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SPATIAL DISTRIBUTION OF CADMIUM AND LEAD (Cd AND Pb) ALONG OWERRI – ORLU ROAD HIGHWAY IN IMO STATE, NIGERIA

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ABSTRACT: *Vehicular emissions have been found to constitute the major sources of soil and air pollution. This study attempts to investigate the spatial influence of vehicular emissions on the accumulation of heavy metals (cadmium and lead) in some of the roadside soil of Owerri – Orlu road in Imo state. Four locations were selected on the basis of their high concentration of vehicular traffic in Owerri – Orlu. They include Y- Junction, Umuaka, Okwudor and Amaifeke. The concentrations of two heavy metals (Cadium and Lead) in the soil samples were determined calorimetrically using atomic absorption spectrophotometer (AAS). The heavy metal (Cd and Pb) results obtained indicate that the metals from the four sampled sites showed high concentration of Cd far above the soil permissible limit (3 mg kg-1) on all the sampled sites which farther increase away from the road. The concentration of the Pb was found to be lower than the soil permissible limit (50 mg kg^{-1}). Pb despite been lower than the permissible limit, also follows the same trend as in Cd. A factor strongly controlled by the soil properties especially soil texture which are mainly of high sand particles (86.3 to 91%). Correlation results showed that soil properties heavily influence the amount and the movement of these metals along the road and farther away from the road. Although Pb concentrations were below permissible soil limit long time exposure may pose health hazards. The enhancement of fuel quality and the adoption of emission standards to mitigate the impact of vehicular emissions on human health should be adopted.*

KEYWORDS: Cadmium, Lead, Spatial Distribution, Environmental Pollution, Owerri – Orlu Road Highway.

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INTRODUCTION

The explosion of the human population, massive urbanization as well as the introduction and use of cars have caused an exponential growth in environmental pollution (Environmental Protection Agency (EPA), 2004). Environmental pollution is unwarranted disposal of mass or energy into earth's natural resource pool such as water, land, or air that result in a long or short term detriment to the atmosphere and its ecological health. Its effect according to Hussain, 1998 negatively impact on living beings and their life both quantitatively and qualitatively.

Heavy metals typical from road traffic source contaminants the local ecological environments and thus threaten the public health (Agunbiade and Fawale, 2009). These heavy metals are found in fuels, fuel tanks, engines and other vehicle components, catalytic converters, tyres and brake pads, as well as in road surface materials. Cadmium as an element is most abundant naturally-occurring isotope that is non-radioactive. It is found in nature in the mineral forms and is obtained for commercial uses principally from cadmium ore, called greenockite, which is commonly found in association with zinc ore. Commercial production of cadmium ore depends on the mining of zinc (Agency for Toxic Substances and Disease Registry [ATSDR], 2008). Cadmium is also commercially available as an oxide, chloride, or sulfide. Cadmium metal (Cd^{2+}) refined from the ore is a silver-white, blue-tinged lustrous heavy metal solid at room temperature (National Toxicology Program [NTP], 2004).

Lead as relatively unreactive post-transitional metal with weak metallic character as illustrated by its amphoteric nature. Its toxicity has become widely recognized in the late 19^{th} century, although a number of well-educated ancient Greek and Roman writers were aware of this fact and even knew some of the symptoms of lead poisoning. Lead is a neurotoxin that accumulates in soft tissues and bones; it damages the nervous system and interferes with the function of biological enzymes, causing neurological disorders ranging from behavioral problems to brain damage, and also affects general health, cardiovascular, and renal systems.

Despite the change in petrol specification by the Standards Organization of Nigeria (SON) on zero Lead and the input of the Department of Petroleum Resources (DPR) to ensure that all petrol coming into Nigeria be unleaded since June 2002, the situation of increased pollution from mobile transportation source is on the increase in per capital vehicle ownership. The increase in vehicle ownership has resulted in high congestion on Nigerian roads with consequent increase in the concentration of pollutants in the air and soil, thereby increasing health risk on human population. Human exposure to these pollutants due to traffic is believed to have constituted severe health problems especially in urban areas where pollution levels are on the increase (Han and Naeher, 2006). Presently, there is neither a legislative framework nor a set standard in the State to monitor emission from mobile sources. Although Ministry of Transport is working with the Ministry of Environment to set guidelines on vehicular emissions, this has not come to fruition. As a consequence of various observations, different arms of the government environmental controlling agencies are interested in the effects of vehicular emissions on the soil and on the environment as a whole.

Due to heavy metal persistence and non-biodegradation, these metals accumulate on soil. Some may migrate from the soil surface to the underground water system, thereby causing contamination. The presence of these toxic metals in the environment continues to generate a lot of concern to environmental scientists. Hence, the need to evaluate its availability along

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road side and it relationship with the other soil properties. Therefore, this study aimed at evaluating the levels of cadmium and lead in the soil along Owerri – Orlu road in Imo state.

MATERIAL AND METHODS

Study Area

The study was conducted along Owerri – Orlu road highway. The study location is the highway connecting akwakuma round-about to Banana junction. Owerri – Orlu highway area is a tropical climate comprising of both wet and dry season. The rainy season usually occurs from the month of March to mid or late of October, which is often interrupted by short spell in the month of August. The dry season occurs from the month of November to early March. The annual rainfall values ranges between 2200mm to 2275mm. The rainfall pattern is bimodal with heavy experience from July to September. The temperature ranges from 26^{o}C to 32^{0}C. The relative humidity is 76.43%.

Field Study

A total of twelve soil samples were collected from Owerri – Orlu highway. Three samples each were collected from the Y-Junction, Umuaka, Okwudor and Amaifeke. The samples were collected from a depth of 0 - 15 cm using soil auger from the base of the road (0cm), and at 10cm and 20 m away from the road. The soil samples were air-dried, crushed and sieved through a 2 mm mesh before subjecting them for laboratory analysis. Table 1 showed the detail of the sampling points in the study area.

Table 1: Details of sampling points

Sampling points	Description of sampling points	GPS coordinates of sampling points (Lat; Long)	Elevation (m)
Y-Junction (0 m)	The edge of the road	5.567687;7.014699	124.6
Y-Junction(10 m)	10 m away from the road	5.567674;7.014711	121.2
Y-Junction (20 m)	20 m away from the road	5.567644;7.014815	119.7
Umuaka (0 m)	The edge of the road	5.663740;7.016612	144.2
Umuaka(10 m)	10 m away from the road	5.663751;7.016640	139.4
Umuaka (20 m)	20 m away from the road	5.663859;7.016684	136.8
Okwudor (0 m)	The edge of the road	5.718465;7.011127	115.0
Okwudor (10 m)	10 m away from the road	5.718445;7.011056	110.0
Okwudor (20 m)	20 m away from the road	5.718423;7.010924	108.1
Amaifeke (0 meter)	The edge of the road	5.795316;7.018998	180.1
Amaifeke (10 m)	10 m away from the road	5.795369;7.018908	175.5
Amaifeke (20 m)	20 m away from the road	5.795389;7.018899	168.2

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Laboratory Analysis

Particle size distribution was determined by hydrometer method (Bouyoucos, 1962) using sodium hexametaphosphate as dispersant. The texture class was also determined using the 'textured triangular diagram' (Loganathan, 1984). Soil pH was measured in water suspension (1:2.5) using the glass electrode coupled pH meter. The percent organic matter (%OM) was calculated from the percent organic carbon (OC%) measured using Walker-Black wet oxidation method. The concentrations of heavy metals, Pb and Cd were determined using atomic absorption spectrophotometer (AAS) following the standard procedures as given in APHA (1995). All analyses were done in duplicates.

Data Analysis

Analysis of Variance and descriptive statistics was done using SPSS 25. Correlation analysis and graphs were done using MS Excel, 2010. The results were represented in tables and graphs.

RESULTS AND DISCUSSION

The Soil Physicochemical Properties of the Study Area

Table 2 shows some physicochemical properties of soil collected from four different locations along Owerri – Orlu road. Significant differences ($P < 0.05$) were observed in Soil pH and soil organic matter while no significant difference was recorded in % clay, % silt and % sand of the four locations (Table 2). Soils from the study locations had the mean sand, clay, and silt contents ranging between 85.0% and 88.7%, 6.7% and 10.0%, and 3.7% and 6.0% respectively. The texture of the soils collected along and away from the road, falling within the sandy and loam sand textural classes. Soils belonging to these textural classes are characterized by high porosity and permeability, which may facilitate leachate, migration into surrounding environments. The soils may also have low sorption capacity because of the low clay content.

The mean soil pH of the soils along Owerri – Orlu road ranged from 6.7 to 8.1 with many of the samples having pH values above 7.0 (Table 2). These pH values obtained were close to neutral, neutral and above neutral. This is because the soil pH near roads is influenced strongly by traffic activities (Viard *et al*., 2004). The dynamics in pH at the four analyzed distances in Owerri – Orlu road of soil samples taken directly next to the road at four point sampling locations showed no definite trend moving away from the express road. Studies conducted by Lee *et al*. (2012), confirmed a higher pH of soil in the direct proximity of a road. The higher pH observed away from the road might be due to accumulated residues from dead animals, plants, and plant roots since the site has been colonized by weeds (Tripathi and Misra, 2012).

The mean soil organic matter (SOM) in the four sampled locations along Owerri – Orlu road ranged from 12.38 to 22.24g kg^{-1} with the highest value and lowest value at Amaifeke (22.24 g kg^{-1}) and Okwudor (12.38 g kg^{-1}) respectively (Table 2). The SOM also showed no specific trend as observed in the soil pH values along and away from the road. The reason might be the same as in soil pH as reported by Tripathi and Misra, 2012.

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Table 2: Some selected physicochemical properties of the study area

Distance (m)	pH (H_2O)	OM (g kg^{-1})	Clay (%)	Silt (%)	Sand (%)	Textural class
Y - Junction						
0	8.5	6.19	6.0	5.0	89.0	Sand
10	7.3	24.76	10.0	4.0	86.0	Loamy sand
20	6.8	28.20	14.0	2.0	84.0	Loamy sand
Mean	7.5^{ab}	19.72^{a}	10.0^{a}	3.7^{a}	86.3^{a}	
Umuaka						
0	7.8	6.88	12.0	6.0	82.0	Loamy sand
10	7.0	20.64	8.0	6.0	86.0	Loamy sand
20	7.0	24.76	8.0	5.0	87.0	Sand
Mean	7.3^{ab}	17.43^{a}	9.3^{a}	5.7^{a}	85.0^{a}	
Okwudor						
0	8.4	13.07	8.0	11.0	81.0	Loamy sand
10	8.0	7.57	6.0	3.0	91.0	Sand
20	7.9	16.51	6.0	4.0	90.0	Sand
Mean	8.1^{a}	12.38^{b}	6.7^{a}	6.0a	87.3a	
Amaifeke						
0	6.3	2.75	8.0	3.0	89.0	Sand
10	7.0	34.39	7.0	4.0	89.0	Sand
20	6.9	29.58	8.0	4.0	88.0	Sand
Mean	6.7^{b}	22.24^{a}	7.7^{a}	3.7^{a}	88.7^{a}	

The Heavy Metal Concentration of the Study Area

The heavy metal (Cadmium and Lead) concentrations of soil collected from four locations along Owerri – Orlu road were represented in Table 3. Lead showed significant while Cadmium showed no significant influence ($P < 0.05$) along the four locations sampled along Owerri – Orlu road. Mean concentration of lead in soil samples collected ranged between 0.053 to 0.148 mg kg^{-1}. A higher lead concentration was found on the soil collected from Y – Junction (0.148 mg kg^{-1}) while soils collected at Okwudor (0.052 mg kg^{-1}) gave the lowest lead concentration. This results obtained might be due to traffic density around the said area with Amaifeke and Y- junction having more traffic density (Viard *et al*., 2004).

Mean concentration of cadmium in all the collected soil samples ranged between 9.619 to 13.679 mg kg^{-1} (Table 4.2). The highest cadmium was found from soil collected in Umuaka (13.679 mg kg^{-1}) while the lowest cadmium was recorded in soil collected from Amaifeke (9.619 mg kg^{-1}). The concentration cadmium in the soil along Owerri – Orlu road showed variations along the studied locations as found in Pb. The variation in cadmium concentration along the different sampled area might be attributed to other anthropogenic activities outside dust from the combustion of petrol, in brake linings and is also present in the rubber used for tire production (Adachi and Tainosho, 2005 and Lin *et al*., 2005).

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Table 3: Concentration of the heavy metals (Cd and Cr) in the soils of the study area

Distance (m)	Cadmium (mg kg^{-1})	Lead (mg kg^{-1})
Y - Junction		
0	8.533	0.107
10	13.343	0.163
20	13.576	0.174
Mean	11.817a	0.148a
Umuaka		
0	10.861	0.028
10	15.05	0.075
20	15.127	0.083
Mean	13.679a	0.062b
Okwudor		
0	9.309	0.048
10	12.412	0.067
20	14.351	0.043
Mean	12.024a	0.053b
Amaifeke		
0	7.99	0.147
10	9.154	0.158
20	11.714	0.059
Mean	9.619a	0.121ab

The authors Turer and Maynard, 2003; Li, 2005; Kluge and Wessolek, 2012 documented that heavy metal contents in road side soils decrease with further distance away from the road as well as soil depth. The results of Cd and Pb in this study revealed higher concentrations which further increases with distance away from the road (Figure 4.1 and 4.2). This might be attributed to the gradient effect of the study locations as seen in Table 1, which is in line with the work of Jian-guo *et al.,* 2014. It could also be as a result of the texture of the study area which is greatly dominated with sand and little amount of clay to enable adsorption (Madzhieva *et al.,* 2014). This implies that soil that is highly dominated with sand texture and road been at the high elevation, there is likelihood that the heavy metal will be redistributed. According to Mazur *et al*. (2013), the heavy metal content in soil is connected with the distance from the transportation route, intensity of traffic, structure of the landforms and land use. In all as shown in Figure 4.1 and 4.2, cadmium (Cd) content was found to be higher than the permissible soil limit with Pb been lower than the soil permissible limit (World Health Organization/ Food and Agriculture Organization of the United Nation [WHO/FAO], 2001).

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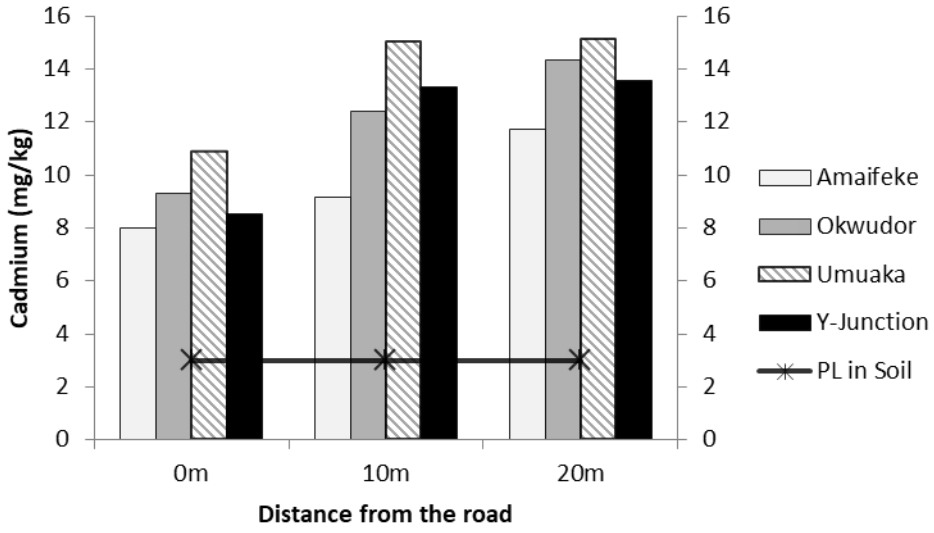

Figure 1: Cadmium concentration in the roadside soil of Owerri – Orlu road

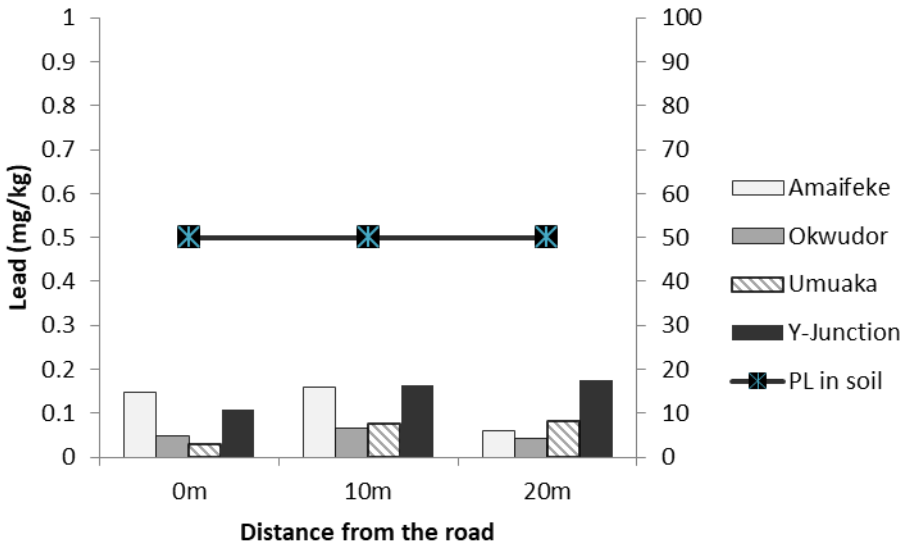

Figure 2: Lead concentration in the roadside soil of Owerri – Orlu road

Note: PL = Permissible Limit in the soil (Source: WHO/FAO, 2001)

Relationship between Soil Properties and Heavy Metal Concentration

Soil pH, soil texture, organic matter content, and cation exchange capacity influence the movement of heavy metals in soils (Ahmadipour et al., 2014; Ngole-Jeme and Babalola, 2020; Teta and Hikwa, 2017). In this Study, heavy metal concentrations displayed a strong correlation with the soil properties evaluated (Table 4). Lead and cadmium concentration and mobility away from the road in the two sampled locations (Y- Junction and Umuaka) were strongly affected by soil pH, OM, amount of clay, silt and sand (Table 4). In Ameifeke, Cd

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showed a significant correlation with soil pH, OM, amount of silt and sand except with the amount of clay with Pb only showing strong positive correlation with sand and weak negative correlation with clay. Cd in Okwudor also showed no correlation with OM but correlated with other soil properties evaluated while Pb had only OM as the only soil properties with strong correlation though negative. Variations between the heavy metals, Cd and Pb correlation in association with OM in Okwudor could be attributed to other factors which could be anthropogenic.

Table 4: The relationship between soil properties and heavy metal concentration in the study area

	CD	*OM*	*pH*	*Clay*	*Silt*	*TS*	*Pb*
			Y - JUNCTION				
CD	1						
OM	0.995	1					
pH	-0.969	-0.990	1				
Clay	0.886	0.929	-0.973	1			
Silt	-0.782	-0.843	0.912	-0.982	1		
TS	-0.933	-0.966	0.993	-0.993	0.954	1	
Pb	0.994	1.000	-0.991	0.932	-0.847	-0.968	1
			UMUAKA				
CD	1						
OM	0.979	1					
pH	-1.000	-0.975	1				
Clay	-1.000	-0.975	1.000	1			
Silt	-0.514	-0.678	0.500	0.500	1		
TS	0.985	0.999	-0.982	-0.982	-0.655	1	
Pb	0.993	0.996	-0.991	-0.991	-0.612	0.998	1
			OKWUDOR				
CD	1						
OM	0.256	1					
pH	-0.980	-0.058	1				
Clay	-0.924	0.132	0.982	1			
Silt	-0.875	0.245	0.954	0.993	1		
TS	0.886	-0.221	-0.961	-0.996	-1.000	1	
Pb	-0.066	-0.982	-0.134	-0.319	-0.426	0.404	1
			AMAIFEKE				
CD	1						
OM	0.638	1					
pH	0.645	1.000	1				
Clay	0.212	-0.617	-0.610	1			
Silt	0.741	0.990	0.991	-0.500	1		
TS	-0.952	-0.373	-0.381	-0.500	-0.500	1	
Pb	-0.916	-0.277	-0.286	-0.585	-0.410	0.995	1

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CONCLUSION

In this study the results of heavy metals showed that transportation infrastructure may have a negative influence on the soil environment. The values of the analyzed heavy metals Cd and Pb which was found near the road (0 meter) were shown to increase in concentration as the distance away from the expressway increased. Soil highly dominated with sand texture and the road been at the high elevation, was likelihood the reason for the obtained results. The contents of Cd in all the sampled area irrespective of the distance away from the road were higher than the permissible Cd soil limit while the Pb were below the permissible Pb soil limit. Although Pb concentrations was below permissible soil limit, washing of this heavy metal over time by erosion into the local areas used for farming, may pose serious health hazards. Extreme care must be taken to maintain a low level of heavy metal concentration on roadside dust as these metals are bioaccummulative and the dust can travel to long distance to human residence. However, the enhancement of fuel quality and the adoption of emission standards to mitigate the impact of vehicular emissions on human health should be made mandatory.

REFERENCE

Adachi, K. and Tainosho Y. (2005). Characterization of heavy metal particles embedded in tire dust. Environ. Int. 2004, 30, 1009–1017. 31.

Agunbiade, F. O. and Fawale, A. T. (2009). Use of Siam weed biomarker in assessing heavy metal contamination in traffic and solid waste polluted areas. Internat. Env. Sci. Tech. 6(2): 267-278.

Ahmadipour, F. Bahramifar, N. and Mahmood Ghasempouri, S. (2014). "Fractionation and mobility of cadmium and lead in soils of Amol area in Iran, using the modified BCR sequential extraction method Chemical," Speciation & Bioavailability, Vol. 26, pp.31 36.

APHA (1995). American Public Health Association. Standard Methods for the Examination of Water and Waste Water, 19th edn. APHAAWWA-WPCF, Washington, DC. p. 525-987.

ATSDR (Agency for Toxic Substances and Disease Registry). (2008). Toxicological Profile for Cadmium Draft. United State Department of Health and Human Services: Atlanta. GA. USA.

Bouyoucos, G. J. (1962). Hydrometer method improved for making particle size analyses of soils. Agro. J. 54:464.

Han X. and Naeher L. P. (2006). A review of traffic-related air pollution exposure assessment studies in the developing world. Environment International, 32:106-120.

Hussain M. (1998). Environmental Degradation, Realities and Remedies. Ferozsons (Pvt.) LtdLahore, Pakistan.

Jian-guo Li, Li-jie Pu, Qi-lin Liao, Ming Zhu, Li-li Liu, Li-fang Zhang, Qi-qi Wang, Xiao-ging Dai. (2014). The sources and gradient effect of soil heavy metal concentrations in Wuxi City. Scientia Geograhica Sinica, Vol. 34, 4:496 – 504.

Kluge, B. and Wessolek, G. (2012). Heavy metal pattern and solute concentration in soils along the oldest highway of the world—The AVUS Autobahn. Environ. Monit. Assess., 184, 6469–6481.

Article DOI: 10.52589/AJENSR-OG92M3QX
DOI URL: https://doi.org/10.52589/AJENSR-OG92M3QX

Lee, M.A., Davies, L. and Power, S.A. (2012). Effects of roads on adjacent plant community composition and ecosystem function: An example from three calcareous ecosystems. Environ. Pollut., 163, 273–280.

Li, L.Y. (2005). Retention capacity and environmental mobility of Pb in soils along highway corridor. Water Air Soil Pollut., 170, 211–227.

Lin, C.C., Chen, S.J., Huang, K.L., Hwang, W.I., Chang-Chien, G.P. and Lin, W.Y. (2005). Characteristics of metals in nano/ultrafine/fine/coarse particles collected beside a heavily trafficked road. Environ. Sci. Technol., 39, 8113–8122.

Loganathan, P. (1984). Laboratory Manual of Soil and Plant Analysis. Rivers State University of Science and Technology, Port- Harcourt, Nigeria.

Madzhieva, S., Minkna, T., Pinskiy, D., Bauer, T. and Sushkova, S. (2014). "The role of soil's particle size fractions in the adsorption of heavy metals,"Eurasian Journal of Soil Science, vol. 3, no. 3, p. 197–205.

Mazur, Z., Radziemska, M., Maczuga, O. and Makuch, A. (2013). Heavy metal concentrations in soil and moss surroundings railroad. Fresenius Environ. Bull., 22, 955–961.

Ngole-Jeme V. M. and Babalola, O. O. (2020). "Heavy metal immobilization potential of indigenous bacteria isolated from Gold mine tailings," International Journal of Environmental Research, Vol. 14, pp. 71–86.

NTP (National Toxicology Program) (2004). Cadmium and Cadmium Compounds. In: 11th Report on Carcinogenesis. Research Triangle Park.

Teta C. and Hikwa, T. (2017). "Heavy metal contamination of ground water from an unlined landfill in Bulawayo," Zimbabwe Journal of Health and Pollution, vol. 7, pp. 18–27.

Tripathi A. and Misra, D. (2012). "A study of physico-chemical properties and heavy metals in contaminated soils of municipal waste dumpsites at Allahabad," India International Journal of Environmental Sciences, vol. 2, pp. 2024–2033.

Turer, D. G. and Maynard, J. B. (2003). Heavy metal contamination in highway soils. Comparison of corpus Christi, Texas and Cincinnati, Ohio shows organic matter I key of mobility. Clean Technol. Environ., 4, 235–245.

US Environmental Protection Agency. (2004) Reporting Cycle, In National Water Quality Inventory: Report to Congress; EPA 841-R-08-001: Washington, DC, USA, 2009.

Viard, B., Pihan, F., Promeyrat, S. and Pihan, J. C. (2004). Integrated assessment of heavy metal (Pb, Zn, Cd) highway pollution: Bioaccumulation in soil, Graminaceae and land snails. Chemosphere, 55, 1349–1359.

WHO/FAO. Codex alimentarius commission. Food additives and contaminants. Food Standards Programme, ALINORM 10/12A. Joint FAO/WHO; 2001. Available: 10.13140/RG.2.1.4910.2560.

Article DOI: 10.52589/AJENSR-OG92M3QX
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