Journal of Environment and Earth Science www.iiste.org
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol 2, No.8, 2012

Heavy Metals Concentrations in Roadside Dust of Different Traffic Density

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Abstract
This study investigated effect of vehicular emission on heavy metals levels along selected roads of different traffic densities in Abeokuta, Nigeria. Roadside dusts were randomly collected from both sides of the roads and digested. The digested sample solutions were then analyzed using Atomic Absorption Spectrophotometer (AAS) for the determination of Pb, Cd, Zn and Ni concentrations. Replicate analyses were carried out on each sample. Data were subjected to descriptive statistics and analysis of variance. Means were separated using Duncan's Multiple Range (DMR) test. Pearson's correlation coefficient was used to determine the relationship between the metals. The mean concentrations of the metals were found to follow the decreasing order: Pb > Zn > Ni > Cd. The road with significantly ($P < 0.05$) higher traffic density had significantly ($P < 0.05$) higher levels of the metals investigated. There was significant ($p < 0.05$) positive correlation between the metals.
Key words: Heavy metals, Roadside, Dust, Traffic density

1. Introduction

Pollution is the introduction into the environment substances or energy liable to cause hazards to human health, harm to living organisms and ecological system, damage to structure or amenity of interference with legitimate uses of the environment by man (Holdgate, 1979). Pollution has increased considerably in recent years as a result of increasing human activities such as burning of fossil fuels, industrial and automobile exhaust emissions. Nigeria crude oil is known to have about 0.003 – 42.31mg/kg of transition metals such as V, Cr, Mn, Fe, Co, Ni and Cu (Nwachukwu *et al*., 1995) some of which can not be completely removed during the crude refining processes and can therefore readily be emitted during combustion. Man, animals, vegetation, dust and soil act as 'sinks' for atmospheric pollutants (Osibanjo and Ajayi, 1980; Ogunsola *et al*., 1994; Bada *et al*., 2001). Metals in dust/smoke emitted by vehicles can enter the human food chain through the milk and meat of the animals fed on plants (Cannon and Bowels, 1962). Several studies have shown that metals such as Pb, Cd, Ni, amongst others, are responsible for certain diseases that have effects on man (especially children and street traders who spend up to 10 h daily selling their goods along the streets) and animals (Giddings, 1973; Gustav, 1974). Work has been done on the heavy metal content of roadside soil and vegetation in Ile-Ife, Osun State (Bada *et al*., 2001) and on the metals content of roadside dusts in Lagos, Nigeria (Ogunsola *et al*., 1994). But much work has not been done on the heavy metal content of soil/ vegetation/dusts along roadside in Abeokuta, Nigeria. Abeokuta as a state capital of Ogun State has been experiencing an increase in both population and traffic density. This is evidenced by the continued expansion of central business district, residential areas and traffic congestion at peak hours. However, information on roadside dust contamination with heavy metals in relation to vehicular emission in Abeokuta is limited and the attempt to bridge this gap formed the thrust of this study. This information is required to put in place appropriate land use and management strategy that will enhance sustainable development. Therefore, the objective was to investigate effect of traffic densities on heavy metal accumulation in roadsides dust.

2. Materials and Methods

2.1 Study area

Abeokuta lies within latitudes 6^0 N to 8^0 N and longitudes 2^0 30' E and 5^0 E in Southwestern Nigeria. Abeokuta contains few but emerging industries, many commercial centers and schools of various levels of learning, hospitals and residential buildings. The main occupation of people in the town is civil service. Other occupations are farming, local textile (tie and dye), trading and pottery .The study was carried out in two commercial roads (Sapon and Omida) and two residential roads (Ibara and Asero Housing Estate) as shown in Figure 1 and their traffic counts were carried out. However, no industrial activity is apparent near the vicinity of the sampling location.

2.2 Traffic counts

This study was carried out in two commercial roads (Sapon and Omida) and two residential roads (Ibara and Asero Housing Estate) and their traffic counts were carried out from 7 a. m to 7 p. m for seven consecutive days. Traffic density per hour was then calculated.

$$\text{Average traffic density per day} = \frac{\text{Total traffic density for seven days}}{7}$$

$$\text{Traffic density per hour} = \frac{\text{Traffic density per day}}{24}$$

2.3 Sample collection

Dust samples were randomly collected from both sides of the road by sweeping roadsides with a plastic brush into a plastic waste packer and kept in well sealed polythene sample bags for analysis. However, no industrial activity is apparent near the vicinity of the sampling location.

2.4 Chemical analysis

Dust samples were dried for 24 h at a temperature of 100 ^{0}C and sieved through 100 (0.1 mm) nylon mesh. In addition, 0.5 g of the fractionated dust samples was digested by adding 10 ml 65 % HNO_3 and 2 ml concentrated HF. This was heated to dryness on a water bath. Then 10 ml of 1 % HNO_3 was added and heated to boiling and the solution allowed to cool to room temperature and finally made up to 50 ml (Ogunsola *et al*., 1994). The digested sample solutions were then analysed for the heavy metals using Atomic Absorption Spectrophotometer (AAS, Varian Spectr AA-400 plus, Varian Techtron Pty limited Mulgrave, Victoria, Australia). Replicate analyses were carried out on each sample.

2.5 Statistical analysis

The data obtained were subjected to descriptive statistics and analysis of variance. Means were separated using Duncan's Multiple Range (DMR) test. Pearson's correlation coefficient was used to determine the relationship between the metals.

3. Results

Commercial roads (Sapon and Omida) had higher traffic density than residential roads (Ibara and Asero). Sapon road had the highest traffic density of 2,500 vehicles / hour followed by Omida, Ibara and Asero road with traffic densities of 1,400, 500 and 300 vehicles / hour respectively (Figure 2). The results of the heavy metals concentrations as determined by AAS were presented in Table1. It was observed that of all the four metals, Pb had the highest concentration followed by Zn, Ni and Cd. This trend was observed for all the four roads. The higher the traffic density the more was the concentration of the metals investigated (Table 1). Sapon road which had the highest traffic density also had the highest concentrations of Pb, Zn, Cd and Ni. This was followed by Omida, Ibara and Asero respectively. Commercial roads (Sapon and Omida) had significantly ($p < 0.05$) higher Pb concentration than the residential roads (Ibara and Asero). In order to establish inter-metal relationships in the samples, correlation coefficient of the metals at the four sampling roads was carried out (Table 2). There was significant ($p < 0.05$) positive correlation among the four metals investigated. The positive relation among the four metals indicated that they are from the same source. The level of heavy metals in this study, Abeokuta, Ogun State was compared with the work carried about in Osun and Lagos States (Table 3). Pb concentration in Abeokuta, Ogun Sate (this study) was higher than that of Osun State but lower than that of Lagos State. Lagos State had higher concentrations of heavy metals investigated followed by Ogun State (this study) and Osun State

4. Discussion

Commercial roads (Sapon and Omida) had higher traffic density compared to the residential roads (Ibara and Asero). This might be due to the commercial activities in Sapon and Omida most especially from 7 a.m. to 7 p.m. when buying and selling activities are going on. Besides, the two roads (Sapon and Omida) serve as link road to different places in Abeokuta. Roadsides dusts of the four roads had highest concentrations of Pb, followed by Zn, Ni and Cd. Motor vehicles introduce a number of toxic metals into the atmosphere adjacent to roadways (Moore and Moore, 1976; Ogunsola *et al*., 1994; Bada *et al*., 2001). The metals are considered to arise from motor vehicle tyre wear and motor vehicle emissions (Lagerwerff and Specht, 1970); both account for 80 % of the air pollution problems in urban areas of Southwestern Nigeria (Osibanjo and Ajayi, 1980). Sapon with highest traffic density had highest concentration of the heavy metal investigated followed by Omida, Ibara and Asero. Elevated metal concentration in street soil of industrialized and /or populated cities resulted from increased automobile circulation (Smith, 1976; Ho, 1979). As in this study, elevated concentrations of Pb, Cd, Ni, V and Zn in roadside soil and vegetation were reported by Bada *et al*. (2001) to vary with traffic densities. Levels of heavy metals in bark and fruit of trees along roads in Nigeria vary according to traffic volume (Ademoroti, 1986). The concentration of Pb and, to some extent, a few other toxic elements are strongly correlated with traffic density (Ogunsola *et al*., 1994). Significant positive correlation was observed between the heavy metals investigated. The positive correlation among the four metals indicated that they are from the same source. Zn and Ni in street soils and dusts emanate from vehicle parts and wear including wear and tear of tyres (Lagerwerff and Specht, 1970). The higher concentration of heavy metals observed in Lagos State compared to Ogun and Osun States might be due to the variation in traffic density.

5. Conclusion

Commercial centre roads with the highest traffic density had the highest concentrations of the heavy metals investigated while residential area road with the least traffic density also had the least heavy metals. There was positive correlation among the heavy metals investigated.

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Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol 2, No.8, 2012

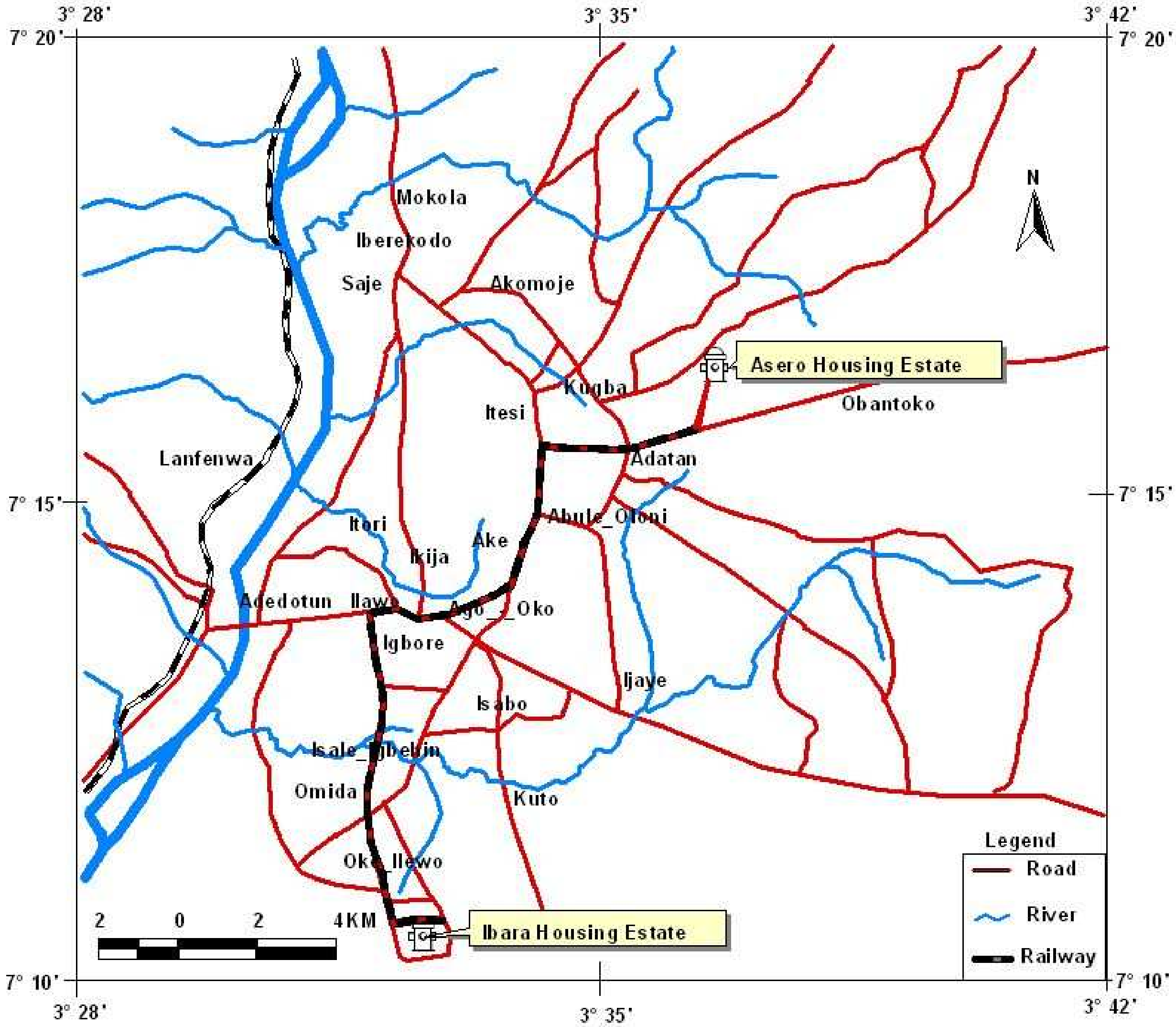

Figure 1: Map of the study area

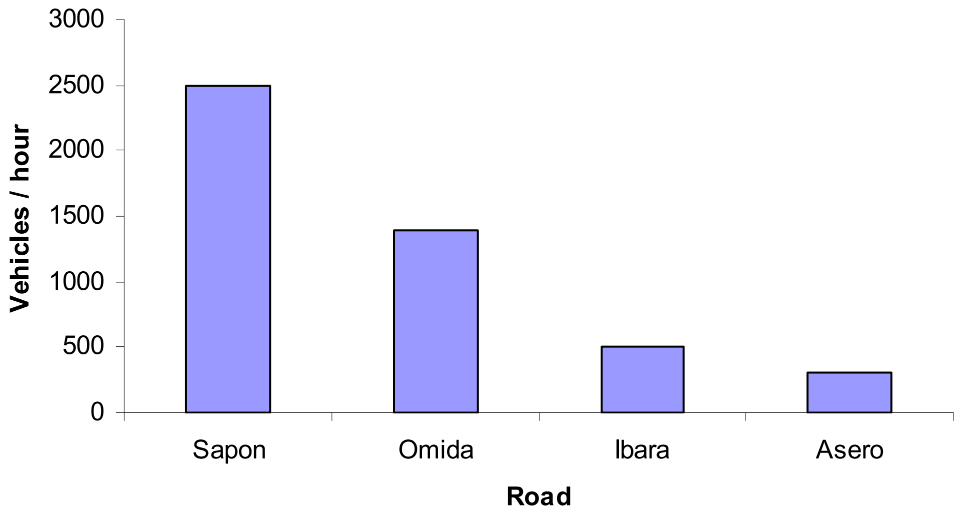

Figure 2: Traffic densities of selected roads

Table 1: Heavy metals concentrations (mg/kg) in roadsides dust

Location	**Pb**	**Ni**	**Zn**	**Cd**
Sapon	216.83a	3.39a	18.84a	1.29a
Omida	193.33ab	3.29a	14.51b	1.28a
Ibara	173.73bc	2.92ab	13.17b	0.99ab
Asero	156.08c	2.26b	12.72b	0.52b

Means in the same column followed by the same letter are not significantly different at $P < 0.05$

Table 2: Correlation coefficients of the heavy metals

	Pb	**Ni**	**Zn**	**Cd**
Pb	1.000			
Ni	$0.926^{\times}$	1.000		
Zn	$0.936^{\times}$	0.738	1.000	
Cd	$0.903^{\times}$	$0.998^{\times\times}$	0.695	1.000

* Correlation is significant at the 0.05 level

** Correlation is significant at the 0.01 level

Table 3: Comparison of heavy metals concentrations (mg/kg) in roadside dust of this study (Ogun State) with similar work in Lagos and Osun States, Nigeria.

Heavy metals	**Lagos State, Nigeria**		**This study (Ogun State, Nigeria)**		**Osun State, Nigeria**	
	Highway	**Residential**	**Commercial**	**Residential**	**HTD**	**LTD**
Pb	640.60	172.20	280.40	200.00	272.17	86.47
Zn	150.62	89.72	32.00	24.00	165.04	13.36
Ni	11.59	11.22	4.10	3.70	5.05	2.27
Cd	0.72	0.70	2.10	0.80	2.09	1.20
TD (vehicle/hour)	10,000	2,000	2,500	500	447	113

HTD: High Traffic Density

LTD: Low Traffic Density

TD: Traffic Density

Lagos State (Ogunsola *et al*., 1994)

Osun State (Bada *et al*., 2001)