –17.380mg/kg for Nekede while in the same vain,Naze recorded 35.16–37.620mg/kg; 8.72 –12.770mg/kg; 0.660 – 1.940mg/kg and 10.340 – 17.860mg/kg. Figure 3 shows soil characteristics in the two locations where the dumpsites are located. While Nekede dumpsite vicinity has more sandy soil with a mean value of about 53%, clay formed foremost part of soil structure at the Naze axis with 58.50%. In both sites silt was lowest with about 10.6% and 7% recorded at Nekede and Naze respectively.

Table 1: Average Physicochemical/heavy metal features of soil at Nekede and Naze dumpsite vicinity

	NAZE AREA			NEKEDE AREA		
Parameter	NZSS1	NZSS2	NZSSC	NKSS1	NKSS2	NKSSC
	N5.46848 E07.04152	N5.46896 E07.04138	N5.47168 E07.04167	N5.46527 E07.02983	N5.46549 E07.02989	N5.46304 E07.02871
PH	4.86	4.73	5.17	4.78	4.45	5.11
TOC (%)	7.30	3.92	0.70	9.50	5.40	1.52
TPH (mg/kg)	<0.001	<0.001	<0.001	0.100	0.153	<0.001
PAHs (mg/kg)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Phosphate (mg/kg)	46.50	45.04	33.10	90.01	60.20	44.00
Nitrate (mg/kg)	10.70	8.30	9.10	20.00	17.55	10.80
Sulphate (mg/kg)	20.70	12.70	12.10	40.55	35.01	17.00
Calcium (mg/kg)	35.160	36.580	37.620	43.800	40.980	44.560
Sodium (mg/kg)	12.770	9.650	8.720	10.500	11.172	13.018
Potassium (mg/kg)	17.860	15.040	10.340	16.040	17.380	12.140
Magnesium (mg/kg)	1.940	1.520	0.660	32.600	35.580	43.640
Fe(mg/kg)	902.20	536.42	69.83	928.07	685.58	81.20
Cd(mg/kg)	90.22	9.41	0.00	76.40	8.01	0.00
Pb(mg/kg)	54.92	8.02	9.10	58.11	10.42	12.48
Cu(mg/kg)	31.48	4.73	5.92	38.05	5.89	6.15
Ni(mg/kg)	5.08	2.92	0.01	7.30	3.82	0.01
Zn(mg/kg)	680.03	493.50	45.30	705.03	522.78	601.71



	NKSS1	NKSS2	NKSSC	NZSS1	NZSS2	NZSSC
Clay	38.41	33.29	36.17	61.29	59.87	54.28
Silt	8.55	9.73	13.45	5.97	8.14	6.06
Sand	52.89	55.97	49.27	31.73	30.96	38.64

Figure 1: Soil composition around dumpsite in Nekede and Naze

IV. DISCUSSION

Values of pH in Table 1 highlight a general acidic soil. According to [27 and [7] soil in the Southeast regions are naturally acidic. pH among variables such as soil structure, the organic matter quantity and the cation exchange potential of the soil could control the circulation and enrichment of heavy metals in soil [29-31]. This could favour the precipitation and bioaccumulation of heavy metals in soil [32-33], such as Mn, Zn and Ni [34]. The high rainfall in the area was responsible for the acidic soil, which may cause soil erosion and consequent leaching of common cations such as Ca^{2+} and K^{+}, Mg^{2+} and Na^{+} [35]. These macro nutrients including copper are more soluble in acidic medium and hence neutralize the acidic property of the soil. [36] opines that some anions such as Phosphate (PO_4^{3-}) and Sulphate (SO_4^{2-}) are acidic and could alter the acid-base load of the body when taken in high concentration and this could be obvious without a corresponding availability of basic cations (K, Ca and Mg) that has potential of balancing it.

The concentration of nutrient, phosphate, nitrate and sulphate followed the trend Phosphate >Sulphate> Nitrate. A study by [37] slightly differed in trend as follows- Phosphate >Nitrate >Sulphate, but aligned with concentration of the nutrients of the prevailing study. The active dumpsite contained more nutrients than the non-active, and as well their concentration attenuated as the distance increased off the dumpsite. This could be an indication of dumpsite aided contamination [38].

So there is a tendency of production of a low grade chronic metabolic acidosis and then hypercalcuria, calcium release from the bone with setting in of osteoclast [32]. Application of fertilizers for soil enhancement for farming purposes could exceed the absorption capacity of the crops on the farm and accumulate in the soil. Hence there is possibility of leaching as soluble phosphate, as well as nitrate into the surface and groundwater where they could pollute surface and groundwater aquifers [39] Nitrate (NO^3) compound is important for fertilizing plants, but a dangerous contaminant of groundwater. Phosphate is one of the key nutrients found in fertilizers and also necessary for plant growth [39]. Discharge of substances containing nitrate or phosphate into aquatic ecosystem could induce eutrophication, which is an excess enrichment of a body of water with mineral and nutrients, causing extreme increase of plants and algae [40]. This could deplete available oxygen in the aquatic ecosystem [41] with consequent adverse impact on the aquatic ecosystem such as creation of 'dead zone' [39]. Hence oxygen available to the organism is highly reduced and may cause death. Higher values of nitrate and phosphate observed in Otamiririver could be responsible for the massive plant growth on the river water. [40] reported that excess fertilizers are washed off as part of runoff into surface waters during heavy rainfall, though with some of the nitrate and phosphate leaching into the soil zone and could be taken up by plants, and then concentrating in their edible tissue which may then be consumed by man [42]. With increased nitrate load in a biological system, there could be biotransformation which may cause the formation of metabolites such as nitrosamine resulting to carcinogenesis, teratogenesis and juvenile methaemoglobinaemia [43-45]. In school children, their thyroid gland state as regards size and functionality have been reported as adversely affected by nitrate contaminated drinking water [40].

The TPH of 0.100 and 0.153 mg/kg at NKSS1 and NKSS2 were probably due to spillages from fueling of waste haulage trucks and other heavy duty equipment for dumpsite management operations. The non-detection at the Naze sample sites could be due to non operational status of the area.

The average TOC of 5.47 % and 3.97 % for the active Nekede and non-active Naze dumpsite shows higher decomposition at the active dumpsite [46].

Generally heavy metals attenuated as distance progressed off the dumpsite. However some control sites were indicative of higher metals such as Zn, Cu and Pb at NKSS3 that measured 601.71 mg/kg; 6.15 mg/kg and 12.48 mg/kg, against nearer to the dumpsite NKSS2 station with corresponding values of 522.78 mg/kg; 5.89 mg/kg and 10.42 mg/kg as displayed in Table 1. Similar trend was observed at the Naze location where Cu and Pb measured higher values at the control locations as compared to the values obtained at NZSS2 which was closer to the dumpsite. Station NKSS3 and NZSS3 which are control sites for Nekede and Naze vicinity are near major roads and hence could account for the increased concentration of lead, Zinc and Copper as has been reported by [47], who documented depositions on highway vegetations and soil of trace metals such as zinc, copper and, which could be from additives utilized in petrol and lubricating oils.

The heavy metal concentration trend for both Naze and Nekede vicinity followed a similar trend as follows Fe>Zn>Cd>Pb>Cu>Ni. Oluseyi*et al.* (2014) obtained Fe>Cu>Zn>Cd>Cr>Pb, while [47] documented Fe>Zn>Mn>Cr>Pb>Cd.

The high level of Fe could be attributed to much presence of Fe in the Southeastern Nigeria [49-50]. Man and other animals could directly take in heavy metals via inhalation of

dusty soil [51]. Heavy metals such as Lead, Zinc, Copper, Cadmium and Nickel play disruptive role when they enter the body system in higher concentration than required amount [52-54]. This often leads to Anemia, brain damage, anorexia, convulsion, vomiting and death [55-56]. Meanwhile plants in terrestrial ecosystem have been reported to bioaccumulate trace metals pollutants from soil in dumpsites, which consequently degrade the rate of phytodiversities [44]. It is noticed that the vegetation condition of both dumpsite locations rather than diverse composition, suffered degradation. [39] opine that degradation of soil quality and decline in vegetation abundance are some of the issues associated with open dumping.

The soil particle size relative abundance as observed for the non-operational Naze dumpsite was silt < sand< clay while for the operational Nekede dumpsite, it was silt < clay< sand as displayed in Figure 3. The Naze dumpsite result differ from the work of [50] and [48] who observed clay < silt < sand, which is in tandem with works by [56-58] who reported high sand constitution of soil in Southeast Nigeria. The difference in the observed trend for the two dumpsites was attributed to activities taking place at the sites, as operational dumpsite soil are organically bound when compared to that in non operational soil. The high proportion of sand in the soil samples for the operational dumpsite bared the sandy loamy texture class of the dumpsite waste [59]. Hence there could be poor metal retention capacity at the Nekede dumpsite. According to [60], there is decrease in the retention potential of soil as clay content decreases. The implication could be infiltration of large amount of leachate due to waste degradation into groundwater as time goes on due to weakly buffered soil. Ground water average flow rate is estimated at 400 m/year and the leachate could move away from its source at same rate [61-65]. So in 5 years, the leachate would have transverse about 2km. This could indicate future potential pollution. Though there is localisation of contamination at the top soil at present, there is potential for ground water pollution in the future if waste dumping persists [66-68].

V. CONCLUSION

The physicochemical, selected heavy metal concentration and organic compounds were evaluated in this study. The result established that municipal solid are potential sources of toxic substances to the ecosystem, these substances can bioaccumulate in the food chain and subsequently cause adverse effect on the ecosystem and humans. This study has shown that municipal soil waste can lead to contamination of soil by heavy metals and organic pollutants. We recommend that continuous monitoring at major dumpsites and stricter environmental policies should be implemented as a matter of urgency. There is therefore urgent need for remediation technology and management of the contaminated soils in this study sites so as to render it fit for ecosystem health.

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