ASSESSMENT OF SOME HEAVY METALS IN ROADSIDE SOILS AND VEGETATION ALONG ANYIGBA-LOKOJA HIGH WAY, KOGI STATE, NIGERIA.

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Abstract

A study of heavy metals in roadsides soils and vegetation is critical in assessing the potential environmental impact of automobile emissions on soils and vegetation. The impact of heavy metals on soils and vegetation between Ayingba to Lokoja highway, Kogi State, Nigeria, was examined by determining the concentration of selected heavy metals. Soil samples were collected from 0-15cm depth and vegetation samples were collected randomly from four settlements in Kogi state; Ayingba, Ojodu, Itobe and Ajaokuta, and a control sample was taken 500m away from the highway. The concentration of the heavy metals was determined using atomic absorption spectrometer (AAS). The concentration levels of heavy metals in soil in Ayingba were 0.41mg/kg,1.45mg/ kg, 2.94mg/kg, 0.16mg/kg, 3.22mg/kg and 1.64mg/kg for Cd, Pb, Zn, As, Cu and Mn respectively, Ojodu;0.36mg/kg 1.34mg/kg, 2.86mg/kg, 0.14mg/kg, 2.96mg/kg, and 1.28mg/kg for Cd, Pb, Zn, As, Cu and Mn respectively, Itobe; 0.36mg/kg, 1.34mg/kg, 2.86mg/kg, 0.14mg/kg, 2.90mg/kg and 1.78mg/kg for Cd, Pb, Zn, As, Cu and Mn, respectively, Ajaokuta;0.44mg/kg, 1.48mg/kg, 3.10mg/kg, 0.18mg/kg, 3.40mg/kg and 1.82mg/kg for Cd, Pb, Zn, As, Cu and Mn respectively, while control site concentration of heavy metals recorded 0.22mg/kg, 1.17mg/kg, 2.23mg/kg, 0.011mg/kg, 2.30mg/kg, and 1.26mg/kg for Cd, Pb, Zn, As, Cu and Mn respectively. And the concentration levels of heavy metals in vegetation in Anyigba were 0.026mg/kg-1, 0.037mg/kg-1, 0.43mg/kg-1, 0.021mg/kg-1, 0.41mg/kg-1, and 0.12mg/kg-1 for Cd, Pb, Zn, As, Cu, and Mn respectively, Ojodu;0.024mg/kg-1, 0.034mg/kg-1, 0.38mg/kg-1, 0.018mg/kg-1, 0.36mg/kg-1, and 0.081mg/kg-1 for Cd, Pb, Zn, As, Cu, and Mn respectively, Itobe; 0.023mg/kg-1, 0.030mg/kg-1, 0.41mg/kg-1, 0.019mg/kg-1, 0.38mg/kg-1, 0.09mg/kg-1 for Cd, Pb, Zn, As, Cu, and Mn respectively, Ajaokuta; 0.031mg/kg-1, 0.042mg/kg-1, 0.46mg/kg-1, 0.023mg/kg-1, 0.40mg/kg-1, and 0.12mg/kg-1 for Cd, Pb, Zn, As, Cu, and Mn respectively. However, the control site was 0.021mg/kg-1, 0.020mg/kg-1, 0.34mg/kg-1, 0.006mg/kg-1, 0.23mg/kg-1 and 0.06mg/kg-1 for Cd, Pb, Zn, As, Cu, and Mn respectively. Higher concentration of heavy metals was observed at all locations when compared to the level of heavy metals concentrations of the control site. The concentration of heavy metals recorded at all the locations were observed to be lower than the maximum permissible limit for heavy metals in soil and vegetation set out by the United Kingdom and European Union standards. However, reduction of greenhouse gas emission should be encouraged to prevent its long-term accumulative effect on the soil and environment as well as it potential risks on human.

Keywords: Heavy metals, Roadside soils, Roadside vegetation, Anyigba, Ojodu, Itobe and Ajaokuta, Kogi State.

IntroductionHeavy or toxic metals are trace metals which are detrimental to human health and having a density at least five times that of water. Once liberated into the environment through the air, drinking water, food, or countless varieties of man-made chemicals and products, heavy metals are taken into the body via inhalation, ingestion and skin absorption (Suruchi and Khanna, 2011). If heavy metals enter and accumulate in body tissues faster than the body's detoxification pathways can dispose of, then a gradual build-up of these toxins occurs. High concentration exposure is not a necessity to produce a state of toxicity in the body, as heavy metal accumulation occurs in body tissues gradually and, over time, can reach toxic concentration levels, much beyond the permissible limits (Suruchi and Khanna, 2011).

Roadside soils in urban areas all over the world are pointers of heavy metal contamination from a variety of sources mostly of anthropogenic influences. Major metal pollutants of the roadside environments are released from fuel burning, old tyres, leakage of oils, and corrosion of batteries and metallic parts such as radiators etc. (Xia *et al*., 2010). Although many heavy metals are naturally occurring, some however, have shown potential health hazards especially in high concentrations in human and plant cells. Heavy metals such as cadmium, lead, and others like copper and zinc are potentially toxic and pose great threat to food safety and human health even in minute concentrations (Abduljaleel *et al*., 2012).

Environmental changes are based on factors like urbanization, population and economic growth, increase in energy consumption and agricultural intensification. The degradation has adverse impacts not only on humans, plants, animals and micro-organisms but also on nature as a whole, since there is an intricate link between living organisms and nature (Tiwari and Raj, 2013).

Lenntech, water treatment and air purification (2004) defined heavy metal as any metallic element that has relatively high density and is toxic or poisonous even at low concentration (Gambus and Wieczorek, 2012; Mohammed *et al*., 2011; Shahzad *et al*., 2018).

Roads are important infrastructure that plays a major role in stimulating social and economic activities. However, road construction has also resulted in heavy environmental pollution (Bai *et al.,* 2008). Pollution of soils by heavy metals from automobile sources is a serious environmental issue. These metals are released during different operations of road transportation such as combustion components, fluid leakage and corrosion of metals. Lead, cadmium, copper, and zinc are the major metal pollutants of roadside environment and are released from fuel burning wear out of tyres leakage of oils and corrosion of batteries and metallic part such as radiation etc. (Dolan *et al*., 2006).

Soil is the critical environment medium, which is subjected to a number of pollutants due to different human activities. (Al-Kashma and Shawabkeh, 2006). The ongoing rapid economic boost has put a great burden on soil. With the increasing demand for metals during the course of industrialization and urbanization, more and more pollutants containing heavy metals has become widespread (Yang *et al*., 2011). Environmental pollution of heavy metal from road traffics emissions has attained much attention in the recent years due to their long-term accumulation. Several studies have proved that roadside environments are polluted by heavy metals released during different operations of the road transport. Heavy metals such as Pb, Cu, and Zn have been reported to be released into the atmosphere during different operations of the road transport (Zhang et *al*., 2012).

Plants have a major contribution in purifying land water and environmental air. Entrance of heavy metals may occur in human and animal food chain as a result of their uptake by edible plant grown in contaminated soil (Bakirdere and Yaman, 2008). The toxic and hazardous effects of some heavy metals on human health are very significant and may cause many fatal diseases. The accumulation of heavy metals on plants depends on various factors, such as distance from the pollution source, physical properties of heavy metals (e.g. mobility), emission intensity (e.g. traffic density), climatic factors (e.g. wind direction and force, precipitation and air circulation), soil and season types, aerosol accumulation and topographical structures (Severoglu *et al.,* 2015; Osma *et al.,* 2012; Yasar *et al.,* 2010).

The objectives of this research are; to ascertain the level of concentration of some heavy metals in roadside soils and vegetation along Anyigba-Lokoja high way, and to compare the level of concentration of some selected heavy metals to environmental standard.

Materials and Methods

Description of Study Area

The study area was between Ayingba to Lokoja in Kogi State. The study was divided into four locations; Ayingba, Ojodu, Itobe and Ajaokuta. Their coordinate is; Ayingba, latitude 7.49 degree North and longitude 7.17 degree east, Ojodu, 7.36-degree North, 7.03 degree east, Itobe,7.42-degree North, 6.72 degree east, Ajaokuta 7.54-degree North, 6.64 degree east. The study area falls within the tropical wet and dry climate region and guinea Savannah with mean annual temperature of 25 degree and a rain fall of about 1600m. (Tokula and Enenche, 2018)

Collection of Soil and Vegetation Samples

Soil samples were collected along major highway in Kogi State. Prominently to the major settlements; Ayingba, Ojodu, Itobe and Ajaokuta, and vegetation Samples were taken at random from each location. Random Samples were collected two meters (2m) from the roadsides, from both sides of the highway at a depth of 0-1 5cm (for soils). Samples were collected 50m apart at each location in proximity to major settlements. Control sample was collected at about 500m from the highway. After the collection, the samples were bulked to get a representative composite sample within each location and composite samples were sent for laboratory analysis.

Soil Sample Preparation

The soil samples were air dried, crushed using a porcelain mortar and pestle and sieved using a 2mm sieve. The soil samples were packaged in a well labeled polythene bag for laboratory analysis.

Plant Sample Preparation

The vegetation samples were oven dried to remove the moisture content at 65-70^{o} C for 72 hours (3 days), the samples were crushed into powder with a clean porcelain mortar, and was passed through a sieve of 2mm for easy digestion. The vegetative samples were packaged in a well labeled polythene bag for laboratory analysis.

Determination of Heavy Metals in Soil

Soil sample of 5kg was weighed into a beaker. Ten (10ml) of an acid mixture (Nitric/chloric acid in ratio2:1) was added to the content. The beaker was placed into a hot plate for about 30minutes until the colour changes from brown to colorless. The digest was allowed to cool and this was read on a Bulk Scientific Absorption Spectrophotometer (AAS) to analyze As, Pb, Cu, Cd Zn and Mn. (Novotry *et al*., 2002).

Determination of Heavy Metals in Plant

Vegetative samples of 2g each was weighed into a beaker for metal analysis was digested using a mixture of 2mL of 60% perchloric acid, 15mL of concentrated nitric acid and 1mL of concentrated sulphuric acid (Burrell, 1974).

Analysis of Heavy Metals: The digested samples were allowed to cool and was analyzed for the metals using atomic absorption spectrophotometer (AAS) (Perkin Elmer Model A Analyst 2002) fitted with deuterium lamp for background correction to analyze As, Pb, Cu, Zn and Mn (Novoltary *et al.,* 2002).

Results and Discussions

Table 1 and 2 represent the results of heavy metal concentration levels in soils and vegetation along roadsides between Ayingba to Lokoja in Kogi State, which was divided into four locations (Anyingba, Ojodu, Itobe and Ajaokuta) the control site and maximum allowable limit of heavy metal in soils and vegetation.

Table 1: Mean concentration of heavy metals at the control site and the interval locations compared to standard limit of heavy metals in soil (mg/kg)

Treatment	Cd	Pb mg/kg	Zn	As	Cu	Mn
Control	0.22	1.17	2.23	0.011	2.30	1.26
Anyigba	0.41	1.45	2.94	1.16	3.22	1.64
Ojodu	0.38	1.42	2.91	0.14	2.96	1.28
Itobe	0.36	1.34	2.86	0.14	2.90	1.78
Ajaokuta	0.44	1.48	3.10	0.18	3.40	1.82
Mean	0.40	1.42	9.95	0.16	3.12	1.62
UK	1.14	70	200	12	63	-
EU	3	300	300	20	140	-
WHO						1000-2000

Key: **UK**: United Kingdom Standard
EU: European Union Standard
Source: Hong *et al*., 2014; WHO, 1982

Discussions This result indicate a significant variation and the mean concentration of the selected heavy metals (As,Pb,Cu,Cd,Zn,Mn) analyzed in the soil sample taken at each location; Ayingba, Ojodu, Itobe and Ajaokuta in Kogi State and compare to the environment standard (European Union and United kingdom). Higher concentration of heavy metals was observed at all locations when compared to the concentration of heavy metals found at the control site.

Cadmium (Cd)

The concentration of cadmium examined at the different locations showed a range of 0.36mg/kg to 0.44mg/kg with a mean value of 0.4mg/kg, while the control site had cadmium concentration of 0.22mg/kg. The concentration of cadmium observed at the all four locations were found to be higher than that of the control site, revealing the impact of cadmium pollution in the soil. However, the concentration of cadmium recorded from each location were found to be lower when compared to the standard permissible limit of 1.4mg/kg and 3mg/kg set out by the UK and EU standard. Cadmium is very much connected with non-residual fraction of heavy metal and this makes cadmium mobile and potentially bioavailable for plant (Zhang, 2009).

Lead (Pb)

The concentration of lead assessed at the different locations ranged from 1.34mg/kg to 1.48mg/kg with a mean value of 1.42mg/kg. This accumulation could be attributed to lead particles from gasoline combustion which consequently settles on the roadside soils. This shows that there was a rapid accumulation of lead in the soil at the different locations when compared with the concentration value of the control site (1.17mg/kg). However, the concentration of lead in the soils recorded from all the four locations were found to be much lower when compared to the standard permissible limit of 70mg/kg and 300mg/kg set out by the UK and EU standard.

Zinc (Zn)

Zinc was ranked the second most abundant metal among the heavy metals (As, Pb, Cu, Mn, Zn, Cd) examined. The concentration of zinc ranged from 2.386mg/g to 3.10mg/kg with a mean value of

2.43mg/kg. The accumulation of zinc could be attributed to motor vehicle tyre rubber exacerbated by poor road surfaces and lubricating oils in which zinc is found as part of many addictive such as Di thiophosphates. (Davies, 1984; Hewitt and Candy, 1990). The concentration of zinc in the four locations were higher than the concentration of the control site (2.32mg/kg). Nevertheless, the concentration zinc recorded from the four interval locations were much lower when compared with the standard permissible limit of 200mg/kg and 300mg/kg site out by the UK and EU standard.

Copper (Cu)

Copper was ranked the first most abundant metal in this research. The concentration of copper recorded from the different locations ranged from 2.90mg/kg to 3.40mg/kg with a mean value of 3.12mg/kg, while the control site recorded a value of 2.30mg/kg. The concentration level of the four locations were observed to be higher than the value of the control site. This indicates a variation in the concentration level of copper in the soils along the highway, which showed the impact of pollution from anthropogenic sources. The concentration of copper recorded from all the four interval locations where below the permissible limit of 63mg/kg and 140mg/kg set out by UK and EU standard.

Arsenic (As)

Arsenic recorded lowest level of concentration in this study. The concentration of arsenic from the four locations ranges from.0.14mgkg to 0.18mgkg with the mean value of 0.16mg/kg. While the control site had a concentration of 0.011mg/kg. This indicates that, there was a progressive accumulation of arsenic in the soil along the highway of the four locations when compared to the value of the control site (0.011mg/kg). Nevertheless, the concentration of the arsenic recorded in all experimental sites, were below the permissible limit of 17mg/kg and 10mg/kg set out by UK and EU standard respectively.

Manganese (Mn)

The concentration of the manganese recorded at the different location showed a range of 1.78bm/kg to 1.82mg/kg with a mean value of 1.63mg/kg while the control site recorded a value of 1.26mg/kg. The concentration of manganese observed at the four locations were found to be higher than that of the control site. However, the concentration of the manganese recorded from the different locations were found to be very low when compared with that of the standard permissible limit of 1000 – 2000mg/kg set out by the WHO. (WHO, 1982). Mn is a composition of soils in northern Nigeria, there availability in trace amount as obtained in this study could be due to local condition of soil weathering Bait *et al*., (2008).

Table 2: mean concentration of heavy metals at the control site and the interval locations compared to standard limits of heavy metals in soil mg/kg.

Heavy Metal	Pb	Cd	As Mg/kg	Mn	Cu	Zn
Control	0.020	0.021	0.006	0.06	0.23	0.34
Anyigba	0.037	0.026	0.021	0.12	0.41	0.43
Ojodu	0.034	0.024	0.018	0.081	0.36	0.38
Itobe	0.030	0.023	0.019	0.09	0.38	0.41
Ajaokuta	0.042	0.031	0.023	0.12	0.40	0.46
Mean	0.036	0.026	0.020	0.103	0.388	0.42
EU STD	300	3.0	20.0	-	140.0	300
UK STD	70	1.4	12.0	-	63	200
WHO	-?	-.	-.	-.	-.	1000-2000

Keys:
EU= European Union Standard,
UK= United Kingdom Standard
Source: Hong *et al.,* 2014.

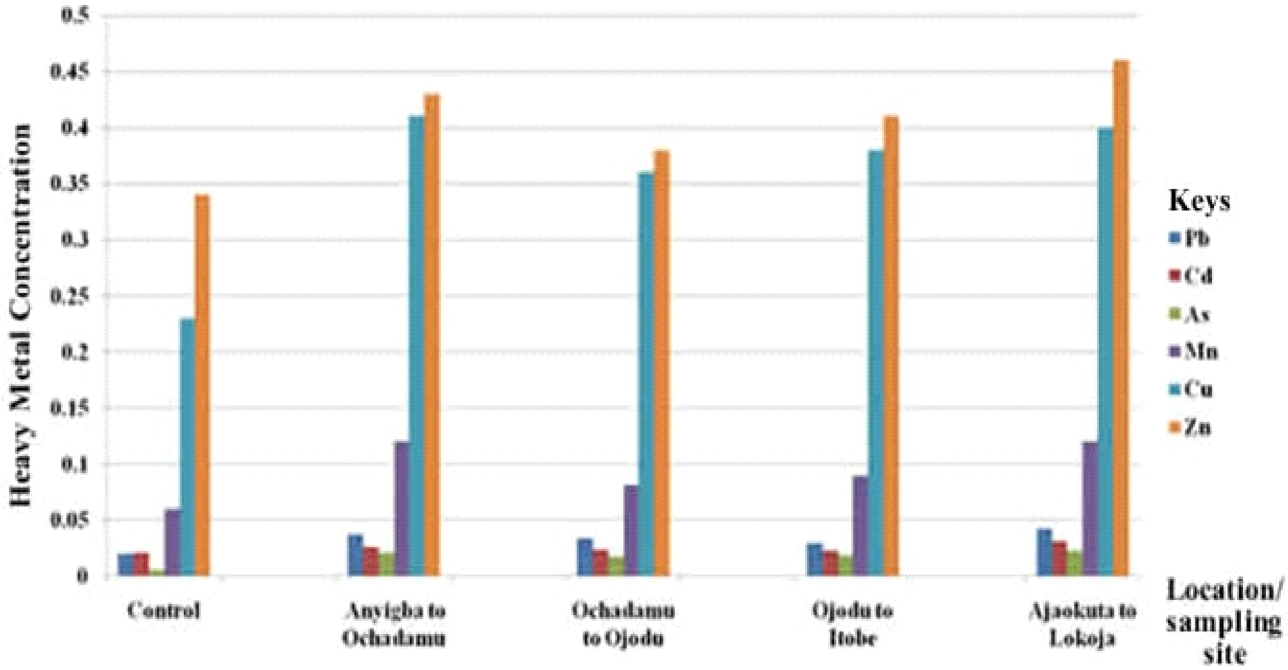

Figure 1: Concentration of heavy metals at different interval locations

Vegetation Discussion

Lead (Pb): The concentration of lead examined at different locations showed a range of 0.030-0.042mg/kg with a mean value of 0.036mg/kg, while the control site has 0.020mg/kg concentration level of Pb. When compared with the concentration level of Pb in EU and UK standard, Pb was found to be lower than the standard permissible limit of 300mg/kg and 70mg/kg. Automobile exhaust gas is one of the potential Pb contributors in urban areas with serious effects on human and the environment Fergusson *et al.,* 1991, Baker *et al.,* 1995. Pb uptake was found to occur in the root system as well as through the plant leaves Strbac et *al.*, 2016, Aksoy *et al.,* 1996. Lead is rapidly washed onto the soil by rain water from the surface also by the death and decomposition of the plant (Harrison et *al.,* 1981, Khattak *et al*., 2013).

Cadmium (Cd): The concentration of cadmium from different locations showed a range of 0.023-0.031mg/kg with a mean value of 0.026mg/kg, while the control site has Cd concentration of 0.021mg/kg. Cadmium was observed to be higher than the control, revealing the impact of Cd pollution in plant. However, the concentration of Cd from all the four different location were found to be lower than the standard permissible limit of 3.0mg/kg, and 1.4mg/kg set out by the EU and UK standards. High level of Cd might be due to the use of Cadmium- containing dusts. Cd is very much connected with non-residual fraction of heavy metal and this makes Cd mobile and potentially bio available for plant (Zhang, 2009). Although, there was a progressive increase of heavy metal in vegetation along Anyigba - Lokoja high way.

Arsenic (As):
The concentration of Arsenic recorded from different locations showed a range of 0.018-0.023mg/kg with a mean value of 0.020mg/kg, while the control site has 0.006mg/kg concentration level. The result shows that the concentration level of As is relatively very low compared to the other heavy metals in various samples. However, the concentration of Arsenic in the samples was found to be lower than the standard permissible limit of 20.0mg/kg and 12.0mg/kg set out by EU and UK standards. Although there was a progressive increase of heavy metal in vegetation along Anyigba - Lokoja high way.

Manganese (Mn): The concentration of Manganese recorded from different locations ranged from 0.081- 0.12mg/kg, while the control site has 0.06mg/kg concentration level. The concentration of manganese observed at the four location were found to be higher than that of the control site. However, the concentration of manganese recorded from the different locations were found to be very low when compared with that of the standard permissible limit of 1000 - 2000mg/kg set out by WHO. (WHO, 1982). Mn is a composition of soils in northern Nigeria, there availability in trace amount as obtained in this study could be due to local condition of soil weathering. Bait *et al.,* (2008). Unfavorable root environment may lead to low bioavailability of Mn.

Copper (Cu): The concentration of copper recorded from different locations ranged from 0.36- 0.41mg/kg with a mean value of 0.39mg/kg, while the control site has 0.23mg/kg concentration level. The concentration level of Cu in all samples were found to be lower than the standard permissible limit of 140.0mg/kg and 63mg/kg set out by the EU and UK standards. Although there was a progressive increase of heavy metal in vegetation along Anyigba - Lokoja high way, when compared to the control. The control (500m far away from highway) showed the least mean value.

Zinc (Zn): The concentration of Zinc in the four locations ranged from 0.38- 0.46mg/kg with a mean value of 0.42mg/kg, while the control site has 0.34mg/kg concentration level. The concentration of Zn recorded from all samples were below the permissible limits of 300mg/kg and 200mg/kg set out by the EU and UK standards. Zn is used in brake linings because of their heat conducting properties and as such released during mechanical abrasion of vehicles. Hjortenkrans (2003), Dolan *et al.,* (2006). The concentration may be as a result of the number of trucks and emissions that pass through these roads. Zn is the most concentrated in all the different interval locations among the selected heavy metals. The accumulation of Zn could be attributed to motor vehicle tyre rubber exacerbated by poor road surfaces and lubricating oils in which Zn is found as part of many addictive such as Di thiophosphates. (Davies, 1984; Hewitt and Candy, 1990). The concentration of Zn in the four locations were higher than the concentration of the control site (0.34mg/kg).

Conclusion

The result of this study revealed the presence of all the selected heavy metals (Pb, Cd, Mn, Zn and As) assessed in the soils and vegetation along the highway. The concentration of the heavy metals in the soils and vegetation are in order of Cu > Zn, > Mn,>Pb, > Cd, >As and As > Cd > Pd > Mn > Cu > Zn respectively.

The concentration of the heavy metals in soils and vegetation along the highway were observed to be within permissible limit of heavy metal in the soil according to the United Kingdom (UK) and European Union standard (EU). However, the contamination accumulation of heavy metals might pose hazard to human and animal health through bioaccumulation and bio-magnification as animals sometimes graze around the area. Hence, possible accumulation in the soil and transfer to plant growing along the edge of highway could occur as a result of continual usage of the road by automobiles. This can also lead to accumulation of heavy metals in the tissues of organism that feed on the plant growing along highways.

Recommendations

Consumption of food sold along roadside should be discouraged. Also, drying of edible food on tarred road in rural and urban community should be discouraged. Agricultural farms should not be close to highways to prevent building of heavy metals.

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