Article Number: 0CD0E6

A Paper Presented at the 2nd International Conference on Strategies and Implication for Education and Technological Advancement. Niger Delta University, Amasoma, Bayelsa State. 18th – 20th November, 2014

ACADEMIC JOURNALS
expand your knowledge

Conference Proceedings

Full Length Research Paper

Heavy metals concentrations in roadside soil collected from various points along three major roads in Benin City

Oghuvwu P. O.

Department of Chemistry, University of Benin, Benin City, Nigeria.

Road construction materials and vehicular emissions have been found to constitute the major sources of soil and air pollution. This study attempts to investigate the influence of road furniture and vehicular emissions on the accumulation of heavy metal in some of the roadside soil of Benin City, Edo State. The objective of this study was to determine the concentration of heavy metals such as Zn, Pb, Mn, Cr, Cd, Cu, and Ni from roadside soil around some selected roads in Benin City. Three locations were selected on the basis of their high concentration of vehicular traffic. A control site with no form of vehicular emission or road construction material pollution was selected outside these three locations. Samples were collected from April to June 2013. The concentrations of seven heavy metals in the samples were determined with an atomic absorption spectrometer, of which the result obtained indicates that the metals from the three sampled sites were higher than that in the control site, whereas the mean concentration of each of the heavy metal in the three locations except for Zinc and Nickel was below the European Union Regulatory Standard (EURS). Although these concentrations were below the European Union Regulatory Standard, these metals, which over time are washed by erosion into the local areas used for farming, 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 made mandatory.

Key words: Heavy metals, soil, pollution.

INTRODUCTION

Benin City is a town in Edo State which lies between latitude 6° 19'N and longitude 5°36'E. It is located in the southern part of Nigeria. The ancient city is urban and had witnessed an overwhelming influx of people from the rural areas in the last few decades, thereby resulting in a tremendous increase in population in the city. The explosion of the human population, massive urbanization as well as the introduction and use of cars have caused an exponential growth in the production of goods and services (Environmental Protection Agency (EPA), 1998).

E mail: peteovo80@yahoo.com.

This growth has been coupled with an increase in waste by-products.

Environmental pollution is insidious and its harmful effects only become apparent after long periods of exposure (Alloway and Ayres, 1997). It is a fact that pollution is now regarded as a global problem since pollutants can cross borders with the help of wind and water, and as a result of these there is need for environmental monitoring in detecting where insidious pollutions is occurring, the types of pollutants involved and their sources.

Heavy metals are typical road traffic source contaminants in the local ecological environments and thus threaten public health. These 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.

In Nigeria, for instance, the State Environmental Protection Agency (SEPA) and the Federal Environmental Protection Agency (FEPA), now the National Environmental Standards and Regulations Enforcement Agency (NESREA) are charged with the responsibility of enforcing environmental laws, regulations and standards in order to deter people, industries and organizations from polluting and degrading the environment. However, these responsibilities were restricted to the control of air, water, and noise pollution, waste disposal and oil spillage. No consideration was given to soil pollution, especially the major threats to environmental health (Olukanni and Adebiyi, 2012).

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.

Trace metals including some heavy metals, are found in the roadside environment at levels which are often elevated. For example, roadside soil may contain significant amounts of Zn, Pb, and Cu (Jarvis et al., 2001). While the soil/dust itself is in part derived from wind-blown local soil, the elevated concentration cannot normally be attributed to this source. The possible metal sources include traffic emissions (exhausts, wear and tear of tyres, brake lining abrasion and automobile body and yellow paint abrasion), waste incinerators, steel plants, smelters, foundries, metals manufacturers, as well as power some of these heavy metals that find their way into the roadside soil from sources that includes indiscriminate refuse combustion and weather. Traffic has the potential to input a vast array of heavy metals to the environment through which it travels, and previous studies have tended to concentrate on the relative inputs from tyre wear, break wear, bodywork degradation, exhaust catalyst wear etc. Vehicle wear and degradation have been proposed by some researchers as the main sources from which these elements are derived. However, with complex nature of the road system, it is difficult to conclusively demonstrate that this is the case and it is likely that other types of input play an important role.

Impact of heavy metals

Heavy metal toxicity can result in damaged or reduced mental and central nervous function, lower energy levels, and damage to blood composition, lungs, kidneys, liver, and other vital organs. Long-term exposure may result in slowly progressing physical, muscular, and neurological degenerative processes that mimic Alzheimer's disease, Parkinson's disease, muscular dystrophy, and multiple sclerosis. These metals contaminants can easily impact people residing within the vicinity of the roads via suspended dust or direct contact. If there are farmlands within the scope that the contaminants can reach, they may enter the food chain as a result of their uptake by edible plants, thus causing serious health risks, because of their toxicity which can be just above the background concentrations naturally found in nature. Therefore, it is important for us to inform ourselves about the heavy metals and to take protective measures against excessive exposure.

The present study therefore, focused on establishing the levels of Zn, Pb, Mn, Cr, Cd, Cu, and Ni in the roadside soil around three major high traffic congested roads in Benin City.

MATERIALS AND METHODS

The samples were collected in triplicate from April to June 2013, from four different points in the three roads selected for the study in Benin City, Nigeria. A total of 36 soil samples were collected using plastic brush and parker and were stored in labeled plastic containers. The samples collected were air-dried and ground, using a pestle and mortar, to ensure homogeneity.

Metal determination

A 0.50 g of dried roadside soil sample was weighed into a flask. And was digested by the addition of 13.3 ml of Aqua Regia mixture and heated for some minutes. 3 ml of concentrated Sulphuric acid was then added and the heating continued until the mixture became clear and allowed to cool. 50 ml of distill water was then added to wash the flask and the insoluble solid was filtered off from the supernatant liquid. The filtrate was then made up to mark, in a 100-ml volumetric flask. This was done for all the samples. Concentrations of Zn, Pb, Mn, Cd, Cr, Cu, and Ni were made directly on each final solution using Atomic Absorption Spectroscopy (AAS) (P.G. 550) model.

RESULTS AND DISCUSSION

The mean concentrations of Zn, Pb, Mn, Cr, Cd, Cu and Ni obtained from the different points on the road surface at Akpakpava Road, Ring Road and New Benin Road from April to June are presented in Table 1 and Figure 1, together with their standard deviations.

Zinc (Zn)

The average amount of Zinc in the sample locations of this study ranges from 8.97 -914.41 mg/kg, this is higher than the average value ranges for similar studies in Lagos (25.87 - 198.32) mg/kg, USA (12.60 - 183.00) mg/kg, China (28.50 - 161.00) mg/kg, and Ethiopia (140.90 - 302.80) mg/kg, but lower than that of similar study conducted in Poland (10.50 - 1547.00) mg/kg as represented in Table 2. When compared with the EU acceptable standard of Zinc concentration in agricultural soil which is 300 mg/kg, it exceeded the EU standard limit Table 2. The high concentration of Zinc in the study might be due to Zinc compounds being used extensively as anti-oxidants and as detergent /dispersant improving agent for motor oil. Literature also has it that vehicle brakes and tyre wear as possible sources of Zinc. This could also be linked to high traffic density in the selected locations and the socio economic activities going on around the locations. Zinc compounds used for galvanized street light poles are also, likely contributors.

Lead (Pb)

This average range concentration (1.48 - 11.16) mg/kg of lead observed for this study was extremely lower than EU upper limit of 300 mg/kg, and the maximum tolerable levels proposed for agricultural soil of 90 – 300 mg/kg. The observed concentrations of lead in this study suggest long accumulation of some level of lead, most likely from vehicle emissions, since there are no industrial activities within the area. The concentration of lead observed for this study could be attributed to lead particle from gasoline combustion which consequently settles on roadside soils. In the same way, vehicles are often moving slowly as a result of the heavy traffic jam in this area and this could also be a factor. The concentration of lead obtained from this study is lower than the concentration obtained from those conducted in the United States (55.4 mg/kg), China (56.0 mg/kg), Poland (50.1 mg/kg), Ethiopia (325.4 mg/kg) and India (623.95 mg/kg) respectively.

Manganese (Mn)

The highest Mn concentration in the roadside soil sample was observed at Akpakpava and the lowest Mn concentration was detected at New Benin. These concentrations are higher than the concentration of manganese in the control site; when compared with the average concentration obtained from similar studies in Lagos, USA, China, Poland, Ethiopia and India, it is found to be lower. The highest range of manganese obtained was lower than the lowest reported in Lagos (3.72 mg/kg) for similar study by Olukanni et al. (2012). It was also lower than the values of 953.52 mg/kg in Lagos, 2532.00 mg/kg in the U.S.A., 1740.00 mg/kg in China, and 1122 mg/kg in Poland. Mn concentration of this study is far below the EU concentration standard for Mn in agricultural soil.

Chromium (Cr)

The source of Chromium in roadside soil is believed to be

Table 1. Mean and standard deviations of metals concentration (mg/kg) of the three selected locations in Benin City.

Sampling points	Zn (mg/kg)	Pb (mg/kg)	Mn (mg/kg)	Cr (mg/kg)	Cd (mg/kg)	Cu (mg/kg)	Ni (mg/kg)
				Akpakpava Road			
A	51.31±1.97	5.12±0.05	0.54±0.07	9.68±0.47	0.32±0.01	0.67±0.01	4.04±0.04
B	914.41±7.17	1.69±0.11	9.23±0.11	0.02±0.02	0.10±0.01	11.93±0.13	72.57±1.17
C	221.71±1.33	2.71±0.21	2.31±0.10	5.06±0.51	0.23±0.07	2.81±0.09	18.06±0.38
D	60. 34±0.85	1.48±0.03	0.61±0.02	3.41±0.34	0.10±0.02	0.77±0.05	4.91±0.10
				Ring Road			
A	33.18±2.21	4.82±0.31	0.31±0.02	8.62±0.13	0.3±0.02	0.43±0.02	2.86±0.17
B	18.85±0.43	11.16±1.66	0.18±0.04	5.40±0.64	0.75±0.08	0.34±0.1	1.54±0.09
C	131.69±3.09	2.32±0.19	1.34±0.07	6.79±0.22	0.13±0.02	1.71±0.04	10.87±0.50
D	60.62±2.30	2.05±0.16	0.60±0.02	10.83±0.52	0.12±0.02	0.73±0.12	4.80±0.23
				New Benin			
A	44.99±1.35	5.28±0.07	0.42±0.03	9.25±0.34	0.32±0.01	0.6±0.03	3.64±0.16
B	26.91±1.54	2.78±0.23	0.30±0.04	5.90±0.73	0.24±0.07	0.38±0.04	2.19±0.05
C	8.97±0.21	5.51±0.50	0.08±0.01	6.55±0.13	0.30±0.02	0.12±0.02	0.75±0.07
D	90.98±5.89	2.28±0.24	0.78±0.23	11.16±0.48	0.16±0.02	1.34±0.09	7.03±0.62
Control	0.51	0.19	0.03	0.02	0.02	0.03	0.20
EU Std.	300.00	90-300.00	1500.00	100.00			50.00

A-Road paint surface, B- Road bitumen surface, C- Road concrete walkway, D- Road drainage grill.

due to corrosion of vehicular parts (Lu et al., 2009). The highest concentration (11.16 mg/kg) of Chromium in this study was obtained from New Benin at sampling point D, while the lowest 0.02 mg/kg is from Akpakpava at sampling point B. This highest concentration value of chromium for this study is lower than the highest concentrations recorded for similar studies in Poland (75.3 mg/kg), India (145.45 mg/kg), China (150.0 mg/kg), and the United States (208.0 mg/kg), and did not exceed the EU acceptable value of 100 mg/kg, for uncontaminated soil (Fabis, 1987). The presence of Chromium in road sides is a slight dependence in traffic volume.

Cadmium (Cd)

The concentrations range of cadmium recorded for this study is 0.10 – 0.75 mg/kg obtained from Akpakpava at sampling points B, D and Ring Road sampling point B respectively. This is lower than the recommended 1 – 3 mg/kg limit specified by EU standard and also those conducted in Ethiopia (1.61) mg/kg, and Poland (1.7) mg/kg, but higher than that obtained from the study conducted in Ota (0.35 mg/kg) (Olukanni et al., 2012). The likely sources of cadmium in these locations includes: automobile fuel metal plating, lubricating oils, old tyres that are frequently used, and the rough surfaces of the roads which increase the wearing of tyres.

Copper (Cu)

The concentration range (0.12 - 11.93) mg/kg of Cu recorded for this study is higher than concentrations of copper (0.03 mg/kg) in the control site soil sample, but lower than the concentrations obtained for copper in similar studies; 42.36 mg/kg in Ota, 48.00 mg/kg in Kaduna, 96.13 mg/kg in Yauri, 101.00 mg/kg in the United States, 55.10 mg/kg in China, 93.00 mg/kg in Ethiopia, 18.00 mg/kg in Poland and 198.23 mg/kg in India. The Cu concentration range for this study was observed to be less than the range (50 - 100 mg/kg) by the European Union regulatory standard for copper in soil (Fabis, 1987).

Nickel (Ni)

The concentration range of Nickel (0.75 - 72.57 mg/kg)

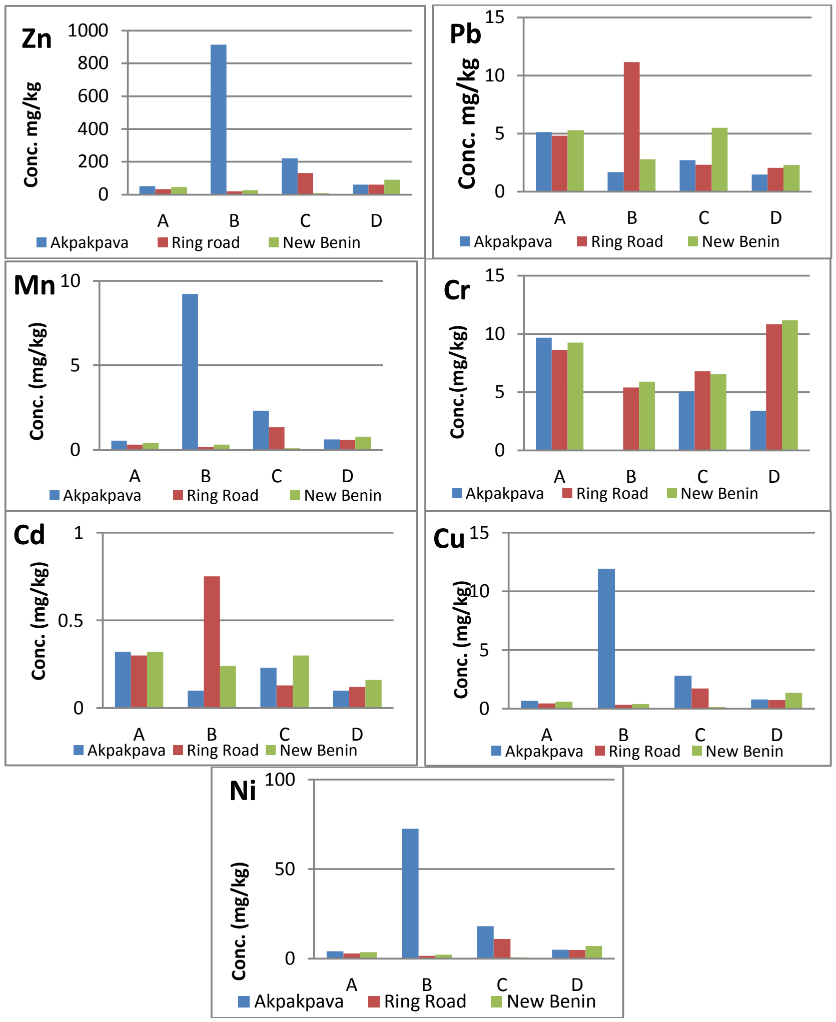

Figure 1. Graphical representation of metals mean concentration in the sampling area.

Table 2. Comparing the mean concentration (mg/kg) values range of this study with those of other studies.

Metals	This study	[a]Study in Lagos	[b]Study in USA	[c]Study in China	[d]Study in Poland	[e]Study in India	[f]Study in Ethiopia	[h]EU Reg. Standard
Zn	8.97 - 914.41	25.87 - 198.32	12.60 - 183.00	28.50 - 161.00	10.50 - 1547.00	ND	140.90 - 302.80	300.00
Pb	1.48 - 11.16	5.57 - 69.20	4.62 - 55.40	9.95 - 56.00	7.10 - 50.10	ND - 623.95	20.30 - 325.40	90.00 - 300.00
Mn	0.08 - 9.23	3.72 - 953.52	43.00 - 2532.00	134.00 - 1740.00	83.00 - 1122.00	NA	NA	1500.00
Cr	0.02 - 11.16	1.58 - 347.00	6.59 - 208.00	19.30 - 150.00	3.70 - 75.30	ND - 145.45	86.30 - 15790.00	100.00
Cd	0.10 - 0.75			3.77				1.00 - 3.00
Cu	0.12 - 11.93			173.00				
Ni	0.75 - 72.57	0.94 - 42.73	2.44 - 69.40	7.73 - 70.90	2.00 - 27.00	343.00 - 1409.00	47.30 - 200.60	50.00

Source: [a] – Olukanni and Adeoye (2012), [b] – Shacklette and Boerngen (1984), [c] – Bradford et al. (1996), [d] – Dudka (1992), [e] – Adida et al. (2009), [f] – Melaku et al. (2005), [h] – (European Commission, 1986); Yahaya et al. (2010). ND = not detected, NA = not available.

for this study is higher than the EU acceptable background value (50.00 mg/kg) for uncontaminated soil (Fabis, 1987). When the concentrations obtained from this study were compared with the levels in similar studies elsewhere, the lowest average concentration range of nickel (0.75 mg/kg) obtained in this study is lower than the least concentration recorded for those conducted in the United States (2.44 mg/kg) and Poland (2.00 mg/kg), China (70.90 mg/kg), Ethiopia (47.30 mg/kg) and India (343 mg/kg). The highest concentration of nickel (72.57 mg/kg) obtained in this study is higher than the highest concentration recorded for those conducted in Poland (27.00 mg/kg), the United States (69.40 mg/kg), and lower than the highest concentration recorded in China (77.30 mg/kg), Ethiopia (200.60 mg/kg) and India (1409 mg/kg).

Conclusion

Results obtained from this study on heavy metals concentrations in roadside soil reveals the following; 1) Zn shows the highest concentrations of metal determined across the three major roads sampled. 2) The highest concentrations of metals (Zn, Pb, Mn, Cr, Cd, Cu, and Ni) for the study are majorly obtained at point B, irrespective of the sampling area except for chromium that its highest concentration is at point D from New Benin. 3) Akpakpava Road in Benin City might be contaminated with Zn and Ni.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

REFERENCES

Adida 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 1:13-22.

Alloway BJ, Ayres DC (1997). Chemical Principles of Environmental Pollution. Second Edition. Blackie Academic & Professional. London.

Bradford GR, Chang AC, Page AL (1996). Background concentrations of trace and major elements in California soils. Kearney Foundation Special Report, University of California, Riverside pp. 1-52.

Dudka S (1992). Factor analysis of total element concentrations in surface soils of Poland. Science Total Environment 121:39-52.

European Commission (1986). Council Directive 66/278/EEC on the protection of environment, and in particular of soil, when sewage sludge is used in agriculture. European Commission, Office for Official publications of the European Communities, Luxembourg.

Fabis W (1987). Schadstoftbelastung von Bo¨den-Auswirkurgen auf Bo¨ den-und wasserqalitat Allg Farstzeitsehr. Munich: BLV Verlaggesellshaft.

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

Jarvis KE, Parry SJ, Piper JM (2001) Temporal and spatial studies of auto-catalyst derived Pt, Rh and Pd and selected vehicle-derived trace elements in the environment. Environmental Science and Technology 35:1031-1036.

Lu X, Wang L, Lei K, Huang J (2009). Contamination assessment of copper, lead, zinc, manganese and nickel in street dust of Baoji, NW China. Journal of Hazardous Materials, 161:1058-1062.

Melaku S, Wondimu T, Dams R, Moens L (2005). Multi-element analysis of Tinishu Akaki River Sediment, Ethiopia, by ICP-MS after microwave assisted Digestion. Canadian Journal of Analytical Sciences and Spectroscopy, 50(1):31-40.

Olukanni DO, Adeoye DO (2012). Heavy metal concentrations in Roadside soil from selected locations in Lagos Metropolis, Nigeria. International Journal of Engineering and Technology 2(10):1743-1752.

Shacklette HT, Boerngen JG (1984). Element concentrations in soils and other surficial materials of the conterminous United States. U.S. Geological Survey Professional Paper, 1270:105. https://www3.epa.gov/ttn/chief/old/ap42/ch11/s03/reference/bref22_c11s03_ch4_1997.pdf

Yahaya MI, Ezeh GC, Musa YF, Mohammad SY (2010). Analysis of heavy metals concentration in road sides soil in Yauri, Nigeria. African Journal of Pure and Applied Chemistry 4(3):022-030.