Available online at www.elixirpublishers.com (Elixir International Journal)

Environment and Forestry

Elixir Environ. & Forestry 110 (2017) 48162-48167

ISSN: 2229-712X

Effect of Traffic Density on Soil along Nwanga-Ekoi- Mfamosing Road Cross River State, Nigeria

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ARTICLE INFO

Article history:

Received: 07 August 2017;

Received in revised form: 31 August 2017;

Accepted: 8 September 2017;

Keywords

Road-Deposited Sediments,

Traffic Density,

Heavy Metals,

Soils.

ABSTRACT

The effect of traffic density on soil along Nwanga-Ekoi- Mfamosing road Cross River State, Nigeria, was carried out. The spatial variability of pollutant concentration in high traffic density areas exerts an importance influence on some road deposited sediment characteristics due to activities of people and vehicles. The movement of vehicles from one point to another may spread contaminants on the soil. The main processes of the movement of vehicles can spread contaminants on the soil which may include wearing of car parts (Exhaust pipes, tires, brakes, engines block, leaking of oil and corrosion metal parts). These processes may release heavy metals on the surface of the soil along roadsides. The heavy metals were analyzed using Atomic Absorption Spectrophotometry (AAS) and paired sampled T-test method were used for the statistical analysis of soil along High Traffic Density (HTD) and Low Traffic Density (LTD) sites. The results from AAS revealed that heavy metals concentration in HTD were Calcium 0.041, Copper 0.037, Iron 0.037, Manganese 0.086, Nickel 0.033, Lead 0.207 and Zinc 0.11 respectively. Heavy metals concentration in LTD were Calcium 0.007, Copper 0.008, Iron 0.007, Manganese 0.007, Nickel 0.005, Lead 0.003 and Zinc 0.003 respectively. The result for the ANOVA analysis shows significant difference of ($F=9.1$, $p<0.05$) between HTD sites and LTD sites. The paired sample t-test also indicates significant difference of ($t_6=2.9$, $p<0.05$).This implies that heavy metals concentration in HTD sites were higher than heavy metals concentration in LTD sites. Therefore, high traffic density sites increases soil heavy metals concentration along roadside.

Introduction

Road deposited sediment consist of both natural and anthropogenic particles. Natural particles derive primarily from soil minerals, while anthropogenic particles derive from road concentration materials, industrial inputs, vehicular maintenance and exhaust or atmospheric depositions (Obi et. al. 2013, 2014 & 2016). The special variability of pollutant concentrations, in high traffic density areas exerts an importance influence on some road deposited sediment characteristics due to activities of people and vehicles. Heavy metals enter the environment through human activities such as industrial production, mining and agriculture, transportation release high density heavy metals on the soil surface (You, et. al., 2015; Osang et. al. 2013, 2016; Ewona et. al. 2013, 2014 & 2016). Though, roadside heavy metals also come from metallic corrosion of vehicles (Napeotte & Day, 1998; Peterson & Batlay, 1992; Sutherland & Tolosa, 2002; Elik, 2003; Charlesworth, et. al., 20012). The heavy metals pollutants released by vehicles on the roadside include, Lead (Pb), Cadmium (Cd), Copper (Cu), and Zince (Zn) (Doland, et. al., 2006). These heavy metals are metallic elements that have relatively high density of $5g/m^3$ (Fergusson, 1990; Lars, 2003). Fluids leakages and corrosion of metals may release heavy metals during vehicular traffic (Ojar et. al. 2014; Pekene et. al. 2015).

The location of United Cement Industry (UNICEM), in Mfamosing Cross River State and other extractive industries have increased vehicular traffic along Nwanga-Ekoi - Mfamosing road. Vehicular traffic releases heavy metals on the soil which may lead to changes in the soil, particularly top soils and plants on the roadside. The movement of vehicles from one point to another may spread contaminants on the soil. The main processes vehicles can spread contaminants on the soil may include wear of cars, tires, brakes, engines, leaking of oil and corrosion. These processes may release heavy metals on the surface of the soil along roadsides (Egor et. al. 2016; Udoimuk et. al. 2014; Uquetan et. al. 2016).

Storm water runoff pollution results from washed off urban road deposited sediments during heavy rainfall (Sorme and Lagerkuist 2002), which is characterized by the occurrence of a number of pollutants such as suspended solids, heavy metals and hydrocarbons that originates from a wide range of non-point sources such as wet and dry deposition, vehicle exhausts (Egor et. al. 2016; Obi et. al. 2016; Osang et. al. 2013; Ushie et. al. 2014).

Several studies have been carried out on the effect of traffic density of heavy metals concentration on the soil (Largerwerff & Specht, 1970; Quinche, 1969; Rodriguez, 1982; Garcia & Millan, 1998; Zhang ,1999; Viard, 2004). Most of the earlier studies on the subject area have been conducted in developed Countries and urban areas in Nigeria.

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Few studies have been carried out in areas were industrial growth is still at the lowest ebb like Cross River State, which have a high traffic density because of the presence of quarries and cement company. However, there is currently paucity of quantitative data on the concentrations of pollutants on soil properties in the study areas from various land use. This study aim at examining vehicle and road wear, vehicle maintenance operators, accident and soil erosion (Yunker etal., 2002). Some studies have indicated that the chemical composition of road sediments vary with grain size, weather conditions, traffic density, industrial conditions, soil PH and the ratio of trace metals released in to the dissolved phase (Wang etal., 1998; Jiries etal., 2001; Sutherland 2003; Adachi and Tainosho, 2005; Osang et. al. 2013). Viklander 1998 reported that concentrations of heavy metals in roadside sediments vary considerably from city to city and the traffic density and this have direct impact on the quality and unique characteristic of the environmental variables and pollution profiling.

The aim of the study is to examine the concentration of heavy metals as a result of traffic density on soil along Nwanga-Ekoi-Mfamosing road in Cross River State, Nigeria.

Soils Particle Density

Particle density represents the average density of all the minerals composing the soil. For most soils, this value is very near 2.65 g/cm3 because quartz has a density of 2.65 g/cm3 and quartz is usually the dominant mineral (Osang et. al. 2013).

$$\partial = \frac{m}{v} \qquad (1)$$

m = Mass

v = Volume

∂ = Density

Study Location

Figure 1 and 2 is the representation of the study area showing Nwanga-Ekoi in Akpabuyo and Mfamosing-Aningeje in Akamkpa Local Government Area in Cross River State, Nigeria. Akpabuyo lies between longitude 8^0 25' and 8^0 40' E, latitude 4^0 45' and 5^0 10' N. Akamkpa lies between longitude 8^0 12' and 9^0 00'E, and latitude 5^0 00' and $5^0$48'N. The soils consist of high fine clay content with good moisture retention properties. Relative humidity ranged from 80 -100% and atmospheric pressure of 29 millibars, (CRBDA, 2002). The study areas fall along the humid semi-hot Equatorial climate in the world map. The temperatures are moderately high, 260 rainy days and rainfall of over 2000MA with a dual peak annual regime (NIMET, 2011).

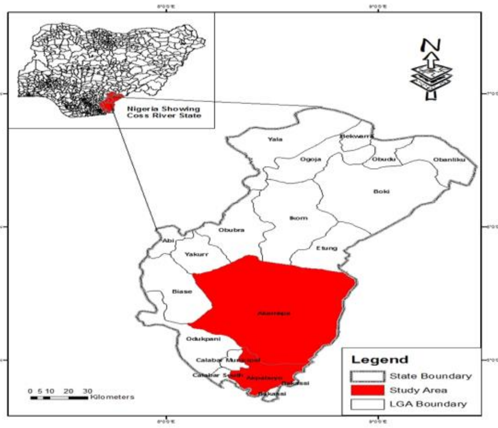

FIG. 1. Map Showing the Study Locations (Akpabuyo and Akamkpa Local Government Areas).

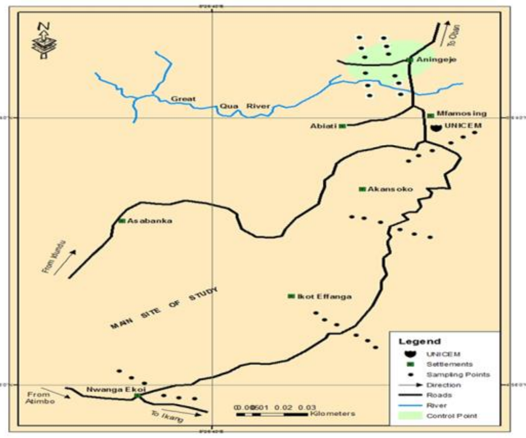

FIG. 2: Study Area showing sampling locations (Compiled from Map of Akamkpa and Akpabuyo LGA of Cross River State Nigeria 1994).

Materials and Methods

Sampling techniques

A systematic sampling technique was used for this study. Three distances were chosen at 20cm, 40cm, and 60cm interval on both sides of the road. Hence, at each location, six soil samples were collected, three on either side of the road. This was to allow for the determination of variation in heavy metal concentration away from the road and also to enable the researcher determine the effect of heavy vehicular traffic along the road on the soils in the study area. The soil samples were stored in self-sealing polyethylene bag, properly labeled and conveyed to the laboratory for analysis.

Laboratory procedure

The soil samples were grinded and sieved with 2mm sieve. The samples were dried in the oven at 90^0C for 24 hours. Samples were subjected to routine laboratory techniques and the process of digestion in order to extract the heavy metals from the soils samples. Atomic Absorption Spectrophotometry (AAS) was used to determine heavy metals concentration in the soil samples.

Data analysis

The SPSS paired sample t-test (IBM SPSS software version 22) was used to determine the difference between heavy metals concentration in the high and low traffic density roadside along Nwanga-Ekoi, Mfamosing and Aningeje in Cross River State, Nigeria.

Results and Discussion

The levels of heavy metals concentration in soils along high traffic density road sites vary from one point to another. The four locations comprise three different distances 20, 40 and 60cm from the sample point. In every 20cm from the road sides, soil samples were collected. In the first location, the mean concentration of calcium was 0.049, copper 0.046, iron 0.042, manganese 0.102, nickel 0.033, lead 0.309 and zinc 0.288mg/kg respectively. In the second location, the mean concentration of calcium was 0.030, copper 0.034, iron 0.035, manganese 0.041, nickel 0.032, lead 0.419 and zinc 0.044mg/kg respectively. The third location mean concentration of calcium was 0.034, copper 0.034, iron 0.039, manganese 0.049, nickel 0.028, lead 0.036 and zinc 0.037mg/kg respectively. The fourth location mean concentration of calcium was 0.048, copper 0.048, iron 0.032, manganese 0.153, nickel 0.038, lead 0.065 and zinc 0.073mg/kg respectively. The total average mean from the four locations in high traffic density road site ranged from calcium 0.041, copper 0.037, iron 0.037, manganese 0.086, nickel 0.033, lead 0.207 and zinc 0.11mg/kg respectively.

TABLE 1. Heavy metal concentration along High Traffic Density LTD Sites.

Distances (cm)	Concentrations of Heavy Metals in Soils Along High Traffic Density (HTD) (mg/kg)						
L1	Cadmium	Copper	Iron	Manganese	Nickel	Lead	Zinc
Sample point at 20	0.057	0.054	0.045	0.215	0.042	0.255	0.429
Sample point at 40	0.047	0.045	0.042	0.046	0.035	0.417	0.389
Sample point at 60	0.044	0.041	0.04	0.047	0.024	0.255	0.047
Mean	0.049	0.046	0.042	0.102	0.033	0.309	0.288
L2							
Sample point at 20	0.034	0.038	0.038	0.043	0.039	0.586	0.046
Sample point at 40	0.03	0.034	0.035	0.042	0.032	0.416	0.041
Sample point at 60	0.027	0.031	0.032	0.04	0.026	0.256	0.047
Mean	0.030	0.034	0.035	0.041	0.032	0.419	0.044
L3							
Sample point at 20	0.037	0.037	0.042	0.059	0.031	0.04	0.048
Sample point at 40	0.034	0.034	0.039	0.048	0.03	0.036	0.036
Sample point at 60	0.031	0.031	0.036	0.04	0.025	0.033	0.028
Mean	0.034	0.034	0.039	0.049	0.028	0.036	0.037
L4							
Sample point at 20	0.052	0.052	0.022	0.022	0.039	0.079	0.075
Sample point at 40	0.048	0.049	0.038	0.38	0.037	0.076	0.074
Sample point at 60	0.045	0.045	0.038	0.058	0.04	0.041	0.071
Mean	0.048	0.048	0.032	0.153	0.038	0.065	0.073
Total Mean Concentration	0.041	0.037	0.037	0.086	0.033	0.207	0.11

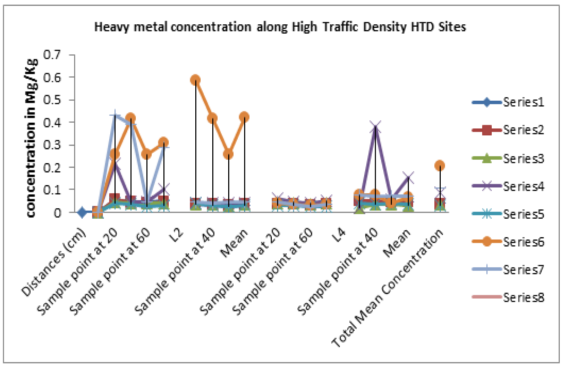

FIG. 3. Showing the trend of heavy metal concentration along High Traffic Density HTD Sites.

The levels of heavy metals concentration in soils along low traffic density road sites may vary from one point to another. The four locations comprise three different distances 20,40 and 60cm from the sample point. In every 20cm from the road sites soil samples were collected.

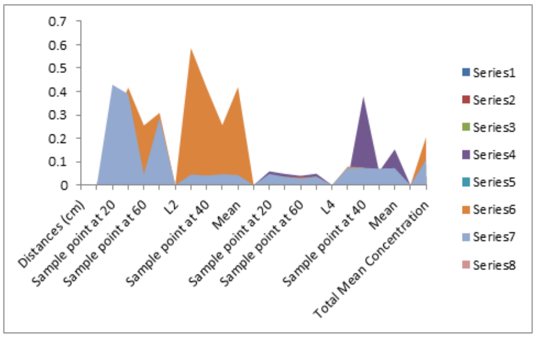

FIG. 4. Showing Area analyses of heavy metal concentration along High Traffic Density HTD Sites.

In the first location, the mean concentration of calcium was 0.009, copper 0.009, iron 0.013, manganese 0.01, nickel 0.011, lead 0.002 and zinc 0.007mg/kg respectively. In the second location, the mean concentration of calcium was 0.01, copper 0.005, iron 0.008, manganese 0.009, nickel 0.006, lead

TABLE 2. Heavy metal concentration along Low Traffic Density LTD Sites.

Distances (cm)	Concentrations of Heavy Metals in Soils Along Low Traffic Density (LTD) (mg/kg)						
L1	Cadmium	Copper	Iron	Manganese	Nickel	Lead	Zinc
Sample point at 20	0.009	0.009	0.013	0.01	0.011	0.0018	0.007
Sample point at 40	0.009	0.009	0.013	0.01	0.011	0.0018	0.007
Sample point at 60	0.009	0.009	0.013	0.01	0.011	0.0018	0.007
Mean	0.009	0.009	0.013	0.01	0.011	0.002	0.007
L2							
Sample point at 20	0.01	0.005	0.008	0.009	0.006	0.008	0.004
Sample point at 40	0.01	0.005	0.008	0.009	0.006	0.008	0.004
Sample point at 60	0.01	0.005	0.008	0.009	0.006	0.008	0.004
Mean	0.01	0.005	0.008	0.009	0.006	0.008	0.004
L3							
Sample point at 20	0.005	0.009	0.006	0.008	0.004	0.003	0.002
Sample point at 40	0.005	0.009	0.006	0.008	0.004	0.003	0.002
Sample point at 60	0.005	0.009	0.006	0.008	0.004	0.003	0.002
Mean	0.005	0.009	0.006	0.008	0.004	0.003	0.002
L4							
Sample point at 20	0.004	0.002	0.003	0.002	0.002	0.001	0.001
Sample point at 40	0.004	0.002	0.003	0.002	0.002	0.001	0.001
Sample point at 60	0.004	0.002	0.003	0.002	0.002	0.001	0.001
Mean	0.004	0.002	0.003	0.002	0.002	0.001	0.001
Total Mean concentration	0.007	0.008	0.007	0.007	0.005	0.003	0.003

0.008 and zinc 0.004mg/kg respectively. The third location mean concentration of calcium was 0.005, copper 0.009, iron 0.006, manganese 0.008, nickel 0.004, lead 0.003 and zinc 0.002mg/kg respectively. The fourth location mean concentration of calcium was 0.004, copper 0.002, iron 0.003, manganese 0.002, nickel 0.002, lead 0.001 and zinc 0.001mg/kg respectively. The total average mean from the four locations in low traffic density road site ranged from calcium 0.007, copper 0.008, iron 0.007, manganese 0.007, nickel 0.005, lead 0.003 and zinc 0.003mg/kg respectively.

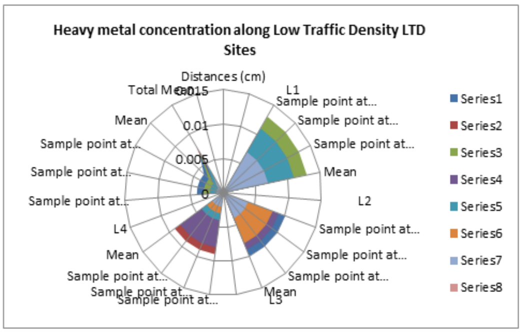

FIG. 5. Showing a Radar analyses of heavy metal concentration along Low Traffic Density LTD Sites.

Table 3 and Fig.6 is the representation of the mean concentration of heavy metals along HTD and LTD sites. Heavy metals concentration in HTD sites were calcium 0.041, copper 0.037, iron 0.037, manganese 0.086, nickel 0.033, lead 0.207 and zinc 0.11 respectively. Heavy metals concentration in LTD sites were calcium 0.007, copper 0.008, iron 0.007, manganese 0.007, nickel 0.005, lead 0.003 and zinc 0.003 respectively.

TABLE 3. Mean Concentrations of Heavy Metals along HTD and LTD Sites.

Concentration of H/M (mg/kg)	HTD	LTD
Cadmium	0.041	0.007
Copper	0.037	0.008
Iron	0.037	0.007
Manganese	0.086	0.007
Nickel	0.033	0.005
Lead	0.207	0.003
Zinc	0.11	0.003

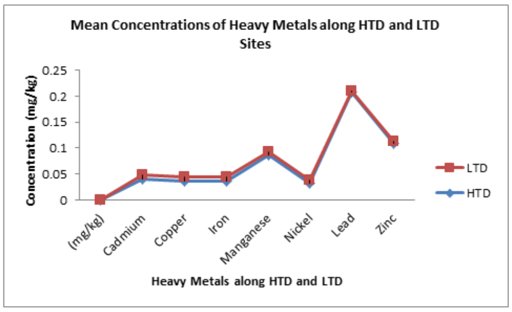

FIG. 6. Analyses of Mean Concentrations of Heavy Metals along HTD and LTD Sites .

Table 4 presents the results of the ANOVA analysis. The result shows significant difference of (F=9.1, p<0.05) on HTD sites and LTD sites. Table 5 represent the results of the paired sample t-test which indicates significant difference of (t_6=2.9, p<0.05). This implies that, heavy metals concentration in HTD sites were higher than heavy metals concentration in LTD sites. Therefore, high traffic density sites increases soil heavy metals concentration along roadside.

Table 4.The ANOVA Analysis of the Concentrations of Heavy Metals along HTD and LTD sites.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.019	1	.019	9.133	.011
Within Groups	.025	12	.002		
Total	.043	13			

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Table 5. The Paired Samples T-Test Analysis of the Concentrations of Heavy Metals along HTD and LTD sites.

	Paired Difference					t	df	Sig. (2 tailed)
	Mean	Std.Deviation	Std.Error	95% Confidence interval of the difference				
				Lower	Upper			
Pair 1 HTD-LTD	.07300	.06543	.02473	.01249	.13351	2.952	6	.026

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