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Spatial Distribution of the Heavy Metals: Ni, Fe, Cr, and Mn in Roadside Soils of Maiduguri Metropolis, Borno State Nigeria

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Abstract- In this research work the level and distribution pattern of the metals: Ni, Cr, Mn, and Fe were determined in soil samples collected within Maiduguri Metropolis. Samples were collected from places of high anthropogenic activity such as automobile maintenance workshop (AMW), Car park or Bus stops (CP), and the highways (HW) to places of low activity the Residential areas (RA) at the depth of 5 to 15cm. To avoid washing away of the metals by rainfall, all collections were done during the dry season in the month of September/October 2012 to April/May of the following year 2013. These periods are period of incessant wind and sandstorm marked with low or no rainfall in this part of the country (far north-eastern part of Nigeria). Soil samples were analyzed using ICP-OES following digestion with aqua-regia and the results shows that; the levels; 14.48, 8264.17, 24.26, and 84.75µgg-1 were observed in the samples from AMW for the metals: Ni, Fe, Cr, and Mn respectively. The RA has the levels; 4.96, 804.50, 4.56, and 13.93 µgg-1 for the metals; Ni, Fe, Cr, and Mn respectively. The HW and CP had level of the metals; greater than the RA but less than the AMW. The high concentration of the metal (Fe) in the soil suggests that this metal could be mainly of natural origin with adequate contribution from anthropogenic influences. The concentrations of the metals was found to decrease with increasing distance from the places of high anthropogenic activity AMW, HW, CP to the places of less anthropogenic activities the RA. The distribution pattern of metals; Ni, Cr, Fe, and Mn in Maiduguri Metropolis could be arranged in the order; AMW > CP > HW > RA. This trend further confirms that automobiles are the main contributor of the heavy metals in the urban environment.

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I. Introduction

Pedos means soil in Greek and the term pedosphere is used to donate the soil cover, the terrestrial part of the earth. Pedology is the science of soil and the method of studying and analyzing it. Soil is the main component of the biosphere, the vital layer of our planet. It is populated by various organisms ranging from tiny bacteria to higher plants, animals and human. It provides the means of physical support for all terrestrial organisms. Presence of heavy metals at elevated levels in the environment may be hazardous to human health. In the urban environment roadside soil has been identified as a sink for heavy metals. Moreover the road side soil is contaminated with heavy metal it can discharge these pollutants into the air and water sectors of the city's environment. It is evident that the urban soil containing the heavy metal pose a serious threat to the safety of the human life by ingestion, inhaling (Wei and Yang, 2010) and through the direct contact with the soil on the road sides contaminated by heavy metal (Yang et al., 2010).

Environmental pollution by heavy metals from road traffics emissions has become a serious issue in the recent past due to their long-term accumulation. Sources of heavy metals in soils in urban environment mainly include; its natural occurrence in the soil derived from parent materials and human activities which are associated with activities such as atmospheric deposition, industrial discharges, waste disposal, waste incineration, urban effluent, long-term application of sewage sludge, fertilizer application in soil, and vehicle exhausts (Bilos et al., 2001; Turer and Maynard, 2003). In many cities in the developing countries in the world, especially in Africa, Nigeria in particular, lack of access to land make many places to be used as garages, parks, including places such as road verges, and any other spot that motorist could occupy. All setbacks along major highways are occupied by motorist and the alarming rate at which this is going is unprecedented. The traffic source of pollutants includes vehicles tire wear, brake linings, fuel combustion, etc. (Pagotto et al., 2001), and road infrastructure such as pavement wear, corrosion of galvanized steel, crash barriers, etc. It has been reported that the pollutants such as As, Cd, Cr, Cu, Ni, Pb and Zn due to traffic density are mostly found at high levels in soils at sites closer to the roadside that can even affect the environmental air quality (Culbard et al., 1988).

These heavy metal pollutants, derived from a growing number of diverse anthropogenic sources, have had enormous impact on different ecosystem (Macfarlane and Burchett, 2002). In urban areas, heavy metals in the roadside soils can be accumulated in human body via direct inhalation, ingestion and dermal contact absorption (Poggio et al., 2008; Lim et al., 2008). The majority of the heavy metals are toxic to the living organism and even those considered as essential can be toxic if present in excess. Excess heavy metals

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can impair important biochemical process posing a threat to human health, plant growth and animal life (Ikenaka et al., 2010). Reports have shown that such pollutants can be harmful to the roadside vegetation, wildlife and the neighboring human settlements (Nakayama et al., 2010). A number of studies have indicated that such metals could be stored in fatty tissues of human beings and consequently affect the functions of the vital organs and disturb the nervous system and endocrine system (Ali and Malik 2010). Diseases related to high level of heavy metal in the system include lung tissue damage, respiratory illness, liver and kidney failure and others (Popescu, 2011). Cr for instance is carcinogenic and can lead to nasal septum perforation, asthma and liver damage, whereas Ni has been reported to cause nasal and lung cancer (Li et al., 2013). This paper is aimed at determining the level and distribution pattern of the heavy metals; Ni, Cr, Fe, and Mn in the roadside soils within Maiduguri Metropolis, the capital city of Borno state, Nigeria.

a) Sample and Sampling Sites

Samples were collected within Maiduguri metropolis. Four different sampling sites were designated for this study, these include: Car parks or bus stop (CP) this site covers areas of; tashan Bama Motor Mark (Mari), Tashan Baga Motor Park (Baga Road), tashsn Kano Motor Park (Maduganari), maiduguri Terminus and Tashan Joni all within Maiduguri Metropolis. The Highways (HW) this site includes; the highway from Post Office to Tashan Baga; from Post Office to Tashan joni (Air port Road); from custom to the University compus; these are the bussiest roads within the Metropolis. Automobile Maintenance workshops (AMW) this site includes: the Bank of the north area of post office, Dauda mechanic workshop area of Leventis super market, and the automobile maintenance workshop around the flour mill area. And the Residential areas (RA), this site covers the areas of Jiddari Polo ward, Silimri ward, Sulemanti ward and Kafanti ward. These sites represent areas of high anthropogenic activities (automobile maintenance workshops, car parks, and highways) as well as areas of less activity (the residential areas). Five different samples were collected at each sampling site. Samples were collected at the depth of five to fifteen centimeters from the surface and at the intervals of two meters apart using broom and hand trowel. To avoid washing away by rainfall, all collections were done during the dry season in the month of September/October 2012 to April/May of the following year 2013. These periods are period of incessant wind and sandstorm marked with low or no rainfall in this part of the country (far north-eastern part of Nigeria). Samples collected were preserved in an acid prewashed cleaned polyethylene bags for subsequent analysis.

b) Sample Preparation and Analysis

Composite samples collected were homogenized, dried at 60°C to a constant weight, grounded into fine powder using an acid pre-washed mortar and pestle and sieved through a 2mm nylon sieve (Ikenaka et al., 2010). Analysis was done using ICP-OES following digestion with 10 ml Aqua regia (Akbar et al., 2006) in a digestion tube, for the level of the metals: Ni, Cr, Fe, and Mn, in the soil samples.

c) Statistical Data Handling

All statistical data handling were performed using SPSS 17 package. Differences in heavy metal concentrations among the different sites of sampling were detected using One-way ANOVA, followed by multiple comparisons using Turkey tests. A significance level of ($P \leq 0.05$) was used throughout the study.

d) Results and Discussion

Table 1 : Mean concentration (μgg-1) of the Heavy metals in the soil from the Mechanical

Sample	AMW ±SD	CP ±SD	HW ±SD	RA ±SD
Ni	14.86 ±5.40**a**	14.82 ±5.12**c**	13.20 ±4.17**e**	4.96 ±2.00**g**
Fe	8264.12 ±10.17	5760.61 ±28.88	6298.43 ±47.76	804.50 ±17.82
Cr	24.26 ±2.45**a**	12.78 ±1.59**c**	4.78 ±1.36**ef**	4.56 ±1.17**gx**
Mn	84.75 ±4.01	51.33 ±2.22	12.96 ±1.73**ef**	13.93 ±2.66**gx**

AMW= Automobile Maintenance Workshop, CP= Car parks or bus stops, HW=Highways and RA= Residential Areas. Differences of the mean values with bold small letters were found not significantly at (p≤ 0.05) according to the Turkey test. Data are presented in mean ±SD (n = 5).

Heavy metals are a group of widespread pollutants in the environment that mostly originate from traffic emission, industrial activities, domestic emission and weathering of buildings and pavements (Kong et al., 2012). Although some natural activities result in the release of heavy metals in the environment, report has it that human activities contributed most to the release of this metals in the ecosystems (Sun et al., 2010).

Table one shows the level and distribution pattern of the metals; Mn, Ni, Cr, and Fe determined in the soil samples collected within Maiduguri Metropolis, Borno state, Nigeria. The level of the observed metals was found in direct proportion with the activities occurring at the sampling sites. The observed level of manganese (Mn) ranged from 12.96μg/g - 84.75 μg/g with the automobile maintenance workshop (AMW) having the highest (84.75 μg/g) whereas the lowest level of 12.96 μg/g came from the highways (HW). In this study, the levels of manganese in soils were relatively low. The highest level of the metal (Mn) observed in this study was much lower than 95.48 mg/kg, 132 mg/kg and 408 mg/kg as reported by (Olukanni and Adebiyi, 2012; Okunula and Uzairu, 2007; Ho and Tai, 1988). It has been reported that the level of manganese in the soil generally ranged between 200 – 3000 mg/kg (Lindsay and Norvell, 1979). Manganese has been reported to be relatively less toxic or harmless, in contact with human, the metal is absorb in the body and the excess excreted (Habeck, 1992).

The level of the metal; Ni in Maiduguri Metropolis ranges from 4.96 μg/g-14.86μg/g. Automobile maintenance workshop (AMW) has the highest level of the metal (14.86 μg/g) whereas the residential area has the lowest value of 4.96 μg/g. Car parks or bus stops and the highways have the levels; 14.82 and 13.20 μg/g respectively. The highest concentration of nickel (14.86 μg/g) observed in this study is lower than the highest concentration recorded for Lagos (42.73 mg/kg) (Olukanni and Adeoye, 2012). On international ground, the highest concentration of nickel (14.86μg/g) observed in this study was found lower than the highest levels recorded in Baoji 72.1mg/kg (Li and Huang, 2007), Ethiopia, 200.6 mg/kg (Melaku et al., 2005) and India 1409 mg/kg (Abida et al., 2009). On the other hand, this value 14.86 μg/g was higher than the concentration recorded in mubi (8.62μg/g) (Shingu et al., 2007). The lowest value of the metal; Ni observed from the residential areas in this study was found higher than what was observed in Enugu(0.8 mg/kg) and Otta Metropolis; 0.33 mg/kg (Ekere and Ukoha, 2013; Olukanni and Adebiyi, 2012). The distribution pattern of Ni in the environment could be arranged in the order; AMW > CP > HW > RA.

The range of the level of nickel in roadside soil samples has been reported by Fergusson and Kim (1991) to be 50-100 µg/g, whereas in this study the range as shown in table was found far less than what was reported by Fergusson and Kim (1991) but the concentration is higher compared to what was observed in the less anthropogenic areas (the residential areas). The largest anthropogenic source of Ni in the urban environment is the corrosion of cars, burning of fuel and residual oils, (Arslan, 2001; Fergusson and Kim, 1991; Akhter and Madany, 1993). Oil contains more Ni than coal; there are also large natural sources of Ni present in the atmosphere, e.g. windblown soil, volcanic activity, forest fires, meteoric dust and sea salt spray or particles which later settle under gravitational force (Frey, 1967).

Chromium (Cr) is considered as a serious environmental pollutant, due to its wide industrial applications. Contamination of soil and water by Cr2+ is of recent concern. The Cr6+ compounds are used in industry for metal plating, cooling water treatment, hide tanning, and until recently, wood preservation (Nriago, 1990). These anthropogenic activities have led to the wide spread contamination that Cr shows in the environment and have increased its bioavailability and biomobility (Kotas and Stasicka, 2000). The level of chromium in this study varies greatly and in accordance to the degree of activities taking place at a given sites. For instance the automobile maintenance workshop was found to have the highest concentration of 24.26 μg/g, the car park or bus stop has 12.78 μg/g and the highways 4.78 μg/g, whereas the residential areas, the site with the less anthropogenic activity has the lowest concentration of 4.56 μg/g. The upper limit of Cr observed in this study (24.26 μg/g) is very much lower than the limit observed in India 343-1409 mg/kg (Abida et al., 2009); in the center of Hail city 95ppm (Odat and Alshammari, 2011); in Ethiopia 86.3mg/kg (Melaku et al., 2005 and the limit of 100 mg/kg recommended by EU (Yahaya et al., 2010). However this limit is higher than the highest level observed in Mubi 5.4 μg/g (Shingu et al., 2007). The natural concentration of Cr in soil has been reported to ranged from 10 to 50 mg kg-1 depending on the parental material whereas (Adriano, 1986). Vehicle exhaust, brake lining, catalytic converters and chrome pigment for automobiles are also some of the primary major source of the metal (Cr) in urban environment (Shu et al., 2001; Fang et al., 2010). Soil is a complex system and its constituents are constantly undergoing changes due to weather conditions, geographic location and human activities, such as traffic, industrial and agricultural ones. With the advent of democracy high and rapid economic development in Nigeria was recorded, the number of motor vehicles has therefore dramatically increased in recent years. Significantly more heavy metals are likely to be emitted into the urban environment by vehicle emissions. The distribution pattern of the metal (Cr) in the environment could be arranged in the order; AMW > CP > HW > RA.

The consistently high load of iron recorded in all the sites is not surprising considering the fact that iron

(Fe) is one of the constituents (alloy) found in almost all vehicles and other metallic substances. Quite a number of research works has it that, the pollution sources of heavy metals in environment especially urban environment are mainly derived from anthropogenic sources. In urban soils and urban road dusts, the anthropogenic sources of heavy metals include traffic emission (vehicle exhaust particles, tire wear particles, weathered street surface particles, brake lining wear particles), industrial emission (power plants, coal combustion, metallurgical industry, auto repair shop, chemical plant, etc.), domestic emission, weathering of building and pavement surface, atmospheric deposited and so on (De Miguel et al., 1997; Han et al., 2006; Morton et al., 2009). The process of corrosion, rusting, wear and tears of all metallic substance in the environment might have contributed to the high concentration of this metal (Fe) when compared with other metals in this research work. Moreover, it had been earlier stated by a good number of researchers that iron occurs in high proportion in Nigeria soil, implying that the concentration is contributed from both anthropogenic and crustal origin. The presence of iron in soils and plants is desirable (Eze and Hillary, 2008) since it is one of the metals that are essential to human biochemical processes, for example haemoglobin in the human blood system contains iron which aids blood formation (Okoye, 1992).

II. Conclusion

The result of the study shows moderate contamination of the soil in the Metropolis by the metals: Ni, Cr, and Mn. The levels of which could be attributed to ninety-five percent anthropogenic source. The high concentration of the metal (Fe) in the soil suggests that these metals could be mainly of natural origin with adequate contribution from anthropogenic influences. The result shows that the concentration decreases with increasing distance from the places of high anthropogenic activity {the automobile maintenance workshop (AMW), the highways (HW), Car park or Bus stops (CP)} to the places of less anthropogenic activities (the residential areas (RA).

References Références Referencias

1. Arslan, H. (2001). Investigation of heavy metal pollution of traffic in Kemalpasa-Turkey. Fresenius Environ. Bull. 10, 405-408.
2. Abida B., Ramaih M., Harikrishma I. K. and Veena K. (2009), “Analysis of heavy metals concentrations in soils and litchens from various localities of Hosur road, Bangalore, India”. EJournal of Chemistry, 2009, Vol. 1, pp. 13-22.
3. Adriano, DC. (1986). Trace Elements in the Terrestrial Environment. New York7 Springer Verlag, p. 105– 23.
4. Akhter, M.S. and Madany, I.M. (1993). Heavy Metals in Street and House Dust in Bahrain. Water Air Soil Poll. 66, 111-119.
5. Ali, S. M. and Malik, R. N. (2010). Spatial Distribution of Metals in Top Soils of Islamabad City, Pakistan. J. Environment Monitoring Assessment, 20: 1-16(2010).
6. Bilos C., Colombo J. C., Skorupka C. N., Rodriguez P. M. (2001). “Sources, distribution and variability of airborne trace metals in La Plata City area, Argentina”. Environmental Pollution. Vol. 111, pp. 149-58.
7. De Miguel, V., Llamas, J.F., Chacón, E., Berg, T., Larssen, S., Royset, O. and Vadset, M. (1997). Origin and patterns of distribution of trace elements in street dust: unleaded petrol and urban lead, Atmospheric Environment 31; 2733–2740.
8. Culbard E.B., Thornton I., Watt J., Wheatley M. and Moorcroft S., Thompson M. Metal contamination in British urban dusts and soils, J Environ Qual., 17, 226–234 (1988).
9. Eze S, Hilary M. (2008). Evaluation of heavy metals pollution of soils around the derelict Enyigba Mines and their sources. Inter. Journal of applied environmental science. 2008; 13 (3):4.
10. Fang, G.C., Huang, Y.L. and Huang, J.H. (2010). Study of Atmospheric Metallic Elements Pollution in Asia during 2000-2007. J. Hazard. Mater. 180: 115–121.
11. Fergusson, J.E., 1991. The Heavy Elements: Chemistry Environment Impact and Health Effects. Pergamon, Oxford London.
12. Fergusson, J.E. and Kim, N.D. (1991). Trace elements in street and house dusts: sources and speciation. Sci. Total Environ. 100, 125-150.
13. Habeck, M. (2011).Toxicological Profile for Manganese Agency for Toxic Substances and Disease Registry, United States Public Health Service (1992) http://www.ecousa.net/toxics/chemicals/disclaimer.shtml.
14. Han, Y., Du, P., Cao, J. and Posmentier, E.S. (2006). Multivariate analysis of heavy metal contamination in urban dusts of Xi'an, Central China, Science of the Total Environment 355; 176–186.
15. Ho, I. B., and Tai, K. M, (1988). Elevated levels of lead and other. Metals in Roadside Soil and Grass and their use to monitor Aerial metal Depositions in Hong Kong. Environ Pollut, Vol. 49: 37-51.
16. Kabata-Pendias, A. and Pendias, H. 1984. Biogeochemistry of trace elements. (in Polish), PWN, Warszawa, 397.
17. Kotas J, Stasicka Z, 2000. Commentary: chromium occurrence in the environment, and methods of its speciation. Environ Pollut, 107: 263–283.
18. Li, X. and Huang, C. (2007) Environment impact of heavy metals on urban soils in the vicinity of

industrial area of Baoji city, P.R. China, Environmental Geology 52; 1631–1637.
19. Li, P.H., Kong, S.F., Geng C. M., Han, B., Lu, B., Sun, R. F., Zhao, R. J. and Bai, Z.P. (2013). assessing the hazardous risks of vehicle inspection workers' exposure to particulate heavy metals in their work places. Aerosol Air Qual. Res. 13: 255–265.
20. Lim, H., Lee, J., Chon, H., and Sager, M. Heavy metal contamination and health risk assessment in the vicinity of the abandoned Songcheon Au–Ag mine in Korea, Journal of Geochemical Exploration 96 (2008) 223–230.
21. Lindsay, W. K., and Norvell, W. A, Development of a DTPA soils test for zinc, iron, manganese and copper. J. Soil Sci. Soc. Am., 1979.Vol. 42: pp 421-428.
22. MacFarlane, G.R., Burchett, M.D., 2002. Toxicity, growth and accumulation relationships of copper lead and zinc in the Grey Mangrove Avicennia marina (Forsk.) Veirh. Marine Environmental Research 54, 65–84.
23. Melaku S., Wondimu T., Dams R. and Moens L. (2005). "Multi-element analysis of Tinishu Akaki River Sediment, Ethiopia, by ICP-MS after microwave assisted Digestion". Can. J. Anal. Sci. Spec. Vol. 50, pp. 1.
24. Morton-Bermea, O., Hernández-Álvarez, E., González-Hernández, G., Romero, F., Lozano, R. and Beramendi-Orosco, L.E. (2009) Assessment of heavy metal pollution in urban top soils from the metropolitan area of Mexico City, Journal of Geochemical Exploration 101; 218–224.
25. Nakayama MMS, Ikenaka Y, Muzandu K, Choongo K, Oroszlany B, Teraoka H, Mizuno N, Ishizuka M. (2010). Heavy Metal Accumulation in Lake Sediments, Fish (Oreochromis niloticus and Serranochromis thumbergi), and Crayfish (Cherax quadricarinatus) in Lake Itezhitezhi and Lake Kariba, Zambia. Arch. Environ. Contaminat. Toxicol., 59(2):291-300.
26. Nriago J O, 1990. Global metal pollution: Poisoning the biosphere. Environment, 32: 7–33.
27. Odat, S.and Alshammari, A. M. (2011). Spacial Distribution of Soil Pollution along the Main Highways in Hail City, Saudi Arabia. Jordan Journal of Civil Engineering, Volume 5, No. 2, 163-172.
28. Okoye BCO. (1992) Nutrients and selected chemical analysis in the Lagos Lagoon surface waters. Intern. J. Environ.Studies.1992; 38: 131-135.
29. Olukanni D. O. and Adebiyi S. A. (2012). "Assessment of vehicular pollution of road side soils in Ota Metropolis, Ogun State, Nigeria". IJCEE-IJENS, Vol. 12, No. 4, pp. 40-46.
30. Pagotto C., Remy N., Legret M. and Lecloirec P. (2001) Heavy metal pollution of Road dust and road side soil near a major rural highway, Environ. Technol., 22, 307-319.
31. Poggio, L., Vřščaj, B., Hepperle, E., Schulin, R. and Marsan, F.A. (2008). Introducing a method of human health risk evaluation for planning and soil quality management of heavy metal-polluted soils—an example from Grugliasco (Italy), Landscape and Urban Planning 88; 64–72.
32. Popescu, C. G. (2011) Relation between vehicle traffic and heavy metals from the particulate matters, Romanian Reports in Physics, Vol. 63(2), 471-482.
33. Popoola O. E., Bamgbose O., Okonkwo O. J., Arowolo T. A., Odukoya O. and Popoola A.O. (2012). "Heavy metals content in playground topsoil of some public primary schools in metropolitan Lagos, Nigeria". Research Journal of Environmental and Earth Sciences. Vol. 4, No. 4, 434-439.
34. Turer D. and Maynard J.B., (2003): Heavy metal contami¬nation in highway soils. Comparison of Corpus Christi, TX and Cincinnati, OH shows organic matter is key to mobility. Clean Technology and Environmental Policy, 4: 235–245.
35. Wei, B. and Yang, L. (2010) "A review of heavy metal contaminations in urban soils, urban roads, urban road dust and agricultural soils from China" Microchemical Journal, 94, 99-107.
36. Yang, T., Liu, Q.S., Li, H.X., Zeng, Q.L., and Chan, L.S., (2010). Anthropogenic magnetic particles and heavy metals in the road dust magnetic identification and its implications. Atmospheric Environment 44, 1175e1185.
37. Yassi, A.. and Niober, E. (1988). Carcinogenity of chromium compounds. In: Nriagu, J.O., Nieboer, E. (Eds.), Chromium in the Natural and Human Environments, Wiley Series, 20: 514– 530.
38. Yisa, J. (2010). Heavy Metals Contamination of Road- Deposited Sediments. Bida, Nigeria American, J. Applied Sciences, 7 (9): 1231-1236.
39. Zhang, F., Yan, X., Zeng C., Zhang, M., Shrestha, S., Devkota, L.P. and Yao, T. (2012). Influence of Traffic Activity on Heavy Metal Concentrations of Roadside Farmland Soil in Mountainous Areas. Int. J. Environ. Res. Public Health 9(5):1715-1731.