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Assessment of the Concentrations of Heavy Metals in the Soils of Abuja Metropolis, Nigeria

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ABSTRACT

This paper explains the mean concentrations of some selected heavy metals in the soils of Abuja metropolis at depth of 15cm. Aqua Regia (HCl/HNO_3) method was employed to evaluate total metal concentrations in Abuja soils samples. Concentration levels of Pb, Cd, Fe, Ni, Zn, Al, Mn, Cu, Cr and As in Abuja Metropolis soil samples collected from motor parks, industrial zones, near auto mechanic zones, residential areas and an urban forest were investigated. Total mean concentrations of heavy metals in Abuja urban soil samples were found to be; Pb(0.18±0.07), Cd(0.29±0.07), Fe(4.21±0.01), Ni(0.19±0.009), Zn(7.00±0.02), Al(2.65±1.8), Mn(1.43±0.00), Cu(6.30±0.03) Cr(0.03±0.02)and As(1.43±0.00). Mean concentration of sub-urban soils were; Pb(0.38+0.03), Cd(0.02±-0.01), Fe(2.25±0.57), Ni(0.2±00.02), Ni(0.30±0.02), Zn(5.35±0.02), Al(1.59±0.02), Mn(1.0±90.07), Cu(4.15±0.03), Cu(4.15±0.03), Cr(0.1±10.03) and As(1.50±0.02). Results were below the limit of regulatory authorities. Zn had the highest mean concentrations in Abuja urban soils in the following sequence of decreasing order: Zn>Cu>Fe>Al>Mn>As>>Cd>Ni>Pb>Cr and in the sub-urban soils, it was; Zn>Cu>Fe>Al>As>Mn>>Pb>Ni>Cr>Cd.. Zn mean concentration was observed to be highest in Asokoro Forest samples too. Excess Zn like its deficiency in plants, results in Zn phytotoxicity which disrupts plant photosynthesis among other things, this increases the amount of CO_2 in the atmosphere thereby increasing global warming. This implies that Abuja Metropolis is in danger of global warming due to excess of Zn in the oils. Relevant authorities should be conducting periodic environmental risk assessments of Abuja soils in order to checkmate the rising toxic metal build up in the metropolis.

Keywords: Abuja Metropolis, Mean concentrations, Heavy metals, Phytotoxicity, Global warming

INTRODUCTION

Pollution related to soil has become a major threat to humanity (Zhao *et al*., 2022). Heavy metal pollution is a serious and widely environmental problem due to the persistent and more non-degradable properties of these contaminants (Sarkar *et al*., 2014). In recent times, metals in soil and water are becoming serious issues of concern at all levels, since they constitute a crucial component of the environment (Ochelebe *et al*., 2017). As a result of this, there is now the understanding that the environment affects people's health and life longevity as a result of this, there is now the understanding that the environment affects people's health and life longevity which has led to the emergence of the concept of the environmental safety of residential areas as one of the key factors taken into consideration when choosing housing accommodation in cities around the world (Zhogoleva, 2015).Heavy metals occur in soils at low concentrations generated by natural processes such as weathering of rocks and minerals (Robinson *et al*., 2019). But due to human interference in the natural geochemical cycle, heavy metals become toxic and are regarded as contaminants in the environment when their rate of generation through anthropogenic cycles are more rapid relative to natural

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ones (Aryal *et al*, 2017). Increasing levels of heavy metals in soil has become a serious concern for human health because they can be easily transferred into the human body through contaminated food web (Mehmud *et al*, 2019). Due to the constant urbanisation and industrialisation in many parts of the world, metals are constantly spreading to the environment and pose a great threat to human health (Vural *et al*, 2021).

Globally, there are more than 10 million sites of soil pollution reported with greater than 52% of the sites contaminated with heavy metals and / or metalloids and it has been estimated that heavy metal pollution has a combined worldwide economic impact of more than US$10 billion per year (Montano-Lopez and Biswas, 2021). Climate change and landscape transformation have led to rapid expansion of sub-urban areas globally (Samaneh *et al*., 2022).

Studies of environmental pollution in Africa indicated that toxic metal pollution has reached unprecedented level over the past decade, as human exposure has become a major health risk on the continent (Fayiga *et al*, 2017). Apart from heavy metal hazard to humans and animals, .they also retard plant activities through phytotoxicity Zn phytotoxicity for instance decreases the rate of photosynthesis in plants thereby increasing CO_2 in the atmosphere which increases global warming subsequently. This paper will dwell on this issue so as to contribute towards finding natural solutions to global warming.The aim of the paper is to assess the concentrations of heavy metals in the soils of Abuja Metropolis, Nigeria.

MATERIALS AND METHODS

Sampling Method

Abuja soils samples were divided into urban, sub-urban and Asokoro Forest (control) for easy analysis and samples were collected from various points from the mentioned soil samples at 15cm depth using plastic shovel. Samples were collected in polythene bags and taken to the laboratory and dried for 3 days using air dry method.

Sampling Area

Abuja metropolis is a city comprising of Abuja city and its environs which comprise several sub urban communities, an industrial park and Asokoro forest, between the coordinates of Longitude 9.07^{o}N and Latitude 7.40^{o}E (Orisakwe *et al*., 2017). Asokoro forest is considered to be an unexploited land which is not used for farming or any anthropological activities as of the time of carrying this work.

Samples Preparation

Pretreatment was carried out including oven heating of sub samples at 65ºC for 16 hours to eliminate any microbial activity (Mehlic, 1979). Samples were homogenized to give uniform size of components and sieved using 200mm sieved cloth (pore size) for more uniformity in samples.

Sample Digestion

Sieved soil samples were digested by adding 10mL each (from 1 mole of HCl and HNO_3) at 1:1:1 HCl-HNO_3-H_2O mixture to 20.00g of soil samples and heating at 98^{0}C for 1 hour. Heated samples were allowed to cool and then centrifuged at 3500xs for 10 minutes. An aliquot of the supernatant was pipetted and made to volume with 5% conc. HCl. Samples were kept in 50mL capacity polythene bottles for instrumental analysis (Oliveira, 2012).

RESULTS AND DISCUSSION

Results of concentrations of metals in both Abuja soils and Asokoro Forest soil as control are outlined in tables 1 and 2 below.

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Table 1: Mean Concentration of metals in Abuja soil samples

	Pb	Cd	Fe	Ni	Zn	Al	Mn	Cu	Cr	As
S 1	0.01±7.07	0.05±7.07	0.38±0.00	0.09±0.10	1.78±0.03	0.19±0.00	0.19±0.01	0.10±0.001	0.00±0.01	0.27±0.00
S 2	0.02±0.01	0.02±0.01	0.40±0.00	0.01±0.00	2.00±0.08	1.00±0.01	0.12±0.10	2.25±0.01	0.00±0.01	0.19±0.00
S 3	0.02±0.00	0.02±0.00	0.32±0.01	0.02±0.02	0.79±0.01	0.16±0.01	0.15±0.02	0.68±0.00	0.00±0.00	0.20±0.00
S 4	0.01±0.00	0.00±0.00	0.30±0.01	0.02±0.00	0.88±0.03	0.16±0.01	0.29±0.01	0.13±0.01	0.00±2.21	0.21±0.00
S 5	0.01±0.00	0.20±0.00	7.23±0.04	0.02±0.00	1.21±0.01	0.65±0.02	0.27±0.02	0.76±0.00	0.00±0.00	0.13±0.01
S 6	0.10±0.00	0.00±0.00	1.27±0.01	0.02±0.00	1.26±0.01	0.21±0.01	0.20±0.01	1.01±0.00	0.00±0.00	0.23±0.00
S 7	0.01±0.00	0.00±0.00	0.31±0.01	0.01±0.04	0.86±0.03	0.28±0.04	0.21±0.01	2.42±0.00	0.00±0.00	0.20±0.00
Total	**0.21±0.01**	**0.30±0.01**	**11.65±0.00**	**0.50±0.07**	**13.35±0.10**	**5.60±0.00**	**2.47±0.00**	**12.21±0.03**	**0.00±0.01**	**2.58±0.00**
Control	**0.00±0.00**	**0.00±0.00**	**0.28±0.00**	**0.02±0.00**	**2.49±0.01**	**0.31±0.01**	**0.31±0.01**	**1.73±0.01**	**0.00±0.00**	**0.16±0.01**
Standards:										
NESREA	164	3	-	70	421	10000-	200	100	100	-
WHO	300	3.08	-	0.05	2800	30000	300	1500	100	-

NESREA = National Environmental Safety, Regulatory and Enforcement Agency,

WHO = World Health Organisation

Mean concentration of metals in Abuja urban soils in decreasing order:
Zn>Cu>Fe>Al>Mn>As>>Cd>Ni>Pb>Cr

Mean concentration of metals in Asokoro forest soils in decreasing order:
Zn>Cu>Mn>Al>Fe>As>Ni>Cr>Cd>Pb

Table 2: Result of Mean Concentration of Metals in Abuja Sub Urban Soil Samples (ppm).

	Pb	Cd	Fe	Ni	Zn	Al	Mn	Cu	Cr	As
S 1	0.12±0.01	0.00±7.07	0.34±0.01	0.03±0.02	0.90±0.01	0.22±0.02	0.16±0.03	1.56±0.000	0.11±0.01	0.19±0.00
S 2	0.00±0.00	0.00±0.00	0.28±0.21	0.06±0.03	0.83±0.04	0.16±0.04	0.16±0.04	2.11±0.00	0.00±0.00	0.19±0.01
S 3	0.16±0.00	0.00±0.00	0.40±0.01	0.04±0.00	0.60±0.00	0.31±0.01	0.17±0.01	1.84±0.00	0.00±0.00	0.22±0.01
S 4	0.00±0.00	0.00±0.00	0.25±0.06	0.014±0.01	0.52±0.03	0.21±0.01	0.17±0.17	2.90±0.00	0.00±4.60	0.23±0.00
S 5	0.0020.00	0.00±0.00	0.39±0.01	0.02±0.00	0.81±0.01	0.19±0.00	0.20±0.00	0.48±0.00	0.00±7.00	0.18±0.01
S 6	0.00±0.00	0.00±1.41	0.31±0.01	0.02±0.00	0.90±0.01	0.20±0.01	0.20±0.01	0.16±0.01	0.00±0.00	0.22±0.00
S 7	0.004±0.01	0.02±0.01	0.28±0.05	0.02±0.01	0.79±0.01	0.30±0.00	0.03±0.00	1.10±0.01	0.00±0.00	0.27±0.00
Total	**0.28±0.03**	**0.02±0.01**	**2.25±0.57**	**0.20±0.01**	**5.35±0.02**	**1.59±0.02**	**1.09±0.07**	**4.15±0.03**	**0.11±0.01**	**1.50±0.02**

Mean concentration of metals in Abuja urban soils in decreasing order

Zn> Cu>Fe>Al>As>Mn>>Pb>Ni>Cr>Cd

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Comparison of mean metal concentrations in some selected sites of Abuja Metropolis is highlighted here. Abuja urban sample S1(table 1) had Pb mean concentration of 0.01±7.07, lower than in sub-urban sample S1(table 2) having 0.12±0.001 which could be due to pesticide residues at Nyanyan community; this does not conform to the findings of Brown *et al*., (2015). Urban sample S2 had Pb mean concentration of 0.02±0.0007, higher than in sub-urban S2 having 0.001±0.001; which could be due to trace of Pb from passing cars at the sub-urban S2 site; this does not conform to the findings of Wade *et al*., (2021).

Urban sample S5 (table 1)had Pb mean concentration of 0.01±0.0003, higher than in sub-urban sample S5(table 2) having 0.002±0.0007, which could be due to human and vehicular activities at urban S5 site; this conforms to the findings of Levin *et al*., (2021). Urban sample S6 had Pb mean concentration of 0.10±0.0003, higher than in sub-urban sample S6 having 0.002±0.001; which could be due to higher anthropogenic activities at urban S6 site; this conforms to the findings of Conrad-Rooney *et al*., (2023)

Urban sample S1(table 1) had mean concentration of Cd as 0.05±7.07, higher than in sub-urban ample S1(table 2) having 0.002±7.07, which could be due to higher deposited smokes from passerby smokers and vehicular traffic at S1site, this confotms to the findings of Adeyi and Babalola, (2017). Urban sample S2 mean concentration of Cd was 0.02±0.0007, higher than in sub-urban S2 having 0.001±0.001, which could be due to cigarette smoke residues at s1 site being a public area; this conforms to the findings of Ricter *et al*., (2017). Urban sample S5 had Cd mean concentration of 0.02±0.0007, higher than in sub-urban sample S5 having 0.003±0.0007, which could be due to atmospheric as well as cigarette smoke from passersby at urban site; this conforms to the findings of Feng *et al*., (2019). Urban sample S6 had mean concentration of Cd of 0.001±0.0003, higher than in sub-urban S5I having 0.0002±0.1.41, this could be due to atmospheric deposition of cadmium at urban S6 site; this conforms to the findings of Li-li *et al*., (2019).

Urban sample S1(table 1) had mean concentration of Fe of 0.38±0.003, higher than in sub-urban S1(table 2) having 0.34±0.007, this could be due to absorbed or precipitated oxides in the soil of urban S1 than on to sub-urban S1 soil; this conforms to the findings of Famuyiwa *et al*., (2022). Urban sample S3 had Fe mean concentration of 0.32±0.01, lower than in sub-urban S2 having 0.40±0.004; which could be due to industrial processes and absorbed or precipitated secondary oxides in the soil of sub-urban S2 site; this confotms to the findings of Ozaki *et al*., (2019). Urban S5 had Fe mean concentration of 7.23±0.04, higher than in sub-urban sample S5 having 0.39±0.01; which could be due to Fe-organic matter deposition as a result of constant human activities and urban vegetation at urban S5; this conforms to the findings of Nyiramigisha and Sajidan, (2021).

Urban sample S1(table 1) with Ni mean concentration of 0.09±0.01, higher than in sub-urban sample S1(table 2) having 0.03±0.02, which could be due to atmospheric emission including soil-forming processes and anthropological activities at urban S1 area; this conforms to the findings of Agyeman *et al*., (2022). Urban sample S2 had Ni mean concentration of 0.01±0.001, lower than in sub-urban sample S2 having 0.06±0.03, which could be due to agricultural activities and dust fall at sub-urban S2 area; this conforms to the findings

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of Said, (2022). Urban sample S5 had Ni mean concentration of 0.02±0.004 which was equal to that of sub-urban sample S6; which could be due to anthropological activities at both sites; this conforms to the findings of Vischetti *et al*., (2022).

Urban sample S1(table 1) has Zn mean concentration of 1.78±0.03 which is higher in sub-urban sample S1(table 2) which was 0.90±0.007, this could be due to atmospheric deposition, runoff debris and anthropological activities at urban S1 area; this conforms to the findings of Pardo, (2021). Urban sample S3 had mean concentration of 0.88±0.03, higher than sub-urban sample S3 having 0.52±0.03, this could be due to atmospheric deposition and runoff at urban S3 area; this does not conform to the findings of Yu *et al*., (2022). But Zn phytotoxicity is detrimental to Abuja environment, since excess or deficiency of Zn retards photosynthesis among other things, thereby increasing the amount of CO_2 in the atmosphere according to the findings of Vassilev *et al*., (2011), who concluded that "excess Zn triggers disturbances in the waters relations, which affect photosynthesis".

Urban sample S1(table 1) had Al mean concentration of 0.19±0.002, lower than in sub-urban sample S1(table 2) having 0.22±.02 which could be due to high presence of aluminium oxides at Nyanyan site I; this does not conform to the findings of Weber *et al*., (2021). Urban sample S2 had Al mean concentration of 2.00±0.08, higher than in sub-urban sample S1 having 0.16±0.04 which could be due to proximity of urban S2 site to a dump site and urban transportation, this conforms to the findings of Yakeen and Onifade, (2012). Urban sample S4 has Al mean concentration of 0.19±0.01, lower than in sub-urban sample S3 having 0.21±0.007; which could be due to high presence of aluminium oxides, other industrial processes and atmospheric deposition of Al at sub-urban S3 industrial area; this conforms to the findings of Jacukowics-Sobala *et al*., (2015).

Urban sample S1(table 1) had Mn mean concentration of 0.19±0.01, higher than in sub-urban S1(table 2) having 0.16±0.03, which could be due to deposition of food debris and atmospheric deposition of Mn at urban S1 site; this conforms to the findings of Gunawardena *et al*., (2015). Urban sample S2 had Mn mean concentration of 0.12±0.10, lower than in sub urban sample S1 having 0.16±0.04, this could be due to anthropogenic activities at sub-urban S1 site; this is not in conformity with the findings of Pavlons *et al*., (2015). Urban sample S5 had Mn mean concentration 0f 0.27±0.02, higher than in sub-urban sample S7 having 0.03±0.002, which could be due to proximity of the site to Wuse market (a hotspot for metal deposition); this conforms to the findings of Uebari and Boisa, (2019).

Urban S1(table 1) had Cu mean concentration of 0.10±0.007, lower than in sub-urban sample S1(table 2) having 1.56±0.001, which could be due to this is not in conformity with the findings of Xing *et al*., (2020). Urban sample S3 had Cu mean concentration of 0.68±0.003, lower than in sub-urban sample S3 having 1.84±0.007, which could be due to industrial emissions and wastes at sub urban sample S3 area; this conforms to the findings of Stanojevic, (2021). Urban sample S4 had Cu mean concentration of 1.13±0.005, lower than in sub-urban sample S4 having 2.90±0.007, which could be due to industrial emission as well as other biosolids wastes at sub-urban S4; this conforms to the findings of Galyas, (2019).

Urban sample S1(table 1) having Cr mean concentration of 0.002±0.007 had lower concentration than in sub-urban sample S1(table 2) having 0.11±0.007, which could be due to deposition of fertilizer, agricultural produce remnants and pesticides residues at sub-urban sample S1; this conforms to the findings of Xu *et al*., (2021). Urban S3 had Cr mean concentration of 0.002±0.007, higher than in sub-urban sample S3 having 0.001±0.0007, which could be due to atmospheric deposition at urban sample S3; this does not conform to the findings of Ullah *et al*., (2023).

Urban sample S5(table 1) had As mean concentration of 0.13±0.01, lower than in sub-urban sample S7(table 2) having 0.27±0.004, which could be due to atmospheric deposition of As, sub-urban S7 site, being a mining community near River Wupa; this conforms to the findings of Ye *et al*., (2021). Urban S7 had As mean concentration of 0.21±0.003, lower than in sub-urban S9 which is 0.29±0.02, this could be due to proximity of sub-urban S9 site to a dumpsite; this conforms to the findings of Beldowski *et al*., (2016).

CONCLUSION

From the results above, the total mean metal concentrations in Abuja urban soil samples were found to be in the decreasing order; Zn>Cu>Fe>Al>Mn>As>>Cd>Ni>Pb>Cr, in sub-urban soils it was; Zn>Cu>Fe>Al>As>Mn>>Pb>Ni>Cr>Cd. AsokoroForest had; Zn>Cu>Mn>Al>Fe>As>Ni>Cr>Cd>Pb. Mean metal concentrations in samples of Abuja urban centres were found to be higher than in sub-urban communities soil samples indicating high anthropogenic activities in Abuja city centres. Zn and Cu were discovered to be the metals with the highest mean concentrations in Abuja Metropolis soils. Pb, Cd, Ni, Zn, Al, Mn, Cu and Cr had concentrations below regulatory authorities' limits, Fe and As had no available standard limits from regulatory authorities as of the time of this research.

From the sequence of metal availability in Abuja Metropolis soils, especially in Asokoro Forest, it can be said that themetropolis could be sitting on Zn deposit. Excess Zn can cause Zn phytotoxicity which inhibits plant photosynthesis mechanism among other things; this increases the amount of CO_2 in the atmosphere thereby increasing global warming within the metropolis. Thus, Abuja Metropolis can be said to be in danger of the consequences of global warming..Relevant authorities should give more attention to periodic environmental risk assessment of Abuja soils in order to checkmate the rising metal build up in the metropolis.

REFERENCES

Adeyi, A. A. and Babalola, B. A. (2017). Lead and Cadmium levels in residential soils of Lagos and Ibadan, Nigeria. *Journal of Health and Pollution*, 7(13), 42-55.

Agyerman, P. C., Krbonye, N. M. and John, K.(2022). Prediction of nickel concentration in Peri-Urban and Urban soils using hybridized empirical Bayesian krigin and support vector machine regression. *Scientific Reports*, 19(2022), 803-815.

Aryal, B., Bhattari, B. P., Padley, M. and Giri, R. (2017). Carbon sequestration and CO_2 mitigation in a burned ecosystem of *pinusraxbushi*plant in Lantang National Park, Nepal. *Tropical Plant Research*, 4(2), 297-306.

Beldowska, J., Szuboka, M., Emelyanov, E., Gannaga, G., Darzewmika, A., Buldweiska, M., Varninen, P., Ostin, A. and Fabisick, J. (2016). Arsenic concentrations in Baltic Sea sediments close to chemical munitions dumpsite. *Deep Sea Research Part II: Topical*

DOI: 10.56892/bima.v8i2.677

Studies in Oceanography, 128(2016), 114-12.

Brown, S., Chaney, R. and Hettiaradchi, E. M. (2015). Lead in urban soils: A real perceived concern for urban agriculture? *Journal of Environmental Quality*, 45(1), 56-67.

Chen, Y., Shen, G. and Qian, A. (2015). Heavy metals and proximate composition of forest leafy vegetables in oil producing area of Nigeria. *Ethiopian Journal of Environmental Studies Management*, 8(2015), 451-463.

Conrad-Rooney, E., Geartzman, J., Pappas, Y., Pasquerella, V. J., Hutyra, L. R. and Templer, P. H. (2023). Atmospheric wet deposition in urban and sub-urban sites across the United States. *Atmospheric Environment*, 305(2023),,119783.

Famuyiwa, A. O., Davidson, C.M., Ande, S. and Oteyiola, B. O. (2022). Potentially toxic elements in urban soils from public acess in the rapidly changing growing m ega city of Lagos, Nigeria. *Toxics*, 10(14), 154-167.

Fayiga, A. O., Ipiomoroti, M. O. and Chirenje, T. (2018). Environmental pollution in Africa. *Environmental Development Sustainability*, 20(2018), 48-73.

Feng, W., Guo, Z., Xiao, X., Peng, C., Shi, L., Ron, H. and Xu, W. (2019). Atmospheric deposition as a source of cadmium and lead to soil-rice system and associated risk assessment. *Ecotoxicological Environment and Safety*, 180(2019), 160-167.

Galyas, E. (2019). Concentrations of lead, copper and zinc in forest soils near industrial areas. Independent thesis basic level (degree of Bachelor thesis). Digitale Vetenskapliga Arkivet.

Gunawardena, J., Zyath, A. M., Egodowetta, P., Ayaka, E. A. and Gornetilleia, A. (2015). Sources and transport pathways of common heavy metals to urban road surfaces. *Ecological Engineering*, 77(2015), 98-102.

Huang, Q., Yu, B., Qiu, K., Zhou, G., Wang, S., Chi, Y. and Yah, J. (2016). Effect of moisture on sewage sludge connbustion temperature profile and heavy metal leaching. *Drying TechnologyJournal*, 34(15), 110-1819.

Jacukowics-Sobala, I., Ocimski, D. and Kocialek-Belewelder, E. (2015). Iron and aluminium oxides containing industrial wastes as adsorbents of heavy metals: Application possibilities and limitations. *Waste Management Research:The journal for a sustainable Circular Economy*, 33(7), 612-629.

Kartlava, A. J., Mosallan, J. M., Helnavarara, T. J. and Gibert, J. (2022). Top soil carbon stocks in urban green spices of The Hague, The Netherlands. *Research Square*, 20(19), 234-241.

Levin, R., Veira, C. L. Z., Rosenberg, M .H.,Boschoff, K., Mondersks, D. C. and Brown, M. J.(2021). The urban lead (PbP burdens in humans, animals and the natural environment. *Environmental Research*, 175(2021), 134-142.

Li-li, T., Bo-min, Fu, d., Yang, W. U., Fu-Chen, C. A. I. and Yi-bing, M. A. (2023). Linking atmospheric emission and deposition to accumulation of soil cadmium in the middle- lower Yangtze Plai, China. . *Journal of Integrative Agriculture*, 22(10), 3170-31.

Mehlic, A. (1979). New extractant for soil test evaluation of phosphorus, potassium, magnesium, calcium, sodium, manganese and zinc.

Community Soil Science and Plant Analysis,1978,9(6), 477-492.

Mehmud, K., Ahmad, H. R., Abbas, R., Saifullah, S, S. and Murtaza, G. (2019).Heavy metals in urban and peri-urban soils of a heavily populated and industrialised city: Assessment of ecological risks and human health repercussions. *Human risk Assessment: An International Journal*, 26(6), 45-54.

Montana-Lopez, F., and Biswas, A. (2021).Are heavy metals in urban garden soils linked to vulnerable populations? A case study from Guelph, Canada. *ScientificReport*, 11(86), 1289-1298.

Nyiramigisha, P. and Sajidan, K. (2021). Harmful impacts of heavy metals contamination in the soil and crops grown around dumpsites. *Reviews in Agricultural Science*, 9(2021), 271-282.

Ochelebe, I., Ekwere, A. S. and Ekwere, S. J. (2017). Environmental implication of the distribution of heavy metals in soils and water in Okpoma area, south-eastern Nigeria. *International Journal of Science and Engineering Investigations*,6(69), 105-113.

Oliveira, H. (2012). Chromium as an environmental pollutant: insight on induced plant toxicity. *Journal of Botany*, 12(3), 123-132.

Orisakwe, I., Nuofor, O., Noku, C. and Ezodigboth, U. (2017). On the analysis of the changes in the temperatures over Abuja, Nigeria. *Journal of Physical Sciences and Environmental Studies*, 3(2017), 8-17.

Ozaki, H., Ichose, H., Kitaura, E., Yaginuma, Y., Yoda, M., Kumo, K. and Watenabe, I. (2019). Immutable heavy metal pollution before and after change in industrial waste treatment procedure. *Scientific Reports*, 4499(2019), 634-642.

Pardo, C. (2021). Urban remote and atmospheric deposition of Zinc source in the Ekremo watersheds. Geology Senior Thesis, William and Mary, Paper, 17. London, UK.

Pavlons, B.T., Lioy, P.J., Guaxxette, S., Bostock, B.C., Donna, F., Peli, M., Mi, Z., Ronce, S.E. and Luconi, R. G. (2015). Manganese concentrations in soils and settled dust in an area with historic 9ferroally production. *Journal of Expository Science and Environmental Epidemiology*, 25(4), 443-450.

Ricter, P., Faroon, O. and Pappas, R. S. (2017). Cadmium and Cadmium/Zinc ratios and tobacco-related morbidities. *International Journal of Environmental Research and Public Health*, 14(10), 154-163.

Robinson, D. A., Hopmans, J. V., Filipovic, V., van der Ploeg, M., Lebron, I., Jones, S. B., Teinsch, S., Jarvis, N. and Tuller, M. (2019). Global environmental changes impact soil hydraulic functions through biophysical feedbacks. *Global change Biology*, 25(2019), 1895-1904.

Said, I. (2022). Nickel pollution in small ecosystem, Egypt. *Arab Journal of Geoscience*, 158(2022), 988-996.

Samaneh, S., Kalantari, Z., Egidi, G., Gaburova, and Salvati, L. (2022). Urbanisation-driven land degradation and socio-economic challenges in peri urban areas. Insights from Southern Europe. *Ambio*, 14(2022), 1-13.

Sarkar, S. K., Paulo, J. C. F., Rakshit, D. and Satpathy, K. K. (2014). Geochemical speciation nd risk assessment of heavy metals in soils and sediments In: Environmental risk assessment of soil contamination In: Soil Contamination. Springer, NewYork, USA.

Stanojevic, A. B. (2021). Air pollution from the copper smelter complex bar in Serkia. *Annals of Environmental Science Toxicology*, 5(1), 123-126.

Uebari, K. and Boisa, N. (2019). Distribution of manganese and iron in deposited dust from food milling shops in Port Harcourt city, Nigeria. *Nigerian Research Journal of Chemical Sciences*, 7(2, 1-62.

Ullah, S., Liu, Q., Wang, S., Jan, A.U., Sherif, H .M. A., Diffa, A., Wang, E. and Cheng, H. (2023). Sources, impacts and factors affecting Cr uptake in plant and mechanisms behind phytoremediation of Cr-contaminated soils. *Science of the Total Environment*, 899(2023), 726-735.

Vassilev, A., Nikolova, A., Koleva, l. and Lidon, F. |(2011|). Effects of excess Zn on growth and photosynthetic performance of young bean plants. J*ournal of Phytology*, 3(6), 58- 62.

Vincent, F., Manu, J. M., Chessed, G., Vandi, P., Francis, S. and Nora, S. (2022). Assessment of heavy metals content in soil and groundwater within the vicinity of automobile workshops within Gusau town. International *Journal of Science for Global Sustainability*, 5(1), 28-39.

Vischetta, C., Marini, E., Casucci, C. and De Bernardi, A. (2022). Nickel in the environment: Bioremediation techniques for soil with low or moderate contamination in European Union. *Environments*, 9(10), 133-142.

Vural, H., Akbana, A. and Meral, A. (2021).The effect of heavy metal pollution on urban ecosystem and the evaluation of different land classifications in Bingol city, Turkey. *Management of Environmental Quality*, 32(5), 886-901.

Wade, A.M., Richter, D. D., Craft, C.B., Bao, N. Y., Heine, F. R., Osteen, M. C. and Tan, K. G. (2021). Urban soil pedogenesis drives contrasting legacies of lead from paint and gasoline in city soil. *Environmental Science and Technology*, 55(12), 7981-7989.

Weber, C. J., Santowski, A. and Chifflard, P. (2021). Spatial variability in heavy metal concentration in urban pavement joints- a case study. *Soil*, 7(2021), 15-31.

Yakeen, T. A. and Onifade, T. O. (2012). Evaluation of heavy metals in soils along a major road in Ogbomosho, Southwest Nigeria. *Journal of Environment and Earth Science*, 2(8), 73-79.

Xing, W., Yang, J. and Ippolito, A. (2020). Atmospheric exposition of arsenic, cadmium, copper, lead and zinc near operating and an abandoned lead smelter. *Journal of Environmental Quality*, 49(6), 1667-1678.

Xu, Z., Mi, W., Fen, X., Zhou, Y. and Tian, Y. (2021). Scientific role of comprehensive evaluation of soil facility in a desert steppe influence by industrial activities in Northern China. *Scientific Reports*, 19(2021), 174-193.

Ye, L., Zhong, B., Huang, M., Chen, W. and Wang, K. (2021). Pollution evaluation and children's multimedia exposure of atmospheric arsenic deposition in the Pearl River Delta, China. *Science oftheTotal Environment*, 787(2021), 629-638.

Yu, E., Liu, H., Tu, V., Gu, X., Ran, X., Yu, Z. and Wu, P. (2022). Super position effects of Zn smelting atmospheric deposition on soil heavy metal pollution under geochemical anomaly. *Frontiersin Environmental Science*, 10(2021), 1-14.

Zhao, H., Wu, Y. and Lan, X. (2022). Comprehensive assessment of harmful heavy metals in contaminated soil in order to score pollution level. *Scientific Report,* 19(2022), 3552-3561.

Zhogoleva, A. V. (2015). Post-industrial urban planning and architecture for steady development of urban and tradition and innovation in construction and architecture. In: urban planning. Samera books, 54-60, New York, USA.

Zhu, Y., Wang, D., Li, W., Yang, Y. and Shi, F. (2019). Spatial distribution of soil trace element concentrations along an urban-rural transition zone in the black soil region of Northeastern China. *Journal of Soils and Sediments*, 17(9),450-46