PRINT ISSN 1119-8362
Electronic ISSN 2659-1499

Full-text Available Online at
https://www.ajol.info/index.php/jasem
https://www.bioline.org.br/ja

J. Appl. Sci. Environ. Manage.
Vol. 28 (10) 2943-2947 October, 2024

Cadmium Levels and Potential Ecological Risks in Soils from Selected Motor Parks in Benin City, Edo State, Nigeria

[1]ENUNEKU, AA; *[1]OSEGHALE, OE; [2]ISIBOR, PO; [1]ONIYA, SS

[1]Department of Environmental Management and Toxicology, Faculty of Life Sciences, University of Benin, PMB 1154, Benin City, Nigeria
[2]Department of Biological Sciences, College of Science and Technology, Covenant University, PMB 1023, Ota, Ogun State, Nigeria

**Corresponding* Author *Email: edith.oseghale@uniben.edu*
**Tel: +2348026608663*

Co-Authors Email: alex.enuneku@uniben.edu; patrick.isibor@covenantuniversity.edu.ng; sola.oniya@lifesci.uniben.edu

ABSTRACT: The health of the soil is of great concern to us because of the crucial role and support the soil plays in crop production/nutrition which has direct consequences on human health. Therefore, the objective of this paper was to assess the cadmium levels and potential ecological risks in Soils from Selected Motor Parks in Benin City, Edo State, Nigeria. Using Atomic Absorption Spectrophotometer (SOLAAR 969 UNICAM SERIES), after complete acid digestion. Results from the study revealed very low mean Cd concentrations at Station A(Oluku 0.09 mg/kg >Uniben 0.08 mg/kg >Odighi 0.07 mg/kg Ugbowo 0.01 mg/kg), while at station B Cd concentrations were all beyond the recommended levels except at Ring road (Uselu 0.28 mg/kg >Iyare 0.23 mg/kg >Muyi Line 0.18 mg/kg > Ring road 0.05 mg/kg). Atstation C: Cd levels were observed to be only high at Lawarsi and Agip (Lawarsi 0.19 mg/kg >Agip 0.13 mg/kg >Ameosa 0.06 mg/kg > New Benin 0.06 mg/kg. Results from the study portrayed that the cadmium mean levels at Uselu Motor-park, Lawarsi, Agip, Iyare, and Muyi line had higher levels of cadmium compared to other areas. This is crucial in helping to ascertain and monitor the level of cadmium in the soil of motor parks in Benin City and to ensure that anthropogenic activities that can lead to high concentration levels of cadmium are put under control.

DOI: https://dx.doi.org/10.4314/jasem.v28i10.1

Cite this Article as: ENUNEKU, A. A; OSEGHALE, O. E; ISIBOR, P. O; ONIYA, S. S. (2024). Cadmium Levels and Potential Ecological Risks in Soils from Selected Motor Parks in Benin City, Edo State, Nigeria. *J. Appl. Sci. Environ. Manage.* 28 (10) 2943-2947

Dates: Received: 07 August 2024; Revised: 13 September 2024; Accepted: 19 September 2024 Published: 05 October 2024

Keywords: cadmium levels; soils; motor parks; pollution load index; potential ecological risk

Soils are essential components of the environment and acts as a support for plant growth. Hence, there is great need to maintain and improve high levels of soil quality in order to ensure the overall health and wellbeing of man (Anegbe *et al.*, 2016). According to Wuana and Okieimen (2011), soils may be contaminated through mine tailings, application of fertilizers, gasoline, disposal of metal wastes; waste water irrigation, pesticides, accidental or intentional petrochemicals spillage and many other factors which contribute heavily to soil contamination. Heavy metals are toxic elements with metallic properties which are harmful to human health when consumed at concentrations exceeding normal and acceptable limits (Yang *et al.*, 2016). There is need to ensure that this element do not exceed its limits in the environment especially because of its high levels of persistence, biological toxicity, non-degradability, and its ability to penetrate the food chain, as well as to react with some other organic compounds making it more dangerous than its original state (Maceda-Veiga *et al.*, 2013). It has been observed that when the amount of heavy metals exceeds the threshold rates, aquatic life, plants, animals, and human health are greatly affected (Rose *et al.*, 2015). Heavy metal accumulation in soils can penetrate the human body through various routes of

**Corresponding* Author *Email: edith.oseghale@uniben.edu*
**Tel: +2348026608663*

exposure through ingestion (oral), inhalation (nostril), and dermal (skin) contact (Wang *et al.,* 2019). Research has shown that cadmium has detrimental effects on the digestive system and long-term exposure can give rise to bone fragility and lead to organ damage (Mishra, 2019; Mezynska and Brzaska, 2018; Maina and Bharagava, 2016).

MATERIALS AND METHODS

Study Area: This research was carried out within Benin Metropolis (capital and largest city of Edo State) in Edo State (6º30'N, 6º00'E). Edo State is located in the South-South geopolitical region of the Federal Republic of Nigeria and has 18 Local Government Areas. Edo State has a total land area of 19,559km^2. It has a tropical wet and dry or savanna climate with a yearly temperature of 28.78ºC (83.8ºF). The soil samples were collected and their geographic coordinates were also recorded using a Global Positioning System (GPS) at 14 different motor parks, and one control site.

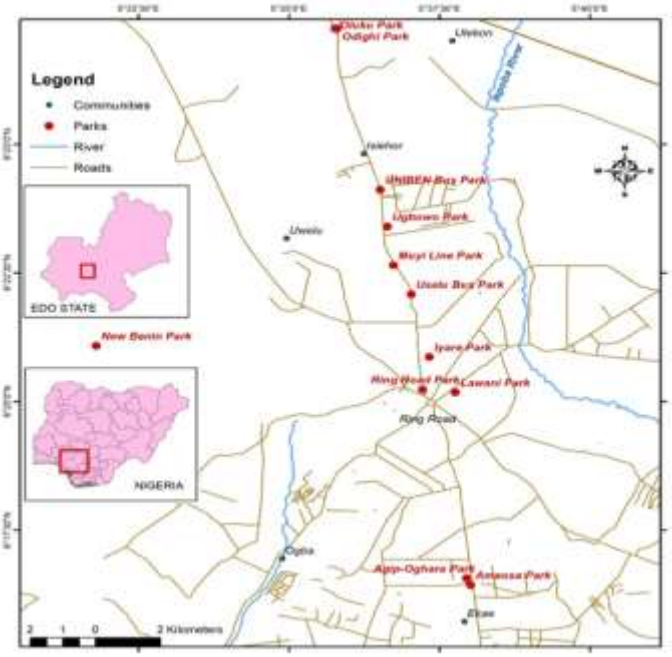

Fig. 1: Map of study area, showing soil sample locations
Source: Arc map, version 10.7

Sample collection and treatment: Soil samples were taken from fourteen different motor parks while the control samples were collected from a community called Iyowa which is few kilometers away from Benin City as can be seen on Table 1. Homogenized soil samples were collected at the depth of 0 – 3cm (top soil) using a cutlass and transferred into black polythene bags and labeled. Two soil samples were collected from each of the motor parks so that average mean of the soil samples could be calculated. Overall, 30 samples were collected from the study area in the month of August. The polythene bags were securely sealed and transported to the laboratory for analysis. In the laboratory, soil samples were air dried and debris was removed. The soil samples were grounded and sieved for further analysis.

Determination of Cadmium in Soil Sample Using Double Acid Extraction Method: Double acid extraction method for the rapid determination of Cd in soil sample using AA after double acid extraction was utilised. Using this technique, the soil samples are not completely digested.

However, the labile fraction of the metals is leached into the extractant solution. Samples were placed in glass petri dishes and dried in the oven at 35ºC. After 24 hours of drying, the lumps present were broken with a glass rod and further exposed to dry. Soil samples were then left in the oven for another 24 hours before grinding. Soil samples were ground using a mortar and a crusher and the samples were then passed through a 2mm sieve.

Extraction Procedure for Soil Samples: Cadmium was extracted by transferring 10g of dried soil sample into an acid–washed 250ml polyethylene extraction bottle. 100ml of extraction reagent was then added. It was shaken for 1hour on the automated shaker. Suspension was sifted through a Whatman No. 42 filter paper. A

blank sample was arranged using a similar method without any soil sample. Filtrate for Cd was then analysed using Flame AA. The analysis of the heavy metal (Cd) was carried out using Atomic Absorption Spectrophotometer (SOLAAR 969 UNICAM SERIES) to determine the concentration of Cadmium (Cd) in each soil samples.

Table 1: GPS Locations of Motor Parks and Soil Sample Sites

Motor Parks/Location	Coordinates
Iyowa (Control Sample)	6º 28' 15''N, 5º 36' 16'' E
Uselu Motor Park	6º 22' 05''N, 5º 37' 02'' E
New Benin (Uniben Shuttle Park)	6º 21' 03''N, 5º 37'43'' E
Lawarsi Motor Park	6º 21' 10''N, 5º 37'48'' E
Ring Road Motor Park	6º 20' 14''N, 5º 37'13'' E
Iyaro (Iyare) Motor Park	6º 20' 52''N, 5º 37'20'' E
First Motor Park	6º 19' 12''N, 5º 37'41'' E
Agip Motor Park	6º 16' 34''N, 5º 37'57'' E
Ameosa Motor Park	6º 16' 26''N, 5º 38'01'' E
Muyi Line	6º 22' 39''N, 5º 36'44'' E
Oluku Motor Park	6º 27' 15''N, 5º 35'46'' E
Oluku (Odighi) Motor park	6º 27' 15''N, 5º 35'48'' E
Edo Omo Motor Park	6º 21' 34''N, 5º 35'55'' E
Ugbowo Motor Park	6º 23' 24''N, 5º 36'38'' E
Uniben Motor Park	6º 24' 07''N, 5º 36'31'' E

Table 2: Cadmium Levels across the Study Area

Cd (mg/kg) Soil Groups	Stations	Odighi	Oluku	Uniben	Ugbowo
A	Min	0.05	0.07	0.06	0.01
	Max	0.09	0.28	0.19	0.09
	Mean	0.07	0.09	0.08	0.01
	SD	0.09	0.10	0.09	0.00
	Stations	Muyi line	Uselu	Iyare	Ring road
B	Min	0.11	0.41	0.26	0.15
	Max	0.01	0.01	0.01	0.00
	Mean	0.18	0.28	0.23	0.05
	SD	0.12	0.13	0.13	0.01
	Stations	New Benin	Lawarsi	AgipOghara	Ameosa
C	Min	0.07	0.24	0.16	0.09
	Max	0.08	0.10	0.09	0.01
	Mean	0.06	0.19	0.13	0.06
	SD	0.06	0.09	0.08	0.02

Statistical Analysis: Significant differences in the sample analysis results were carried out by comparing the cadmium concentration observed at different motor parks with the cadmium concentration obtained at the control site using analysis of variance (ANOVA) is determined as well as the mean concentrations of the soil samples. The statistical analysis was done using Microsoft excel (2009) window application. As can be seen on Table 2, in group A, the lowest mean value of Cd (0.01 mg/kg) was found at Ugbowo while the highest was found at Oluku (0.09 mg/kg). The values obtained were quite higher than the FEPA and WHO, 2003 limits is 0.03 mg/kg while in group B, the lowest mean value of Cd (0.05 mg/kg) was found at Ring Road while the highest was found at Uselu (0.28 mg/kg). In group C, the lowest mean value of Cd (0.06 mg/kg) was found at both New Benin and Ameosa while the highest was found at Lawarsi (0.19 mg/kg).

Pollution Load Index (PLI) and Contamination Factor (CF) of Cadmium (Cd): Tables 3 shows the Pollution load index (PLI) and Contamination factor (CF) of Cd across the studied stations. It was noticed that in all the values obtained across the studied groups/stations were <1. This indicates that the level of pollution was low. The pollution load index was used to assess the severity of the pollution and how it varied (Nweke and Ukpai, 2016). The pollution load index was used to assess the severity of the pollution and how it varied (Nweke and Ukpai, 2016). The equations below display the pollution load index established by Tomlinson et al., (1980).

$$PLI = \sqrt[n]{(Cif1 \times Cif\ 2 \times Cif\ 3 \times \ldots \times Cif\ n)} \quad (1)$$

Where C_f= contamination factor, n = number of metals. Here, the contamination factor (C_f) was expanded to be defined as: $C_f = C^i_f/C_{ri}$

Table 3: Pollution Load Index (PLI) and Contamination Factor (CF) of Cadmium across the Studied Motor Parks

Stations	Odighi	Oluku	Uniben	Ugbowo
PLI	0.05	0.07	0.06	0.01
CF	0.07	0.09	0.08	0.01
DC	0.07	0.09	0.08	0.01
Stations	Muyi line	Uselu	Iyare	Ring road
PLI	0.15	0.23	0.19	0.04
CF	0.18	0.28	0.23	0.05
DC	0.18	0.28	0.23	0.05
Stations	New Benin	Lawani	AgipOghara	Ameosa
PLI	0.05	0.15	0.10	0.05
CF	0.06	0.19	0.13	0.06
DC	0.06	0.19	0.13	0.06

The contamination element was described using the Cif values which range from 1 to 6, with 6 being the highest. Cif values range from 1 to 3, with 3 being the lowest and 6 being the highest. The total number of contamination variables is known as the degree of contamination (DC) (Tomlinson *et al.*, 1980). According to Tomlinson *et al*., (1980); the level of contamination was characterized using these terminologies Dc = 6, low level of contamination; Dc = 6, intermediate level of contamination; Dc = 12, a significant level of contamination; Dc = 24, extremely high level of contamination. PLI values of > 1 suggest pollution, while 1 indicates no pollution and PLI = 1 indicates heavy metal loads that are relatively close to background levels. (Cabrera *et al.*, 1999).

Table 4: Potential Ecological Risk (Peri) of Cadmium across the Study Stations

Stations	Odighi	Oluku	Uniben	Ugbowo
Eir	0.07	0.09	0.08	0.01
RI	0.07	0.09	0.08	0.01
Stations	Muyi line	Uselu	Iyare	Ring road
Eir	0.18	0.28	0.23	0.05
RI	0.18	0.28	0.23	0.05
Stations	New Benin	Lawarsi	AgipOghara	Ameosa
Eir	0.06	0.19	0.13	0.06
RI	0.06	0.19	0.13	0.06

It was observed that in all the values obtained across the studied groups/stations were <1. This indicates that the level of pollution was low. To assess the probable ecological risk of heavy metals, this research used "the Potential Ecological Risk Index" (PERI) developed by Hakanson, (1980). "Degree of contamination (CD), toxic-response factor (TR), and potential ecological risk factor" make up the three fundamental components that make up PERI (ER).

The following equations can be used to determine the total potential ecological risk index (RI) and the potential ecological risk index of a particular element (EiR) using this approach:

$$C^i_f = C^i_D/C^i_R \quad 2$$

$$E^i_R = T^i_R \times C^i_f$$

$$RI = \sum_{i=1}^{m} E_R^i$$

Where CiR stands for a reference number, in this case, the background level of each heavy metal in the sediment, and CiD stands for the measured concentration of each heavy metal in each sampling point; TiR is the biological toxic factor of a single element, which was determined for Cd = 0.2. Cif =CiD /CiR is the pollution of a single element factor; RI is a comprehensive potential ecological risk index; and EiR is the potential ecological risk index of a single element (Martin and Meybeck 1979).

RESULTS AND DISCUSSION

After analyzing the soil samples, the observable results show the mean concentration of cadmium at different motor parks. The lowest mean concentration found in group A was 0.01 mg/kg found at Ugbowo motor park while the highest in this group was 0.09 mg/kg which was found at Oluku motor park, the mean concentration value being highest at Oluku motor park was different from the mean concentration of Cadmium that was observed by Xi *et at.*, (2023) which had the mean concentration of cadmium in the surface soils of urban parks as 2.52 mg/kg in Central China. The difference observed could be as results of anthropogenic activities which could increase the level of cadmium at the Megacity of Central China. The lowest mean concentration of cadmium found in group B was 0.05mg/kg at Ring Road Motor Park while the highest found in group B was 0.28mg/kg at Uselu Motor Park. Comparing the highest mean concentration found in group B at Uselu with the cadmium mean concentration that observed by James *et al.*, (2023) who found the concentration of cadmium

in the soils of the motor parks at the KatimaMulilo urban motor park, Namibia as 0.33mg/kg. The mean concentration value in group C, has the lowest mean concentration recorded as low as 0.06 mg/kg at Ameosa and New Benin motor parks while the highest mean concentration of cadmium in group C was found at Lawarsi as 0.19mg/kg. In station A, the mean concentration occurred in the following order 0.09mg/kg > 0.08mg/kg > 0.07mg/kg > 0.01 (Oluku, Uniben, Odighi, Ugbowo). In station B, the order is as follow 0.28mg/kg > 0.23mg/kg > 0.18mg/kg, > 0.06mg/kg (Uselu, Iyare, Muyi Line, Ring Road). In station C, the order is as follow 0.19mg/kg > 0.13mg/kg > 0.06mg/kg, as both New Benin and Ameosa have the same mean concentration (Lawarsi, Agip, New Benin and Ameosa).

Conclusion: It was observed that cadmium levels in the soils of selected motor parks in Benin City varied across the different study stations. The cadmium mean levels were compared with one another across the study areas and it was observed that Uselu Motor-park, Lawarsi, Agip, Iyare, and Muyi line had higher levels of cadmium. These data is crucial in helping to ascertain and monitor the level of cadmium in the soil of motor parks in Benin City and to ensure that anthropogenic activities that can lead to high concentration levels of cadmium are monitored so as not to endanger human and plant life. Soils with high levels of cadmium can be remediated by adding manure or other organic materials which can help limit cadmium uptake by plants. The addition of agricultural lime can also help to raise soil pH and can also limit plant cadmium uptake. This is highly recommended especially in agro-based locations and sites in the study area.

REFERENCES

Anegbe, B; Okuo, JM; Okieimen, FE (2017). The impact of inorganic and organic pollutants in soil from the vicinity of mechanic workshops in Benin City. *Intl J. Chem. Studies*, 4(3):106-112.

Cabrera, F.; Clemente, L; Barrientos, DE. (1999). Heavy metal pollution of soils affected by the guadiamar toxic flood. *Sci. Tot. Environ.* 242(1–3): 117–129.

Hakanson, l. (1980). An ecological risk index for aquatic pollution control; a sediment ecological approach, Water Res., 14: 975 - 1001.

Maceda-Veiga, A; Monroy, A; Navarro, E; Viscor, A; Sostoa de, A (2013). Metal concentrations and pathological responses of wild native fish exposed to sewage discharge in a Mediterranean river, *Sci. Tot. Environ.* 449(2): 9–19.

Maina, HM; Jonathan, BY; Maitera, ON. (2016). Heavy metal pollution assessment in the sediments of Lake Chad, Nigeria sector. Bayero. *J. Pure Appl. Sci.*, 9(1):213–216.

Martin, J. and Meybeck, M., (1979). Elemental Mass-Balance of Material Carried by Major World Rivers. *Mar. Chem.*, 7(3): 173-206.

Mezynska, M; Brzaska, MM (2018). Environmental exposure to cadmium-A risk for health of the general population in industrialized countries and preventive strategies. *Envtal. Sci. Pol. Rs.*, 25:3211-3232.

Mishra, A; Singh, R; Gautam, N.; Gupta, R. (2019). Heavy metals and living systems: an overview. *Indian J. Pharm.*, 43(3):246–253.

Nweke, MO; Ukpai, SN (2016). Use of Enrichment, Ecological Risk and Contamination Factors with Geo accumulation Indexes to Evaluate Heavy Metal Contents in the Soils around Ameka Mining Area, South of Abakaliki, Nigeria. *J. Geog., Env. Earth Sci. Intl*, 5(4): 1-13.

Rose, M; Fernandes, A; Mortimer, D; Baskaran, C. (2015). Contamination of fish in UK fresh water systems: risk assessment for human consumption, *Chemosphere*, 122(2): 183–189

Tomlinson, DC; Wilson, DJ; Harris, CR; Jeffrey, D.W. (1980). Problem in heavy metals in estuaries and the formation of pollution index. *Helgol.Wiss. Meere-sunlter*., 33(1-4):566-575.

Wang, M; Xie, T; Chen, W; Uwizeyimana, H. (2019). Impacts of urbanization and landscape patterns on the accumulation of heavy metals in soils in residential areas in Beijing. *J. Soils Sediments*. 19(1):148–158.

Wuana, RA; Okieimen, FE; Imborvungu, JA. (2011). Removal of heavy metals from a contaminated soil using organic chelating acids, *Intl J. Envl Sci. Tech.*, 7(3): 485–496

Yang-Guang, G; Qin, L; Yan-Peng, G. (2016). Metals in exposed-lawn soils from 18 urban parks and its human health implications in southern China's largest city, Guangzhou. *J. Cleaner Prod.*115:122–129.