ASSESSMENT OF SELECTED HEAVY METALS IN FARM LAND SOIL ALONG ILARO-IBESE ROAD, OGUN STATE, NIGERIA.

AJAYI Adetola Abiola[1*]& AJAYI Rhoda Monisola[2]
[1]Department of Science Laboratory Technology, Federal Polytechnic, Ilaro, Ogun State, Nigeria
[2]Department of Food Technology, Federal Polytechnic, Ilaro, Ogun State, Nigeria
Corresponding author's email: adetola.ajayi@federalpolyilaro.edu.ng; rhoda.olowofola@federalpolyilaro.edu.ng
Telephone: +2348061587558

Abstract

This study is aimed at determining the level of heavy metals in soil from a farmland along the Ilaro–Ibese route. The samples were taken fromdistances of 5, 10, and 15 meters from the roadside, while the control was taken from Ebute-Igbooro village, a rural settlement near Ilaro. The sample was digested with a mixture of HNO_3, HCl, and H_2SO_4. The level of Cd^{2+}, Cr^{3+}, Cu^{2+}, Pb^{2+}, and Ni^{2+} were determined using Inductively Coupled Plasma-Optical Emission Mass Spectroscopy(ICPOES). The presence of Cd was not found in all the soil samples. The concentrations of heavy metals at the three distances from the road showed significant differences (p >0.05). Heavy metal concentration in control sample for Cr, Cu, Ni and Pb, are 0.1391±0.0006, 0.1149±0.0045, 0.0719±0.0049 and 0.0319±0.0042 respectively. Heavy metal concentrations in soils from 5, 10 and 15 m for Cr ranged between; 0.1969±0.0042 mg/L, 0.1549±0.00470 mg/L and 0.1363±0.0074 mg/L respectively, Cu ranged between 0.1149±0.009 mg/L, 0.1105±0.0099 mg/L and 0.1069±0.0049 mg/L, respectively. The average concentrations of Ni in soil from 5, 10 and 15 m ranged between 0.0976±0.0091 mg/L, 0.0569±0.0233 mg/L and 0.0557±0.119 mg/L, respectively, Pb ranged between 0.0319±0.0042 mg/L, 0.0822±0.0052 mg/L, 0.0569±0.0233 mg/L and 0.0557±0.1119 mg/L, respectively. Cr had the highest value of (0.1969 mg/L) while Pb was recorded lowest (0.0822 mg/L). Heavy metals concentrations in soil were in the following order: Cr > Cu > Ni > Pb > Cd. Hence, Soil far from the highways was better for cultivation than those closer to the highway.

Keywords: heavy metals, contamination, soil

Introduction

Soil is a natural medium for plant growth and other developmental activities that consist of unconsolidated minerals and organic material found near the earth's surface (Haliru, Ling, and Suhaiza, 2014). Mineral compounds, organic matter (humus), living organisms, air, and water are all found in soil, and it manages the natural cycles of these elements (Keesstra et al., 2012). Heavy metals are found naturally in soils that are created by geological processes such as the alteration and erosion of subterranean geological elements (Kabir et al., 2012). Aside from the parent material, agricultural and industrial pollutants are among the many sources of contamination in soils (Moor, Lymberopoulou, and Dietrich, 2001). Heavy metal pollution has become a global issue in recent years, owing to the fact that, unlike other pollutants, heavy metals do not degrade (Bazrafshan et al., 2015). As a result, they are not detoxified and instead accumulate in the environment as bioaccumulation. Any metallic element with a high density (greater than 5g/cm^3) that is dangerous or poisonous even at low concentrations is referred to as a heavy metal (Inobeme et al., 2014). Heavy metals are discharged into the environment as a result of man's industrial, household, and commercial activities as well as industrial effluents, pesticides, fungicides, vehicular traffic, and poultry farm waste (Ukpong et al., 2013). Heavy metal poisoning of soil has major health consequences, particularly for crops and vegetables cultivated on such soils (Steffana et al., 2017). The majority of these heavy metals, such as Fe, Zn, Mn, Cu, Co, and Ni, are required for plant and animal growth and normal functions in trace amounts, but excessive amounts of any of them can cause acute or chronic toxicity. Mental lapse, kidney failure, and central nervous system illness are all long-term effects of heavy metal exposure in humans and higher animals (Nwaogu et al., 2014). Chronic exposure to Cad, for example, can cause lung cancer, bone fractures, kidney dysfunction, and hypertension. Pb poisoning can result in plumbism, anaemia, nephropathy, gastrointestinal colic, and symptoms of the central nervous system (Hu et al., 2017). The physiological character of a plant determines the distribution of pollutants within it. Some plants have a proclivity for accumulating pollutants in specific organs. And since most plant species cannot adapt to high levels of heavy metal contamination, some can survive, thrive, and reproduce in heavy metal-contaminated soils. The vast majority of these plants can withstand high metal concentrations and keep the majority of heavy metals in their roots, with just minor transfer to the leaves. Hyper accumulators have the opposite tendency

in terms of heavy metal absorption and distribution in the plant (Hall, 2021). Their activity entails actively absorbing significant amounts of heavy metals from the soil. Heavy metals are translocated to different areas of the plant rather than being retained in the roots.

As a result of increasing anthropogenic activities, heavy metal pollution of soil, water, and atmosphere represents a growing environmental problem affecting food quality and human health. The presence of toxic metals in soil can severely inhibit the biodegradation of organic contaminants. Heavy metal contamination of soil may pose risks and hazards to humans and the ecosystem through direct ingestion or contact with contaminated soil, the food chain (soil-plant-human or soil-plant-animal-human), drinking of contaminated ground water, reduction in food quality (safety and marketability) via phytotoxicity, reduction in land usability for agricultural production, causing food insecurity and land tenure problems.

Thus, the aim of this research is to determine the levels of heavy metals in soil around the Ilaro-Ibese road, Ogun State, Nigeria.

Materials and Method

Study Area

The sampling locations were chosen to span a wide range of traffic density and to give a good geographical coverage of the Ilaro-Ibese area of Ogun State. Ilaro and Ibeshe are Local Government areas in Ogun west district. It has an estimated population of more than 59,098 as at 2015 and approximately 8.8 square kilometers in area. Geographic coordinates of Ilaro, lies within Latitude: 6°53'20" North, Longitude: 3°00'50" East. It has a tropical wet climate with average rainfall of 7.3 inches and an average daily temperature of 23°C. The major occupation of the Yewa/Egbado people is mostly farming of arable crops and cash crops like cocoa, coffee, kola nuts, oranges and pineapples. Other farm products includes, Cassava, yam, okra, rice, bananas, plantains, water leaf and spinach. Mineral resources found in Ilaro includes, Phosphate and limestone. The Ilaro soils are mostly loamy and humus, rich in manure and element that support the growth of cocoa, cashew, pawpaw, kolanut, maize, sugarcane, and potatoes.

Sample Collection

Soil samples were collected at random from three farmlands located along the busy Ilaro-Ibeshe road. Samples were collected at a depth of 0–10 cm at distance intervals of 10, 15, and 20 metres from the roadway with a sterilised auger in a polythene bag. Three soil samples were taken from three points at each distance and mixed together to form composite samples.

Sample Preparation and Digestion

Samples were air-dried and sieved through a 2 mm sieve to remove coarse particles before chemical analysis. Measured 0.5g of air-dried ground soil was transferred into 250 ml conical flask; 5ml of concentrated H_2SO_4 was added followed by 25 ml of concentrated HNO_3 acid and 5ml of concentrated HCl. The flask was heated at 200°C for 1hr in a fuming hood and then cooled to room temperature. After cooling, 20ml of distilled water was added and the mixture was filtered to complete the digestion. Finally, the mixture was transferred to a 50ml volumetric flask, filled to the mark and left to settle for at least 15 hours. The filtrate was analysed for total Cu, Pb, Zn, Ni, and Cd using Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES).

Determination of Heavy Metals

The determination of heavy metals from the resultant supernatant (filtrate of soil collected) samples was carried out for Cu, Cr, Pb, Ni, and Cd using ICP-OES.

Results and Discussion

Table 1: summarizes the concentrations some selected metals; Cr, Cu, Ni, Pb and Cd) found in the farm land soil samples at 5, 10 and 15 m in distance from the Ilaro-Ibeshe road. Heavy metal levels in the soil ranged from 0.1969 mg/L to 0.0822 mg/L, with Cr registering the highest value (0.1969 mg/L) and Pb the lowest (0.0822 mg/L) in specimens. In control samples, the amounts of heavy metals tended to be lower.

Table 1

Heavy Metals in Soil Along Ilaro-Ibese Road

METAL	CONTROL	X	Y	Z
Cr	0.1391±0.0006[a]	0.1969±0.0042[a]	0.1549±0.00470[a]	0.1363±0.0074[b]
Cu	0.1149±0.0045[a]	0.1149±0.0009[a]	0.1105±0.0099[a]	0.1069±0.0083[a]
Ni	0.0719±0.0049[a]	0.0976±0.0091[b, c]	0.0569±0.0233[a, c]	0.0557±0.0119[a, c]
Pb	0.0319±0.0042[a]	0.0822±0.0052[b]	0.0569±0.0233[a]	0.0557±0.01119[a,c]
Cd	ND	ND	ND	ND

X is denoted as 5m away from the highway.
Y is denoted as 10m away from the highway.
Z is denoted as 15m away from the highway.
ND is denoted as elements not detected from the highway.

Discussion

The results showed a substantial difference in heavy metal concentrations between the distance of 5, 10 and 15 m from the main roadwhich ranged from0.1969 mg/L to 0.0822 mg/L with Cr registering the highest value (0.1969 mg/L) and Pb the lowest (0.0822 mg/L) in specimens. The data exhibited a decreasing trend from 5m to 15m away from the highway.

The lower the p-value, the more evidence that there is that the null hypothesis should be rejected. A statistically significant AP-value is less than 0.05 (usually 0.05). It indicates significant evidence against the null hypothesis, as the probability of the null being corrected is less than 5%. (the results are random). The level of heavy metals in the soil observed in this study is generally lower than the WHO/FAO acceptable limit (2001). There was a drop-in concentration of heavy metals as one move farther away from the highway. Also, the analysis had shown that the contents of total and available Cr, Cu, Ni and Pb varied significantly with the distance from the road edge, with Cr being the main pollutant. The most polluted area was the zone between 0 and 5m away from the high way. The high concentration of chromium (0.1969±0.0042 mg/L) in the soil samples may be attributed to emission caused by pavement abrasion or engine oil from repairing of vehicle along the road which enters the soil through rain. The concentration of copper (Cu) ranged between 0.1149±0.009 mg/L, 0.1105±0.0099 mg/L and 0.1069±0.0083 mg/L. The lowest concentration of copper was found in soil sample collected from 15m away from the road side while the highest concentration in 5m away from roadside. The concentration of Cu in the soil reported in this study was generally lower than the permissible levels set by FAO/WHO, 2001. The average concentrations of nickel in soil grown in farmland 5m, 10m, and 15m away from the Ilaro-Ibese road were 0.0976mg/L, 0.0889mg/L and 0.0830mg/L respectively. The contents of nickel in 5m away from roadside in this study was found to be higher compare to 10m and 15m.

According to Ajayi and Olasunkanmi (2021), this may be due to wide application of various types of pesticides and fertilizer on that location which contributed to the increased availability of Ni in the soil or emission from the nickel added to gasoline and Ni-containing parts of automobiles. The relatively high levels of lead in soil 5m away from the road side might have resulted from accumulation of lead through air pollution such as automobile exhaust fumes and from some pesticides, such as lead arsenates applied during cultivation (Ewers, 1999). The values of Pb obtained in this study were lower than WHO/FAO recommended maximum limit that is 100 mg/kg.

In general, the results of the heavy metals analyzed in the study areas showed that their concentration level is below the standard guide lines for maximum limit proposed for agricultural soil. Even though these heavy metal concentrations fell below the critical permissible concentration level in most heavy metals, it seems that their persistence in the soils of the study site may lead to increased uptake of these heavy metals by plants.
From this study, cadmium (Cd) was the least abundant element in the soil samples. Also, it was found that the vehicular movement along Ilaro-Ibeshe road and various agricultural activities carried out in the farm land was not able to increase the Cd content in the soil.

One-way analysis of variance (ANOVA) was made at 95% confidence level. The results showed that there were significant differences ($p < 0.05$) in the concentrations of the heavy metals Cr, Cu, Ni, Pb and Cd among the analysed soil samples. In general, the mean concentration of heavy metals in soils collected from all sampling site decreased in the order of: Cr > Cu > Ni> Pb> Cd.

Conclusion

The concentrations of heavy metals in soil samples used for farm land from Ilaro-Ibese road were been determined. The study revealed that the soils functioned as the potential source of the heavy metals in the environment and the concentration of the heavy metals: Cr, Cu, Ni, Pb and Cd are all far below the maximum tolerable levels set by FAO/WHO 2001. The significance difference and increase in the elemental concentrations may be due to application of various types of vehicular emission as a result of mechanical abrasion and normal wear and tear, pesticides and fertilizer in the vegetable farming areas. In general, the results also showed that the level of contamination of the soils by the heavy metals is not high at present and the soil is not polluted by heavy metal (cadmium, Cd). Therefore, the soil sample studied was not harmful for the cultivation of plants and other agricultural purposes, so there is no serious implication for health hazard. In conclusion, the present study revealedbrief information about the heavy metal contents of the soil, and these results may serve as a base line data for determination of mineral contents and physicochemical properties of the soil.

References

Ajayi, A., & Olasunkanmi, A. (2021). Heavy Metal in Cassava Roots (Manihot esculenta) Harvested from Farm Land along Ilaro-Ibese Road, Ogun State, Nigeria. *International Journal of Progressive Sciences and Technology.* 29(2) 302-306.

Bazrafshan, E., Mohammadi, L., Ansari-Moghaddam, A., & Mahvi, A. (2015). Heavy Metals Removal from Aqueous Environments by Electrocoagulation Process. *A systematic Review Journal of Environment Health Science Engineering, 13*(74) 1-16.

Haliru, H., Ling, L., Suhaiza, S. (2014). Heavy Metal Concentration Levels in Soil at Lake Geriyo Irrigation Site, Yola, Adamawa State, North Eastern Nigeria. *International Journal ofEnvironment.2*(10) 106–111.

Hall, J. (2021). Cellular mechanisms for heavy metal detoxification and tolerance. *J. Exp. Bot*.

Inobeme, A., Ajai, A., Iyaka, Y., Ndamitso, M., & Uwem, B. (2014). Determination of physicochemical and heavy metal content of soil around paint industries in Kaduna. *International Journal of Science Technology Resolution,3*(8), 221-225.

Kabir, E., Ray, S., Kim, K., Yoon, H., Jeon, E., Kim,Y., Cho, Y., Yun, S., & Brown, R. (2012). Current Status of Trace Metal Pollution in Soils Affected by Industrial Activities. *Sci. World J. 20*(12), 1–18

Keesstra, S., Geissen, V., Mosse, K., Piiranen, S., Scudiero, E., Leistra, M., & Schaik, L. (2012). Soil as a filter for ground water Quality. *Journal of Current Opinion environmental Sustainability*. *4*(5), 507-516.

Nwaogu, L., Ujowundu, C., Iheme, C., Ezejiofor, T., & Belonwu, D. (2014). Effect of sublethal concentration of heavy metal contamination on Soil Physicochemical Properties Catalase and Dehydrogenase Activities. I*nternational journal of biochemistry Research & review4*(2), 141-149.

Moor, C., Lymberopoulou, T., & Dietrich, V. (2001). Determination of Heavy Metals in soils, sediments and geological materials by ICP-AES and ICP-MS. *Mikrochim Acta,5*(139), 123-128.

Shaapera, U., Nnamonu, L. A., & Eneji, I. S. (2013). Assessment of Heavy metals in Ranaesculenta Organs from River Guma, Benue State Nigeria. *America Journal of Analytical Chemistry,4*(09), 496-500.

Steffana, J., Brevika, E., Burgess, L., & Cerda, A. (2017). The effect of Soil on Human health. *Journal of Soil Science*, 1-13.

Ukpong, E., Antigha, R., & Moses, E. (2013). Assessment of Heayy metals content in soils and plants around waste dumpsites in Uyo metropolis, Akwaibom State, *2*(7), 75-86.