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Assessment of the Chemical Parameters and Heavy Metal Contamination of Soil in Selected Locations in Okene Town, Kogi State, Nigeria

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Abstract

Soil samples were collected from selected locations in Okene town, Kogi State. The research assessed the chemical parameters including pH, chloride, nitrate, sulphate, and phosphate from soil samples collected from selected locations in Okene town, Kogi State, Nigeria in January – October 2023. The parameters were evaluated using appropriate pollution indices, to report the levels of the chemical parameters in the soil. The results revealed that the mean value of pH of the soils ranged between6.90±0.45-6.40±2.12, chloride ranged between 60.50±37.48-4.95±0.07, nitrate ranged between 50.10±1.27-9.20±1.70, sulphate ranged between 630.00±70.71-225.00±77.78 and phosphate 4.00±5.66-0.00±0.00.This research showed that the soil in these locations do not have any potential to harmed living organisms. The results further indicate that the soils from the sampling sites need to be monitored frequently to forestall good health and prevent further contamination. However, the mean concentration of Zn ranks the highest while Cu has the lowest value. Geo-accumulation factor (Mn 1.08 – Cu 2.02), Contamination factor (Mn 12.11 – Cu 104.90), Pollution Load Index (Mn 0.20 – Zn 3.64) and Ecological risk factor (Mn 0.20 – Cu 16.17) for heavy metals had values above maximum permissible limits of FAO/WHO indicating the soil in workshops were heavily contaminated. Therefore, this research suggested that frequent test should be carried out regularly to avoid further contaminations.

Keywords: Chemical Parameters, Contamination, Soil, Heavy Metals and Town.

Introduction

Soil is a monumental connection between the biosphere and lithosphere therefore consist a non-renewable natural resource. Soil pollution is one of the major problems that threatens plant and people's ecosystems as such as landfills, solid waste, industrial wastes into the soil, percolation of contaminated water into the soil, rupture of underground storage tanks or excess application of pesticides or fertilizers [1].Soil as one of the components of the biosphere therefore facilitates plant production by soil organic matter decomposition [2] and mineral nutrients recycling [3]. The soil physio-chemical properties are required [4], to ascertain the productive capacity of an area for the support of forest vegetations. Land use transforms affect the changes in the biogeochemistry, hydrology, and climate of the earth. The impact of land uses affects the soil quality status, which is not direct but instead the complex to guarantee any generalizations [5]. Soil consists of several minerals, broken rocks and organic compositions that have emanated to the alteration of reactions in the environment [6]. The various contaminants and pollutants are naturally absorbed by the soil and this made the soil to become a natural sink to all pollutants. This resulted to transformations in the chemical and physical characters of the soil. The capacities of the soil to infiltrates impurities, absorb oxygen, destroy disease causing agents and releasing carbon dioxide to the atmosphere made it a natural purifier [6]. Human activities has increased the contamination of soil, such pollution resulted to life challenges that threatens the existence of humans, animals and plants life. The biological nitrogen fixation, phosphorus solubilization and decomposition of organic matter in rhizosphere and non-rhizosphere zones of plants increases soil organic matter, improving soil structure and nutrient cycling of soils [7]. Also, the compositions of nutrients by various tree species with their potentials to return these nutrients into the soils cause differences in soil characteristics [8].The increase of urbanization, anthropogenic activities resulted to large pollutants release into the urban environment thus, causing great heavy metal contamination of soils [9]. The soil which is a natural sink for various pollutants is naturally made up of varieties of minerals, organic constituents and broken rocks which are altered by environmental reactions [6]. Therefore, this study is aimed to evaluate the risk associated with selected pollutants in soil under different land utilization in Okene Town, Kogi State, Nigeria. The research determines the levels of chemical parameters and heavy metals from the sampling sites.

Materials and Methods

Description of Study Area

Okene is a town in the Okene Local Government Area (LGA) of Kogi State, Nigeria. According to the 2006 census, it had a land area of 328 km^2 and a population of 325,623 [10]. Okene is a semi-city located between latitude 7°32'18.2" N and longitude 6°14'19.8" E and 6°16'19.8" E using a Global Positioning System, The local government area (LGA) borders include Adavi to the North, Ajaokuta to the East and Ogori-Magongo LGAs to the West all in Kogi state, and Okpella in Edo state to the South. Okene is situated in Nigeria's North Central Geopolitical Zone [11]

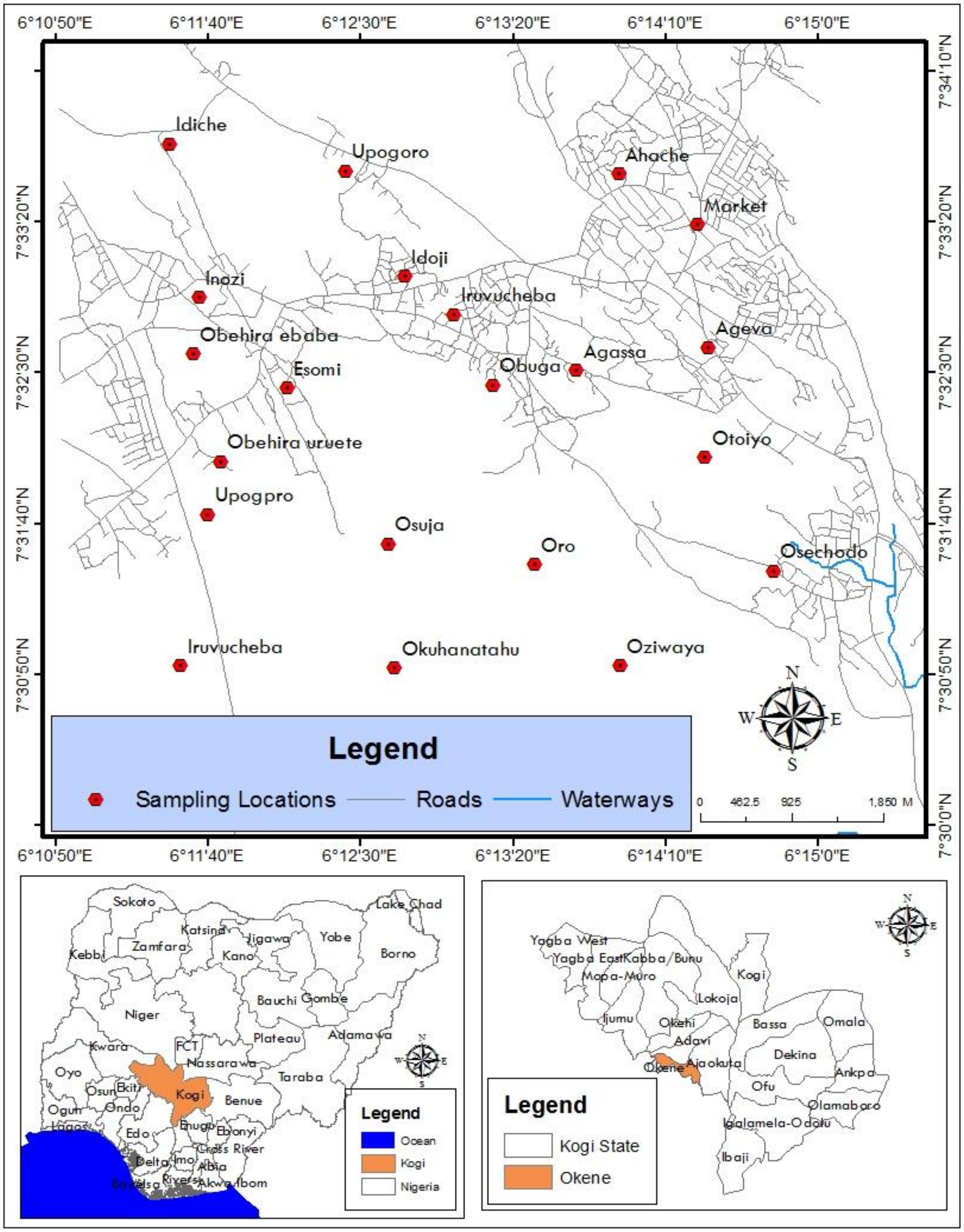

Figure 1.0: Map of Okene Showing Sampling Locations.

Sample Collection

The soil samples were collected using a stainless-steel Auger and stored in properly labeled polyethylene bag. Soils samples are air dried at room temperature (21 – 27°C) for seven days. The samples were grounded using a porcelain mortar pestle and sieved by passing through 2 mm mesh to remove stones, plant roots, coarse materials and debris [11].

Determination of soil pH

Exactly 10.00 g of air-dried soil sample was weighed into a 20 cm^3 beaker, add 10.00 cm^3 of distilled water and allowed to stand for 30 minutes and stirred with a glass rod. The pH meter was inserted into the partly settled suspension and the pH was measured. The soil pH was measured in water. The electrode and probe of the pH meter were rinsed before and after measurement [12].

Determination of chloride (Cl^-)

The soil sample of 5.00 g was weighed into a beaker 5.00 cm^3 of distilled water was added and allowed to stand for 30 minutes and stirred the mixture with a glass rod at intervals. The conductivity meter probe was inserted into the suspension and the electrical conductivity was measured. The probe of the conductivity meter was rinsed before and after immersion [12].

Determination of nitrate (NO_3^-)

A 50 g sodium acetate was mixed with 250 $cm^3$of distilled water in a 1000 cm^3 volumetric flask. Add 30 cm^3 of Conc. acetic acid to the solution and top up the solution to 1000 cm^3. Also, add 5 g of salt was measured into a shaking bottle and 1/2 spatula full of activated charcoal were added to the bottle, plus 20 cm^3 of extracting solution. Shacked the bottle for two (2) minutes and later filtered. Transferred 1000cm^3 of the filtrate into test tube, then, add 0.5 l of NO_3^-reagent (brucine) and 2 cm^3 of H_2SO_4. Stirred for 30 seconds and keep on to stand for 5 minutes. Mixed with 2 cm^3 of distilled water once again and allowed the test-tube to cool for 15 minutes and finally, the spectrophotometer was set at 470nm and the concentration was recorded [13].

Determination of sulphate (SO_4^{2-})

Preparation of the extracting solution: A 0.5 g of $KH_2PO_4.2H_2O$ was measured into 1000 cm^3 of water. Sieved the soil sample with 2 mm sieved and measured 5 g of the sample into 250 cm^3conical flask and add 25cm^3 of extracting solution, followed by agitation of the mixture on a mechanical shaker for 10 minutes. Then the suspension was filtered out and 10 cm^3 of the filtrate was measured into a 25 cm^3 volumetric flask. Add distilled water to it to a mark of 20 cm^3. 1cm^3 of 10% $BaCl_2$ was added and the final volume was made up to the mark. Shake the mixture for 30 minutes [12].

Determination of phosphate (PO_4^{3-})

Add 15 cm^3 of 1.0 M ammonium fluoride solution into a 500 cm^3 volumetric flask. Weighed 1 g of air-dried soil sample into a centrifuge tube and add 7 cm^3 aliquots of the extracting solution into the tubes. Placed the tubes into the centrifuge machine and centrifuged at 2000 rpm for 10 min. Add 2 cm^3 of aliquots of the clear supernatant solution into boiling tubes. Add 5 cm^3 of distilled water and 2 cm^3 of ammonia solution and mixed thoroughly by shaking the tubes. Eventually, 1 cm^3 aliquots of stannous chloride were added to the tubes and mixed. And the spectrophotometer at 660 nm was used to measure the Absorbance [13]

Soil Pollution Indices.

Pollution assessment models are indicators used to assess the presence and intensity of anthropogenic contaminant deposition on soils. In this study, the following pollution assessment models were employed: contamination factor, geo-accumulation Index, pollution load index and ecological risk factor were used to measure the extent of heavy metal pollution contaminations.

Geo-accumulation index (Igeo)

Geoaccumulation index (Igeo) is popularly used in the determination of contamination by comparing the levels of heavy metal obtained to a background levels originally used with top soil samples [14]

The Igeo has been used to evaluate the pollution level in soils and it can be calculated

using the following equation:

$$I_{geo} = Log_2\left(\frac{C_n}{1.5B_n}\right) \quad \text{……………………. (3.1)}$$

where Cn= is the measured concentration of every heavy metal in the soil (mg kg−1),

Bn= Geochemical Background value in average soil.

1.5 = possible variations of the background data due to lithogenic Effect [15]

Contamination factor

Contamination factor (CF) is defined as the contamination from anthropogenic activities with a single heavy metal [16].It determines the ratio between the content of each heavy metal in the soil to the geochemical background value, calculated by equation 1:

$$CF = Csoil/Cbackground \quad \text{………….. (3.2)}$$

where: Csoil = Concentration of each metal in the soil samples and Cbackground = geochemical background value of each metal [16] categorized the contamination values into four classes such as CF<1 low contamination, CF<1 low contamination, 1<CF<3 moderate contamination, 3<CF<6 considerable contamination, CF>6 very high contamination

Pollution load index

The pollution load index (PLI) of a single site is the root of number (n) of multiplied together with contamination factor (CF) values.

$$(Cf1 \times Cf2 \times Cf3 \times Cf4 \times Cf5 \times Cf6 \ldots \ldots Cfn)^{1/n} \quad \text{........................ (3.4)}$$

Where, n is the number of metals and CF is the contamination factor [17]. PLI assessment standards for soils are as follows: PLI ≤ 1 not polluted, 1< PLI≤ 2 slightly polluted, 2 < PLI ≤ 3 moderately polluted PLI > 3 highly polluted [18].

Ecological risk factor (Er)

The ecological risk factor (Er) is a method used to evaluate the ecological risk in soil which depends on metal toxicity and environmental response factors.

Er is calculated using the following equation:

$$Er = Tr \times CF \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.5)$$

where Tr = toxic-response factor values for each different metal.

The five classes of Er are as follows Er<40 low risk, 40<Er ≤ 80 moderate risk, 80<Er≤160 considerate risk, 160<Er≤ 320 high risk and Er> 320 significantly high risk.

Results and Discussion

Table 1.0 Chemical parameters of the analyzed soil

S/No	Cl^-	NO_3^-	SO_4^{2-}	PO_4^{3-}	pH
AM	4.95±0.07	29.35±1.20	265.00±21.21	0.51±0.70	6.50±0.14
BC	30.65±4.02	35.00±1.41	240.00±56.57	3.01±4.24	6.50±0.14
MK	49.76±27.10	34.65±3.32	495.25±35.00	0.00±0.00	6.65±0.21
HO	14.96±2.10	48.70±2.40	555.00±91.92	4.00±5.66	6.60±0.26
PF	17.00±3.54	31.00±3.54	240.00±56.57	0.00±0.00	6.45±0.07
AB	60.50±37.48	27.95±0.07	480.00±70.71	0.00±0.00	6.50±0.14
OS	15.05±3.46	11.00±0.05	270.00±28.28	1.50±2.12	6.40±2.12
PS	31.40±4.38	50.10±1.27	450.00±63.80	0.50±0.71	6.90±0.45
IN	9.35±0.21	24.10±2.97	225.00±77.78	0.06±0.00	6.65±0.21
CO	15.05±3.46	11.00±=0.05	270.00±28.28	1.50±2.12	6.40±2.12
RT	14.50±2.82	17.20±1.70	630.00±70.71	3.00±4.24	6.70±0.28
WW	8.00±0.71	9.20±1.70	255.00±91.92	0.00±0.00	6.40±2.12

[19]

Soil pH

The results revealed that sampling point with the highest value is petrol station (PS) with pH of (6.90±0.45) followed by road transport (RT) (6.70±0.28) and oil spill (OS), construction (CO) and welder workshops (WW) has the least concentrations (6.40±2.12) each. Soil pH is the degree of acidity or alkalinity of the soil. At soil pH of 6.5, nutrients are at the highest availability to plants and toxic is at the minimum. The pH values of soils investigated in this dissertation support highest availability of nutrients that make toxicity at the lowest. The values also favour activities of microorganisms. The chemical characteristics of the soils as investigated in Table 1.0. The results revealed that soils pH was slightly acidic. Topsoil pH ranged from 6.30 to 6.90. Lower pH in soils were attributed to intensive farming practices.

These values did not conform to FAO/WHO value of (6.50-8.50). The pH has a significant effect on the mobility of heavy metals in soils and lower pH facilitates the sorption capacity of soil than that of neutral or alkaline pH. Therefore, metals mobility increase with decreasing pH and reducing conditions. So, the more acidic the more mobile metals move away also, the more reducing conditions the more the move mobile metals become. This may be due to the nature of parent material in the sampling areas.

Chloride

The maximum mean Cl- value was blacksmith (SM) (77.79±10.16) accompanied by abattoir and forestry (FO) with a value of (60.50±37.48) each, while the minimum mean value of (4.00±1.41) was obtained from refuse dumping (RD). Some non-biochemical roles of chloride require higher concentrations of the element. The symptoms of chloride toxicity (higher concentrations) are related with osmotic effect of saline soils. When chloride uptake increases to the toxic level, it is converted to toxic compounds [20]. The concentrations of chlorides ions in the soils is very low when compared with the values by FAO/WHO of 200. Chlorine occurs in soluble forms in the soil and exists with other minerals or organic matter. High levels of chloride ions result to more uptake by the plants which results in toxicity predicaments in crops and finally reduction in the yield and it is essential to plants photosynthesis [21].

Nitrate

Table 1.0 revealed that the nitrate in all the sampling locations has the maximum value from black smith (SM) sampling sites (64.00±21.21) followed by hospital area (HO) (48.70±2.40), while the minimum values of the nitrate were found in refuse dump (RD) sites with (7.00±1.41). From the nitrate in the sampling sites, higher level of impacts of anthropogenesis activities lead to increase of nitrates in the environment. However, land use activities influenced the nitrate content of the soil. However, high level of nitrate (NO3-) in soil would cause methenoglobinemia commonly called blue baby syndrome which affect children below the age of six months due to the acid in the stomach of the children under six months is strong as the older ones thereby, causing high conversion of nitrate to nitrite due to the concentration of bacteria that an available to do work [22].

Phosphate

The investigation revealed that the phosphate concentration of highest value was obtained from hospitals (HO) (4.00±5.66) followed by the battery charger (BC) (3.01±4.24). There was a lower phosphate content in the study area compared to the standard maximum value of 10 set by the FAO/WHO. The primary sources of PO_4^{3-} in the soil and water could be attributed to anthropogenic activities from fertilizers, pesticides, industry and cleaning compounds while the natural sources include phosphate containing rocks and solid or liquid wastes. Phosphates encouraged the growth of plankton and water plants that serve as food for fish and aquatic life which results in increase of fish population that improves the quality of aquatic life. High concentration of phosphate in domestic water can cause muscle harm, effect breathing and caused kidney failure [23].

Sulphate

Sulphate reported in the research locations indicated that the highest value was recorded in road transport (RT) and residential (RS) with mean value of (630.00±70.71) each respectively and the least values were obtained from institutions (IN) welder workshop (WW) and farm land (FL) with the mean value of (255.00±91.92) each. Sulphate is one of the major dissolved compounds in rain. It occurs naturally due to leaching of gypsum and other minerals [24]. Excess sulphate imposes danger to health. High amounts of sulphate cause bitter taste to water. Sulphate as magnesium sulphate poses laxative effects to children especially in hot weather or climate.

Dendrogram of Chemical Parameters of Wasted Soil

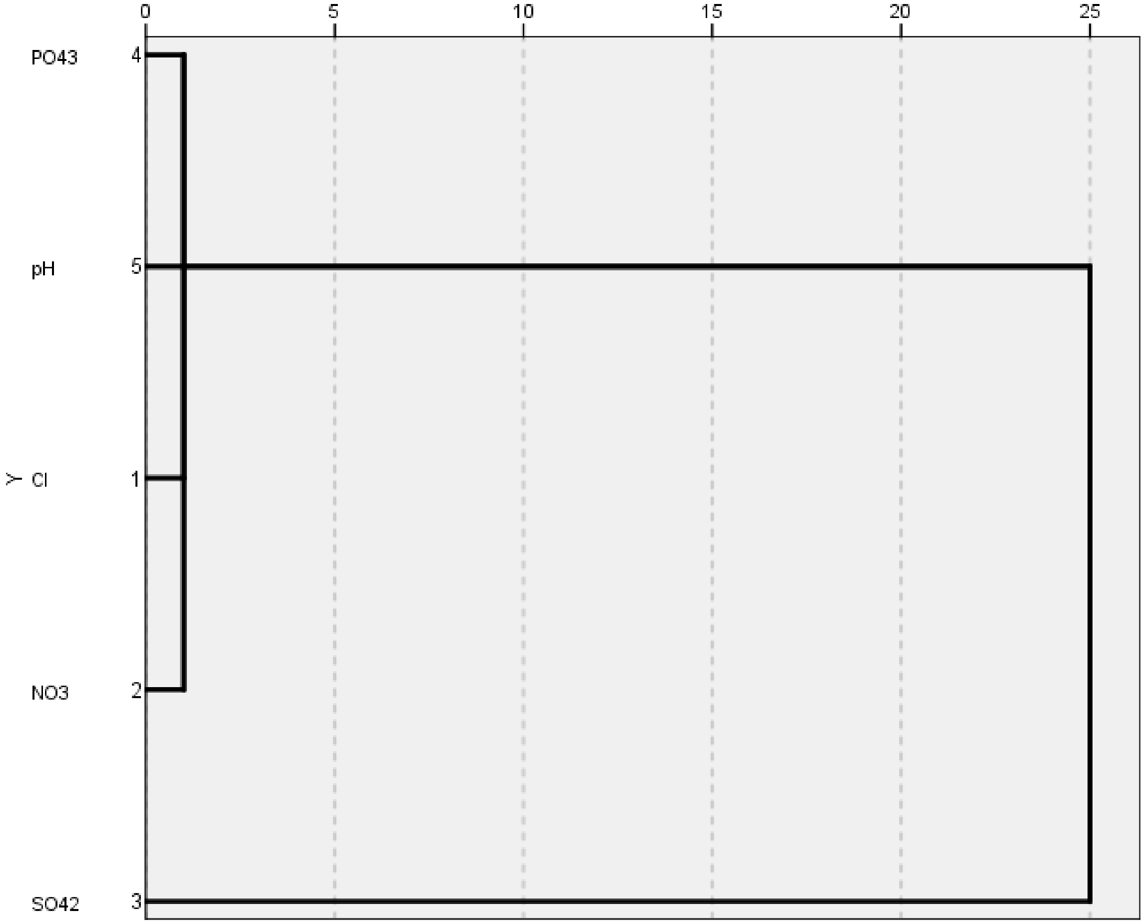

Figure 2.0: Cluster Analysis of chemical Parameters of contaminated soil

Figure 2.0 shows the chemical parameters of the contaminated soil from the sampling locations. The study revealed three distinct portions of clusters which occurs at different similarity levels. Hierarchical Cluster Analysis (HCA) connect between two variables and divides into various clusters to indicate the variables diverse environmental sources [24]. The first cluster consists of two chemical parameters which include PO_4^{-3} and pH. The second cluster indicates Cl^- and NO_3^- while the third Cluster contains SO_4^2

Table 2: Mean Concentration of Heavy Metals

Sample ID	Mn	Cu	Zn
AM	93.25	90.14	311.82
BC	377.25	116.44	492.25
MK	190.79	86.42	431.21
HO	208.56	74.44	510.19

The quantity of huge amount of heavy metals are released into soils during the weathering of rocks and anthropogenic activities that lead to trace metals contamination of soil [25].

Magnesium

The mean concentrations of selected heavy metals (mg/kg) in the polluted soil at Okene sampling areas in Table 2 above revealed Mn pooled the highest value from the battery charges workshop (BC) of 377.25±4.22 and the lowest mean concentration value was obtained from the farm land (FL) 37.01±8.25.As a result of human's activities that lead to increase of Mn in all the sampling sites. In humans, it has been reported that diseases like diabetes, nervous instability, convulsions, bone disorders in babies and rheumatoid arthritis. It is equally, essential for plant functions and act as a cofactor in various enzymes such as in the structure of chlorophyll [26]

Copper

Table 2 revealed Cu ranked the maximum mean concentration value of 460.44±5.84 obtained from welder workshop (WW) among the selected operating areas, while the minimum value of 71.19±3.80 belong to petrol station (PS). Naturals/geological sources are anthropogenically pollute the environment via electrical equipment, chemicals, paints, agricultural pesticides and preservatives, vehicular emission and brake pad wear [27].

Zinc

The concentration of Zn as shown in Table 2 has the highest mean concentration value of 510.19±5.86 at the hospital (HO) sampling area, and lowest value of 44.60±6.08 from the farm land (FL) sampling sites. Anthropogenic input of Zn includes metal works, battery and printing materials and agricultural activities [27].

Table 3: Geo-accumulation index for heavy metals in soil

Sample ID	Mn	Cu	Zn
AM	1.08	1.91	1.57
BC	1.69	2.02	1.76
MK	1.39	1.89	1.71
HO	1.43	1.83	1.78

Table 3 shows the level of geo-accumulation of heavy metals in the selected locations revealed the concentration of metals is high in virtually all the sampling locations and artisan workshops. This result shows the soils completely contaminated. The sequential order of heavy metals are in the following order Cu > Zn > Mn

Table 4: Contamination Factor of the soil sampling locations

SAMPLE ID	Mn	Cu	Zn
AM	12.11	81.21	36.81
BC	48.99	104.90	58.12
MK	24.78	77.85	50.91
HO	27.09	67.06	60.23

The contamination factor of heavy metals is shown in Table 4. The values of Mn varied from (12.11 – 48.99), Cu (67.06 – 104.90) and Zn (36.81 – 60.23). The contamination factor values revealed the locations were heavily contaminated with heavy metals since the values were greater than one (>1) showing considerable contamination. The CF for the pollutants followed the sequential order: Cu > Zn > Mg

Table 5: Pollution Load Index of the soil

SAMPLE ID	Mn	Cu	Zn
AM	0.20	2.50	2.23
BC	0.79	3.23	3.52
MK	0.40	2.40	3.08
HO	0.44	2.07	3.64

The pollution load indexes of heavy metals are shown in Table 5. It revealed the pollution load index (PLI) were greater than 1 in all workshops due to extreme heavy metals contamination with anthropogenic loading from the sampling areas with exception of Mn in all the workshops. The sequential order of PLI were in the following order as Zn > Cu > Mn

Table 6: Ecological Risk Factor

SAMPLE ID	Mn	Cu	Zn
AM	0.20	12.52	2.23
BC	0.79	16.17	3.52
MK	0.40	12.00	3.08
HO	0.44	10.34	3.64

Ecological risk factors of heavy metals in soils from the workshops are given in Table 6. The different ecological risk factor values for the heavy metals were Mn (0.20 – 0.79), Cu (10.34 – 16.17) and Zn (2.23 – 3.64). These values revealed low ecological risk of the locations. Also, the ecological values were in order of Cu > Zn > Mn.

Conclusion

This research reported the levels of selected chemicals parameters and heavy metals contaminations in selected soils of workshops in Okene, Nigeria. The chemical properties of the soil in these locations revealed that the concentrations were within the permissible levels of FAO/WHO, which caused no harm to the environment, while contaminations of heavy metals were above the maximum allowable limits of FAO/WHO, which may pose risk to the environment if not properly managed. Contamination factor values of the analyzed metals were greater than 1 indicating extreme contamination of the selected workshops with Magnesium, Copper and Zinc. Also, Pollution load index shows heavily contamination of the research locations, geo-accumulation and pollution risk factor revealed the workshops were virtually contaminated. This calls on government agency to monitor the soil quality of the research areas constantly to prevent further contamination of the locations.

Reference

[1] Seifi, M, Alimardani, .R, & Sharifi, A. (2010). "How can soil electrical conductivity Measurementscontrol soil pollution? *Research Journal of Environmental and Earth Sciences*, vol. 2, pp. 235-238.

[2] Zhang, W, Yuan, S, Hu, N, Lou, Y & Wang, S. (2015). Predicting soil fauna effect litter decomposition by using boosted regression trees. *Soil Biology & Biochemistry*, vol. 82, pp. 81-86.

[3] Haileslassie, A, Priess, J, Veldkamp, E, Teketay, D & Lesschen, J.P. (2005). Assessment of soil nutrient depletion and its spatial variability on smallholders' mixed farming systems in Ethiopia using partial versus full nutrient balances. *Agriculture, Ecosystems & Environment*, vol. 108, no. 1, pp. 1-16.

[4] Osman, K.T. (2013). *Forest soils*. Cham: Springer. Physical properties of forest soils. pp. 19- 44.

[5] Hoogsteen, M.J.J, Lantinga, E.A, Bakker, E.J, Groot, J.C.J, Tittonell, P.A. (2015) Estimating soil organic carbon through loss on ignition: effects of ignition conditions

and structural water *Eur J Soil Sci* 66(2):320–328

[6] Edori, O & Iyama, I. (2017). "Assessment of physicochemical parameters of soils from Selected abattoirs in Port Harcourt, Rivers State, Nigeria," *Journal of Environmental Analytical Chemistry*, vol. 4, pp. 1-5.

[7] Voroney, R. P. (2007). The Soil Habitat. In: Soil Microbiology, Ecology and Biochemistry, 3rd ed., Elsevier. Burlington: 25-48.

[8] Rawat, R.S. (2005). Studies on interrelationship of woody vegetation density and soil characteristics along an altitudinal gradient in a montane forest of Garhwal Himalayas. *Indian for*, 131 (8): 990-994

[9] Zhang, H, Zhang, Y, Chen, T, Long, Z, Li, M & Pei, Y. (2019). Distribution, ecological risk and source identification of heavy metals in sediments from the Baiyangdian Lake, Northern China. *Chemosphere* 237:124425.

[10] National Population Commission (NPC) (2009). Federal Republic of Nigeria Official Gazette: Legal Notice on Publication of Census Final Results. Federal Republic of Nigeria, pp. 1–42.

[11] Majabi, G.O, Gimba, C.E, Ekwumemgbo, P.A, Uba, S, & Garba, Z.N, (2023). Health risks assessment of heavy metals from the contaminated soils of okene metropolis, north-central, nigeria. *J. Chem. Soc.* Nigeria, Vol. 48, No. 5, pp 837 – 844.

[12] Nwakife, C.N, Esther, U, Musah, M, Morah, E.J, Inobeme, A. & Andrew, A. (2022). Determination of the physicochemical properties and some heavy metals in soils around selected automobile workshops in Minna, Nigeria**.** *African Journal of Environment and Natural Science Research* ISSN: 2689-9434 Volume 5, Issue 1, 2022 (pp. 69-81).

[13] Orodu, V & Morokowei R. (2022). Determination of Nitrates, Sulphates and Phosphates in Soil of Ogobiri and Adagbabiri farmlands in Bayelsa State, Nigeria.*Plant Nutrition and Soil Science International* (2022), ISSN 2616-1745 Vol. 1

[14] Atiemo, S. M., Ofosu, F.G, Kuranchie-Mensah, H, Osei Tutu, A, Palm Linda N.D.M & Blankson, A. S. (2011). Contamination Assessment of Heavy Metals in Road Dust from Selected Roads in Accra, Ghana. *Research Journal of Environmental and Earth Sciences*, *3*(5), 473-480.

[15] Rabee, A. M, Al-Fatlawy, Y. F, Najim, A. & Nameer, M. (2011). Using Pollution Load Index(PLI) and Geoaccumulation Index (I-Geo) for the assessment of heavy metals pollution in Tigris River Sediment in Baghdad Region. Journal of Al-Nahrain University, 14(4), 108-114

[16] Hakanson, L, (1980). Ecologial risk index for aquatic pollution control. A sedimentological approach. *Water Research*, 14(8):975-100.

[17] Harikumar, P. S, Nasir, U. P, Rahman, M. M. (2009). Distribution of heavy metals in the coresediments of a tropical wetland system. *International Journal of EnvironmentalEdjengteDoumo et al.; ARRB, 37(9): 1-17.*

[18] E l-Magd, S, Taha, T.H, Pienaar, H.H, Breil, P, Amer, R. A, Namour, P. (2021). Assessingheavy metal pollution hazard in sediments of Lake Mariout, *Egypt. J. Afr. Earth Sci*. 2021, 176, 104116

[19] FAO/WHO (2011). “Guidelines for the safe use of wastewater and food stuff” Report of the joint WHO/FAO Volume 2 no. 1, World Health Organization (WHO) and Food and Agriculture Organization (FAO), Geneva, Switzerland.

[20] Ezeji, E. U, Anyanwu, C. O and Ukwandu, N.C.D. (2019); Evaluation of Heavy Metals and Physicochemical Parameters of Oil-contaminated Soil and Water Samples from Bonny,*ACRI, 19(2): 1-11,* South-South, Nigeria..

[21] Chukwu, U..J, Anuch,i S.O. (2016). Impact of Abattoir Wastes on the Physicochemical Properties of Soils within Port Harcourt Metropolis.*Int J EngSci 5: 17-21*.

[22] Sanyal, T, Kaviraj, A and Saha, S. (2015). “Deposition of chromium in aquatic ecosystem from effluents of handloom textile industries in Ranaghat-Fulia region of West Bengal, India”, *Journal of Advanced Research*, vol. 6, no. 6, pp. 995–1002.

[23] Gao, S, Wang, Z, Wu, Q and Zeng, J. (2020). Multivariate statistical evaluation of dissolved heavy metals and a water quality assessment in the Lake Aha watershed, Southwest China. *Peer J*, 8; e9660.

[24] Ogunmodede, O. T, Ojo, A. A and Jegede, R. O. (2016). Evaluation of Pollution Loads in andAround Municipal Solid Waste Dumpsite. *World Applied Sciences Journal* 34 (6): 720-732.

[25] Wu, H, Liu, Q, Ma, J, Liu, L, Qu Y, Gong, Y, Yang, S, Luo, T. (2020). Heavy Metalloids intypical Chinese tobacco-growing soils: concentrations, influence factors and potential health risks. *Chemosphere* 245:125591

[26] Cui, S, Zhang, F. Hu, P., Hough, R., Fu, Q., Zhang, Z. An, L., Li, Y., Li, K., Liu, D. and Chen, P. (2019). Heavy Metals in Sediment from the Urban and Rural Rivers in Harbin City, Northeast China. International Journal of *Environmental Research and Public Health*, 16, 4313.

[27] Yunus, K., Zuraidah, M.A. and John, K. (2020). A review on the accumulation of heavy metalsin coastal sediment of Peninsular Malaysia. *Ecofeminism and Climate Change*, 1(1),21-35.