Assessment of Heavy Metal Contamination of Soil in Mechanic Workshops at Neked and Orji, Owerri zone, Imo State, Nigeria

ABSTRACT

Assessment of heavy metal contamination of soils in mechanic workshop of Nekede and Orji, Imo State was conducted. Using soil auger, triplicate soil samples of 0 – 15 cmwere collected from sample point 1(SP) 20m away from (SP2) and 40m from (SP 3).A control points 1kmaway from each of the automobile workshopswere established. Altogether, twelve (12) samples were used for the study which were analyzed and determined the concentrations of theheavy metals (Lead, Copper, Zinc and Nickel) using AA Atomic Absorption Spectrophotometer. Data generated were subjected to statisticalanalysis such as meansandStandard deviation using least significant difference (LSD). Results showed lower concentrations of theheavy metals in soil from control point ~~as~~ compared to sample soil collected from mechanic workshop. Across the sampling point, Zn, Pb, Cu and Ni recorded/measured1.75-89 mg/kg, 1.15-51.15 mg/kg, 0.55-29.35 mg/kg and 0.3-4 mg/kg respectively. Mean concentrations of Zn(49.27 mg/kg), Pb(23.70 mg/kg), Cu(18.25 mg/kg) and Ni(3.58 mg/kg) were higher in soils of auto workshops of Orji compared to Nekede. Across the different sampling points, both Zn(89 mg/kg) and Pb(15.36 mg/kg) were higher in Nekede SP 1whereas Cu(29.35 mg/kg) and Ni(4 mg/kg) were higher in Orji SP 1 and SP 2 respectively. Assessment of the extent of lead contamination / pollutionshowed that Zn contamination ranged from very slight ‘severe, Pb varied from very slight,moderate, Cu ranged from slight- Very severe pollution while Ni varied from very slight’ slight. The study therefore, recommends the control and supervision in the use of land allocated as mechanic workshop to reduce the accumulation of heavy metals.

Keywords: Assessment, heavy metal, Mechanic workshop, Imo State

1. Introduction

According to [1], a heavy metal is any chemical element with a reasonably high density and at least five (5) times the specific gravity of water. Heavy metals and metalloids include mercury (Hg), lead (Pb), cadmium (Cd), arsenic (As), copper (Cu), and manganese (Mn), to name a few. Indicators of the concentrations of other contaminants that may be associated include trace metal levels in soil. Heavy metals are elements that naturally exist in the earth's crust, unlike biological contaminants.As such, heavy metalare concentrated in organisms, sediment, waterways, and soils at a very low level.The bioaccumulation nature of heavy metals makes them hazardous. This indicates that a biological organism's concentration of a chemical rises relative to the ambient concentration [2.] According to [3], heavy metal contamination of the soil increases plant absorption, which leads to buildup in plant tissue, phytotoxicity, and changes in the plant community.Due to their unique mobile and soluble nature, which dictate their specification, heavy metal accumulation can also have a significant negative impact on soil ecosystems, the environment, and human health [4]. These substances are naturally present in soils, rocks, sediments, and ground and surface water bodies in varying quantities [5]. Heavy metal of copper has been reported in salt samples [6]. When compared to contributions from geogenic or natural processes, unchecked industrial and human activities have greatly contributed to high pollutionlevels of these metals in surface and subsurface soils [7].One of the main health issues throughout the world with heavy metal is their environmental contamination, even at low levels, and the ensuing long-term cumulative health impacts [5]. In tiny amounts, some metals like copper, manganese, and zinc are necessary for the survival of plants and animals. Animals and plants may become poisonous in excess [8]. Heavy metals can biodegrade and cause soil to become poisoned for an extended period of time [9]. All metals that weigh more than 5000 kg per cubic meter are considered heavy metals, such as lead, zinc, copper, etc. The sort of waste produced within the mechanic workshop is a significantconcern especially due to its consequential impact on man and the environment.Heavy metal contaminants can localize and lay dormant by precipitation of their compounds or by ion exchange into soils and muds, which can have detrimental impacts on the ecosystem. Heavy metals do not decompose, in contrast to organic contaminants, and provide unique challenges for cleanup. Their tenacity in the soil, propensity to bioaccumulate, travel up the food chain, and ability to harm soil microorganisms all add to the problem [10].

Soil as a component of the physical environment is a vital resources for agriculture, human settlement, recreational activities etc. As a result of the accumulation of heavy metal pollutants, soil pollution caused by human activities of man is now harmful to soil. Due to their toxicity, widespread occurrence, lack of biodegradability, and propensity for accumulation, heavy metals are a significant source of worry [11]. Similarly, the transfer of these elements to aquatic media, their uptake by plants, and their subsequent introduction into the food chain, the accumulation of heavy metals in environmental samples represents the potential threat to human health. This worry is additionally heightened by the unlawful and careless way hydrocarbon products are disposed of around mechanic shops in Nigeria, which has resulted in an enhanced concentration of heavy metal. In Nigeria, there are areas or clusters of car mechanic businesses known as "Mechanic Villages." These are the locations designated for engine vehicle repairs and overhauls.Auto mechanic operations are one of the main causes of the rise in the content of heavy metals in Nigerian ecosystems [12]. These auto mechanic businesses are located close to urban towns and cities in groups of open plots of land [13-14]. People that work in the clusters specialize in electrical components of vehicle repairs, while others work on brake and steering repairs, automatic or standard transmission engine repairs, spray painting, auto battery recharge, welding, and soldering, among other auto repairs.Automobile usage has also resulted in heavy metal and trace element contamination of the soil, which has detrimental effects on creatures that live in the soil [15]. In certain organisms, the toxicity or impacts of heavy metals are based on genetic anomalies as a result of physiological impairments, according to [15], but in others, they are based on their food chain.The environment is seriously threatened by the existence of dangerous heavy metals and hydrocarbons (HCs) in a number of mechanic workshops throughout Nigeria and other developing nations [16]. Heavy metals are released into the soil and groundwater through a number of processes used in auto repair businesses, including as combustion processes, the recycling of engine and lubrication oils, battery charging, welding, and soldering.Metal scraps, old batteries, packing materials, used lubricants, and worn-out parts—which include pollutants such heavy metals—are among the waste products generated in the auto mobile workshop environment as a result of artisan operations [17-18]. When such operations are not adequately regulated and monitored, they may result in the environment having higher than normal concentrations of metals and hydrocarbons.According to [19], used engine oil is any petroleum-based or synthetic oil that has undergone contamination and has thus lost its original qualities or is no longer acceptable for its intended use. [20] defines used engine oil as any lubricating oil that has outlived its usefulness in a vehicle, been removed from its application area, and is deemed unfit for its original function due to contamination by physical or chemical contaminants. According to reports, it is black to brown in color and detrimental to the soil environment [21].

The engine oil picks up a variety of extra compounds and particles from engine wear as it runs within the car [22]. Spent motor oil has been deemed to be more harmful than crude oil due to the additives and subsequent pollution [23]. Public concern has been sparked by the alarming extent to which pollution in the area of densely populated cities and towns, as well as the discharge of industrial effluents and automotive exhaust, has grown. The mechanic industry in Nigeria is one of the main contributors to the ecosystem's elevated heavy metal content.This study therefore aim at assessing the concentration of heavy metal and level of contamination due to mechanic activities within Nekede and Orji , in Imo state Owerri, Nigeria.

2.0 StudyArea

2.1 Material and Methods

There are three mechanic villages in Imo State: Nekede(550,362m^2), Orji (408,725m^2),and Okigwe(299,000m^2), [14]. The mechanic villages of Nekede and Orj began with a few workshops and now have many more shops. The activities that take place at the mechanic villages are typical of auto-mechanic repairs and almost always involve working with and spilling heavy metal-containing materials like oils, grease, gasoline, battery electrolyte, paint, and others. They were classified as microelements due to their distinct biological functions and their low general content in soils and plants [24]. Imo State is located between latitude 4°45′N and 7°15′N and longitude 6°50′E and 7°25′E (Figure 1), with an area of about 5100 km2. It lies within the humid tropics and is generally characterized by a high surface air temperature regime year-round [25]. Mean minimum temperature is 23.5°C, mean maximum temperature is 32.3 ºC and mean temperature is 27.9 ºC [21]. Two seasons, wet and dry, are observed in the year, the rainy season which begin in April to October, while the dry season ranges from November to March [25]

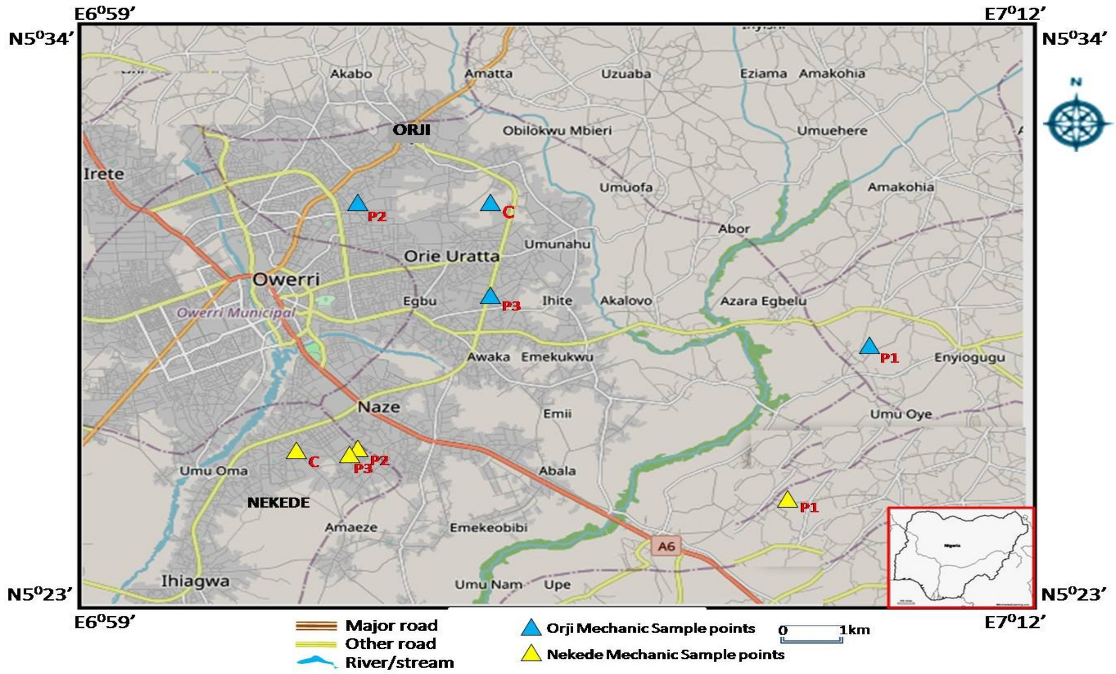

Figure 1 Study Area Imo State showing sample points

3.2 Sample Collection and Analyses

Three (3) samples of soil (0–15 cm) were taken at distances of 0, 20, and 40 meters from the two carautomobile workshop using a soil auger. Additionally, soil samples that acted as controls were gathered from a distance of 1 km from each of the car workshops. To determine the presence of heavy metals, the soil samples were placed in plastic bags, tagged, and submitted to a laboratory. The soil samples were air dried, then used to make a stainlesssteel sieve after being smashed using a mortar and pestle. Ten milliliters of concentrated nitric acid were added to one gram of the sieved soil in an acid-washed round-bottom flask, and the mixture was heated on a hot plate for 15 to 20 minutes. After letting it cool, it was filtered into a 50 ml standard flask and brought up to the appropriate mark with distilled water.

Plate 1: Bags containing sample collected

Table 1:Coordinates of the sampled locations Nekede and Orji Mechanic Village

	Coordinates	
Sample location	**Latitude**	**Longitude**
Control	5^0 26' '49" " N	7^0 02' 54" E
Point 1	5^0 25' '50" " N	7^0 09' 36" E
Point 2	5^0 26' '55" " N	7^0 03' 55" E
Point 3	5^0 26' '58" " N	7^0 03' 49" E
Orji Mechanic Village		
Control	$5^0$31' '03" " N	7^0 02' 43" E
Point 1	5^0 28' '05" " N	7^0 10' 55" E
Point 2	$5^0$31' '10" " N	7^0 03' 44" E
Point 3	5^0 29' '09" " N	7^0 05' 46" E
Point 2	$5^0$31' '10" " N	7^0 03' 44" E
Point 3	5^0 29' '09" " N	7^0 05' 46" E

Source: Field work, 2023.

3.3RESULTS AND DISCUSSION

Data generated on soil heavy metals were subjected to mean, range and standard deviation (Table 2)

Table 2: Heavy metal concentrations of the soils

Location/Parameters	**Sample depth(cm)**	**Zn(mg/kg)**	**Pb (mg/kg)**	**Cu (mg/kg)**	**Ni (mg/kg)**
Nekede SP 1	0-15	89	15.36	2.7	0.75
Nekede SP 2	0-15	2.55	6.8	1.5	0.5
Nekede SP 3	0-15	5.6	1.4	2.45	0.65
Range		**86.45**	**13.96**	**1.2**	**0.25**
Mean		**32.38**	**7.85**	**2.22**	**0.63**
STD		**40.07**	**5.75**	**0.52**	**0.1**
Nekede control	0-15	1.75	1.15	0.55	0.3
Orji SP 1	0-15	52.65	9.2	3.5	4
Orji SP 2	0-15	52.85	51.15	29.35	3.5
Orji SP 3	0-15	42.3	10.75	21.9	3.25
Range		**10.55**	**41.95**	**25.85**	**0.75**
Mean		**49.27**	**23.70**	**18.25**	**3.58**
STD		**4.93**	**19.42**	**10.86**	**0.31**
Orji control	0-15	37	2	2.05	2.85
LSD(0.05)		**17.96***	**9.64***	**6.48***	**0.91***
W.H.O (mg/kg)		**50**	**< 20**	**< 2.5**	**0.75**

STD= standard deviation, SP= sampling point, LSD=least significant difference
Source: Authors work, 2023

Zinc

In the automobile shops of Nekede, a range of 2.55-89 $mgkg^{-1}$ with mean value of 32.38 $mgkg^{-1}$ was recorded for Zn whereas lower value of 1.75 $mgkg^{-1}$ occurred in its control soils. In Orji mechanic workshop, it varied from 42.3-52.85 $mgkg^{-1}$ with mean value of 49.27 while lower value of 37 was recorded at its control site. This indicated that the activities in automobile workshops significantly increased Zn contents especially in sampling point 1(SP 1) and sampling point 2(SP 2) ofNekede and Orji respectively. Considering the sampling locations, mean values indicated that soils under mechanical workshop of Orji were more contaminated with Zn. A range of 3.80-4.31mg/kg with a mean value of 4.0825±.21077mg/kg was recorded by [26] insoil around automechanic workshops in Anyigba, Kogi State**.** According to level of WHO, the critical level of Zn is 50 $mgkg^{-1}$ showing that the Zn contents in soils of SP 1 of Nekede as well SP 1 and SP 2 were above the critical limit of WHO. The study location has no industry it is thus believed that the increase of Zn levels in the study area was from the auto mechanic shops, since this element is found as part of many additives to lubricating oils. The concentration may also be due to factors such as age of the mechanic workshops, volume of work done on each site, types of automobile service or repairs, type of lubricant commonly used, mode of wastes disposal and type of soil. The concentration of Zn in this study is similar the findings of other studies [14]. Also, [27]reported that high concentration of Zinc in heavy traffic zones indicate that fragmentation of car tyreare likely source of the metal. Other possible sources of zinc in relation to automobile traffic in addition to wearing of brake lining are losses of oil and cooling liquid of vehicles and wearing of road paved surface [28]. The high concentration of zinc recorded in the study area are probably as a result of the access road leading to many towns and many vehicles move to and from the towns to rural areas.

Lead

Lead (Pb) values were generally lower than Zn concentrations at most of the sample points, as shown in Table 1. In the area of the auto business in Nekede, lead varied substantially (P 0.05) from 1.4 to 15.36 mgkg-1 (mean: 7.85 mgkg-1), but in Orji, it ranged from 1.15 to 51.15 (mean: 23.70 mgkg-1). In contrast to Nekede, greater levels of Pb (1.15 mgkg-1) were found in Orji at the various control locations. Orji SP 2(51.15) soils have high Pb contamination when compared to the WHO-posited threshold limit of 20 mgkg-1. In a comparable study, [26] found that the concentration of lead at the control location ranged from 1.23 to 1.43 mg/kg, with a mean value of 1.3175.08016 mg/kg.The Pb levels found in this study, however, were far lower than the 1162 mg/kg reported by [14] for the vicinity of an auto mechanic workplace in Owerri, South-East Nigeria. The operations of the auto mechanic in the research region are readily blamed for a substantial portion of the high lead content in these places, which attested to the overall high degree of environmental pollution with this metal. These levels of Pb are increased by the quantity of waste oil, the presence of automotive fumes, and the outdated motor batteries that are carelessly abandoned by nearby battery chargers and auto technicians. The length of time the auto-mechanic workshop has been open in the study region affects the level of heavy metals in its soil.

Copper

Similar to other examined heavy metals, copper (Cu) level was substantially higher (P 0.05). In the soils of Nekede SP 1, SP 2, SP 3, and control, it was 2.7, 1.5, 2.45, and 0.55 mgkg-1, respectively. It was 2.22 mgkg-1 on average across sample locations inside Nekede's auto workshops. Cu concentrations in SP 1, SP 2, SP 3, and control in Orji were 3.5, 29.35, 21.9, and 2.05 mgkg-1, respectively. Regardless of sample location, a mean value of 18.25 mgkg-1 was found inside the sampling points of the Orji auto workshops, indicating that Cu was more concentrated in Orji than Nekede. According to WHO's theories, soil Cu concentration should not exceed 2.5 mgkg-1. Particularly in Nekede SP 1 and all the test sites at this level in the soil

Copper has a huge quantity in the soil at this level, notably in Nekede SP 1 and all of the sample locations in Orji auto workshops, indicating that the soil is polluted. This finding supports [29] claim that locations with high automobile traffic and a greater rate of human activities in urban settlements have higher levels of soil pollutants than those with low vehicular traffic.

Nickel

The concentration of nickel (Ni) differed substantially (P 0.05) among the Nekede auto shops. Its range was 0.5-0.75 mgkg-1, with a mean value of 0.63 mgkg-1; control soils had a lower value of 0.3 mgkg-1. It ranged from 3.25 to 4.01 mgkg-1 at the Orji mechanic workshop, with a mean value of 3.58; the lowest value (2.85 mgkg-1) was found in the control site (Table 2). This showed that Ni content has been considerably raised by activities in auto shops, particularly in sample point 1 (SP 1) of both locations. The sample site, auto-mechanical workshops, may be related to these quantities of nickel in the research region. considering that [30] and [31] both concurred that the level of heavy metal contamination in metropolitan areas varied according to location

Table 3: Contamination / Pollution Index of the studied soils

Parameters	Zinc(mg/kg)	Lead (mg/kg)	Copper (mg/kg)	Nickel (mg/kg)
Nekede SP 1	0.61	0.18	0.08	0.02
Nekede SP 2	0.02	0.08	0.04	0.01
Nekede SP 3	0.04	0.02	0.07	0.02
Nekede control	0.01	0.01	0.02	0.01
Orji SP 1	0.36	0.11	0.10	0.11
Orji SP 2	0.36	0.60	0.82	0.10
Orji SP 3	0.29	0.13	0.61	0.09
Orji control	0.25	0.02	0.06	0.08

SP= sampling point.

Source: Authors work, 2023

3.4 Contamination / Pollution (C/P) Index of the studied soils

According to the ratings postulated by [23] level of soil contamination are stated as follows; <0.1: Very Slight contamination, 0.10 -0.25: Slight contamination, 0.26 - 0.50: Moderate contamination, 0.51 - 0.75: Severe contamination, 0.76 - 1.00: Very severe contamination, 1.1 - 2.0: Slight pollution, 2.1 -4.0: Moderate pollution, 4.1 - 8.0: Severe pollution, 8.1 - 16.0: Very severe pollution, > 16: Excessive pollution. Based on the above ratings, soils of Nekede SP 2, Nekede SP 3 and Nekede control was very slightly contaminated with zinc. Soils of Orji control was slightly contaminated with zinc. While soils of automobile workshop in Orji were moderately contaminated, Nekede SP 1 was severely contaminated with zinc. This result is similar to [32] who reported that the C/P index for zinc range from 0.28 in to 0.98 (moderate contamination - very severe contamination) Omolege dumpsite.
Assessment of the extent of lead contamination / pollution showed that Nekede SP 2, SP 3, Nekede control and Orji control were very slightly contaminated with Pb, slightly level of contamination was recorded in soils of Nekede SP 1, Orji SP 1 and Orji SP 3 whereas it was moderately contaminated in soils of Orji SP 2. Results also showed that there was slight contamination of copper all the soils of Nekede as well as control site of Orji. Moreover, soils from Orji auto workshops were contaminated with Cu at different degree as slight, severe and very severe in Orji SP 1, Orji SP 3 and Orji SP 2 respectively. Among all the heavy metals studied, it was only Nickel that showed the least contamination as it was contamination was very slight in all the soils with the exception of Orji SP 1 and 2 that was slightly contaminated.

CONCLUSIONS AND RECOMMENDATIONS

This study investigated the levels of heavy metals contamination in different soils of mechanic workshops Nekede and Orji, Imo State. The high concentrations of Zinc, Copper, Nickel and lead in the soil of the mechanic workshops in Nekede and Orji would pose a serious ill-health to the inhabitants of the area. Both plants and animals could be affected that can lead to serious health challenges if proper monitoring is not engaged as the different chemicals and substances discharged daily in soil around mechanic workshop are potentially dangerous to both environment and humans. The study therefore, recommends the continuous monitoring and further studies on the level of these heavy metals in the near future and at intervals to ascertain long-term effects of this anthropogenic impact. This should also involve larger coverage with studies on heavy metals and in nearest surface water around such locations. The study also recommends the control and supervision in the use of land allocated as mechanic workshop to reduce the accumulation of heavy metals.

REFERENCES

[1]Oguntimehin I, Ipinmoroti K (2008), Profile of Heavy Metals from Automobile Workshops in Akure Nigeria . J Environ. Sci. Technol. 1(1):19-26.

[2] Kampa, M. and Castanas, E. (2008). Human Health Pollution. Environ pollut. 151(2):362-7.

[3] Gimmler, H., Carandang, J., Boots, A., Reisberg, E. and Woitke, M. (2002). Heavy metal content and distribution within a woody plant and after seven years continuous growth on municipal solid waste (MSW) bottom slag rich in heavy metals. Appl Bot. 76: 203-217.

[4] Kabata-Pendias, A. and Pendias, H. (1992). Trace Elements in the Soil and Plants. 2 ndedition, CRC press, Boca Raton.

[5] Hutton M, Symon C (1986). The Quantities of Cadmium, Lead, Mercury and arsenic entering the UK. Environment from human activities. Science of the Total Environment, 57:129 - 150.

[6] Nwaka, B.U., Avwiri, G.O., Eze, J.O. (2022). Analyses of physicochemical characteristics and heavy metals risk assessment in locally processed salt and refined iodized salt brand consumed in Ebonyi State, Nigeria. FUNAI Journal of Science & Technology, 5(1):48 – 63.

[7]Dasaram B, Satyanarayanan M, Sudarshan V, Keshav KA (2010). Assessment of soil contamination in Patancheru industrial area, Hyderabad, Andhra Pradesh, India. Res. J. Environ. Earth Sci. 3: 214-220.

[8]Ideriah J.K.T, Onuora O.T.V. and Adiukwu P.U. Global J. of Environmental Sciences, 2005 vol. 4. (1)2005-1- 4. [7] Alloway B.J. Heavy Metals in Soils, John wiley and Sons Inc. New York, 1990 pp. 26, 40-73.

[9] Alloway, B.J. (1990). Soil processes and the behaviour of metals. In: Heavy metals in soils, B.J. Alloway, ed. Blackie and Son Ltd. *Glasgow*.

[10]Udousoro II, Umoren IU, Asuquo EO (2010). Survey of some heavy metal concentrations in selected soils in South Eastern parts of Nigeria. World J. Appl. Sci. Technol. 2(2):139 – 14.

[11] Yu Rui-lian, Yuan- xing, Zhao, Yuan-hui, Hu, Gong-ren, and Tu. Xian-lian. (2008). Heavy metal pollution in intertidal sediments from Quanzhou Bay, China (j). Journal of environmental Sciences, 20(6): 6664-669.

[12] Adewole MB, Uchegbu LU (2010). Properties of Soils and plants uptake within the vicinity of selected Automobile workshops in Ile-Ife Southwestern, Nigeria. Ethiopian J. Environ. Studies Manage. 3:3

[13] Nwachukwu, M.A., Huan, F. and Kennedy, A. (2010). Integrated study for automobile wastes management and environmentally friendly mechanic villages in the Imo River, Basin, Nigeria. *African Journal of Environ sci.* 4(4):234-249.

[14] Nwachukwu MA, Feng H, Alinnor J (2011). Trace metal Deposition in soil from Auto-mechanic village to urban residential areas in Owerri, Nigeria. *Proc. Environ. Sci*. 4: 310-322

[15] Gupta UC, Gupta SC (1998).Trace Element Toxicity Relationship to Crop Production, Livestock and Human Health, Comm. Soil Science, Plant Anal. 29 (11-12):1491-1522.

[16] Vincent, F; Manu, J. M; Chessed, G; Vandi, P; Francis, S; Norah, S (2022). Assessment of Heavy Metals Content in Soil and Groundwater within the Vicinity of Automobile Mechanic Workshops in Yola and Jimeta Towns, Adamawa State, Nigeria. J. Appl. Sci. Environ. Manage. 26 (11) 1749- 1755

[17] Pam AA, Sha'Ato R, Offem OJ (2013a). Contributions of Automobile Mechanic Sites to Heavy Metals in Soil: A Case Study of North Bank Mechanic Village Makurdi, Benue State, Central Nigeria. J. Chem., Biol. and Physical Sci. 3(3):2337-2347.

[18] Pam AA, Sha'Ato R, Offem OJ (2013b). Evaluation of heavy metals in soils around automechanic workshop clusters in Gboko and Makurdi, Central Nigeria. Journal of Environmental Chemistry and Ecotoxicology, 5 (11):298- 306.

[19] Nduka JK.(2009) Heavy metal pollution in Nigeria. Ph.D seminar presentation. Nnamdi Azikiew University Awka, Anambra state, Nigeria.7 - 19.

[20] Long XX, Yang XE, Ni WZ.(2002)Curent status and prospective on phytoremediation of heavy metal polluted soils. April Ecol. 13:757- 62. 5.

[21] Nwachukwu R. Ekere, Okiri P. Ukoha (2013). Heavy metals in street soil dusts of industrial market in Enugu, South East, Nigeria. International Journal of Physical Sciences. 8(4):175- 178.

[22] Sherene T. Mobility and transport of heavy metals in polluted soil environment. Biological Forum — An International Journal. 2010;2(2):112-121.

[23] Singh J, KalamdhadAS.(2012b) Reduction of heavy metals during composting-a review. Int. J. Environ. Prot. 22(9):36-43

[24]Lacatusu,R.(1998). Appraising levels of soil contamination and pollution with heavy metals. In: Land information system for planning the sustainable use of land Resources. Herinike,H.J, Eckelman,W. Thomasson,A.J, Jones,R.J.A., Montanarella,L. Burkley,B(Eds). Eur. Communities, Luxembourg. 393-402.

[25] Ajiere S1 Diagi B.EEdokpaD.O(2021)Impacts of Climate Variability on Sustainable Agriculture in Imo State, Nigeria.Journal of Geographical Research | Volume 04 | Issue 01 pages 9-17DOI: https://doi.org/10.30564/jgr.v4i1.2531

[26]Ogunkolu A.B, Moses, O, Oyetunji A. Bashir A.A. (2019). Assessment of Heavy Metal Contamination of Soil around Auto Mechanic Workshops in Anyigba, Kogi State. *Journal of Environmental Studies*. 13. 79-89.

[27] Onder S, Dursun S, Demirbas A (2007). Determination of Heavy Metal Pollution in Grass and soil of City centre Green Areas (Konya, Turkey). Polish J. of Environ. 16(1):145 - 154.

[28] Osakwe S.A (2009). Heavy Metal distribution and bioavailability in soils and Cassava (Manihotesculentagrantz) along Warri-Abraka Expressway, Delta State, *Nigeria. J. Chem. Soc. Nigeria*, 34(1): 211-217.

[29] Adelekan B.A, Alawode A.O (2011). Contributions of refuse dumps to heavy metal concentrations in soil profile and groundwater in Ibadan, Nigeria. *J. Appl. Biosci*. 40:7227-2737

[30] Francis, D.A. (2005). Trace heavy metals contamination of soils and vegetation in the vicinity of livestock in Nigeria. Elec. *J. Environ Agric*., 4(2), 863-870.

[31]Onianwa, P.C. (2001). Roadside Topsoil Concentrations of Lead and other Heavy Metals in Ibadan, *Nigeria soil sediment contaminants*, 577-591.

[32]Adaikpoh, E. O. & Kaizer, A. N. (2012), Trace metal enrichment in sediments from Otofure and Teboga waste dump sites in Benin City, Nigeria *International Journal of Chemistry*. 4 (4) : 14-27. Doi:10.5539/ijc.v4n4p14