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Environmental Pollution from Road Transport System in Ogbomosoland, Southwestern Nigeria

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ABSTRACT

Environmental pollutions from road transport system in Nigeria poses serious health hazards to the ecosystem because of presence of heavy metals and other pollutants. There are researches on assessment of heavy metals contamination of road side soils but most of them investigated the concentration of the heavy metals at the edge of the road pavements but did not considered the concentration at various distances away from the edge of the road pavement. This research therefore focussed on the investigation of the concentration of the contaminants at the edge of the road and at various distances away from the road pavement. A total of 225 soil samples were collected at three sampling depths (0, 10 and 20cm) using three sampling distances of 0.2, 1.5 and 3.0m from Federal, State and Local roads. The soil samples were digested using perchloric acid and trioxonitrate (v) acid and the resulting filterate was analysed using Atomic absorption spectrophotometer for concentrations of Lead (Pb), Copper (Cu), Zinc (Zn), Nickel (Ni) and Cadmium (Cd) at each road. The heavy metals concentration at depth 0cm and distance 0.2m show that the Federal roads had the highest mean concentration of 154.67, 49.43, 124.71, 27.40 and 2.19µg/g for Pb, Cu, Zn, Ni and Cd respectively and the least being Local roads (110.60, 35.57, 104.26, 23.99 and 1.12µg/g). The mean heavy metals concentrations decreased with increasing soil depths and sampling distance for Federal, State and Local roads. Some of the heavy metals concentrations were above the permissible limit (Canadian Council of Ministers of the Environment, 2004). The study revealed that there are heavy metals in the road-side soils and concentrations for some of the roads were found to be above the permissible limits and this possesses serious health challenges to people around the neighbourhood. The concentrations also decreased with increasing sampling depth and distance for all the roads.

Keywords: Environmental Pollution, Heavy metals, Road-side Soils, Sampling depth and distance

1.0 Introduction

Road transport is one of the major means of conveying goods and services from one origin to another destination in Nigeria. This system has provided a great comfort to human beings and improved efficiency in term of delivery of goods and services. In fact, the national economy of every country mostly relies on the efficiency of this system. Likewise, local economy relies on transport links to the national network. Improved transport links are therefore essential if a country is to continue to develop and prosper. However, as good as the transport system is, it has significant negative impacts, such as road traffic accidents, environmental pollution, traffic congestion, nuisance and so on (Figueroa et al, 2005). The pollution from road transport has been found to contribute to climate change, which is a serious global problem that requires urgent attention (Ajayi and Dosunmu, 2002).

The environmental pollutions from road transport can be in form of air, soil, noise and water pollutions. The soil contains natural trace of heavy metals, which are beneficiary to plant, animal and human but are harmful when they are at elevated concentrations in the soil. The high concentration have been found from anthropogenic sources such as agricultural pesticides, waste disposal, industrial activities and emission from automobile parts and exhaust (Onianwa *et al*, 2001). The common heavy metal pollutants from automobiles are Lead, Zinc, Copper, Nickel and Cadmium. They are released during processes such as fuel combustion (petrol and diesel), component wears (tyres, brakes and body parts), fluid leakages (brake, power steering, clutch fluids), radiators, batteries and so on (Akar *et al*, 2006). It was reported in 1994 that approximately 28,390 tons of Pb was emitted in the atmosphere, with a contribution of 70% from road transport at the vicinity of highways in part of former Soviet Union (Han *et al*, 2009).

Several researches have been conducted on heavy metals contamination of roadside soils and vicinities of other automobile related activities (Day *et al*, 1975; Olsen and Skogerboe, 1975; Harrison, 1979; and Harrison, 1980; Farmer and Lyon, 1977; Duggan and Williams, 1977; Solomon and Hartford, 1976; Day, 1977, Olajire and Ayodele, 1997; Li et al, 2001; Liu et al, 2002, Uwagboe and Hymore, 2001, Onianwa et al, 2001, Amusan *et al,* 2003, Fakayode and Olu-Owolabi, 2003, Akbar et al, 2006). Most of the researches were conducted in urban areas of developed and developing countries of the world and less has been done on underdeveloped town like Ogbomoso. Also, in most of the researches, soil samples were only collected either from the top soils or at the edge of the road pavements except Fakayode and Olu-Owolabi, 2003 that considered the variation of the heavy metals concentration in relation to the distance from the road pavement. Therefore, the present research was undertaken in order to investigate the level of heavy metals contamination of roadside soils by automobile along Federal, State and Local roads in Ogbomosoland, Nigeria and the variation of the concentration of the heavy metals at various distances from the edge of the road considering the proximity of residential and commercial buildings to the roads within the study area.

2.0 Materials and Methods

2.1 Description of the study area

The study area comprises five local government areas in Oyo State. The local governments are Ogbomoso North, Ogbomoso South, Surulere, Ogo Oluwa, and Orire. The headquarters of the local government areas are located at Kinnira, Sun-sun, Iresadu, Ajaawa and Ikoyi-Ile respectively. The five local government areas formed what is called Ogbomosoland. The study area is bounded by Kwara State in the east, Osun State in the south, Atiba local government in the west and Olorunsogo local government in the north as shown in Figure 1. The land area of the study location is about 6,100km^2. The distance of the study area from notable cities in Western Nigeria is 104km North East of Ibadan, 57km South West of Ilorin and 58km North West of Osogbo, Southwestern Nigeria. It lies between longitude 4^0 00' and 4^0 15' east of the meridian and latitude 8^0 00' and 8^0 08' north of the equator.

The climate in Ogbomosoland is characterized by two distinct seasons, namely: dry and rainy seasons. The dry season is between late October and early April while the wet season starts in April and ends in early October while the rainy season is bimodal in nature with the heaviest rains falling from April to July and a weaker rainy season in October. In August, there is always a brief relative dry season, called “August break”. In the dry season, from December to February, the flow of the north-east trade wind from the Sahara Desert across the study area brings along Harmattan; a dry, dusty wind. The maximum and minimum temperature is 33 and 28^{o}C respectively (Olaniyi and Akanbi, 2008). Most of the roads within the study location are single carriageway, two-lane. The width of most of them is about 7.3m excluding the shoulder. The major means of transportation is through motorcycles, commercial cars (taxis) and private cars. There are some buses for intra-city transit and trucks for conveying goods and services. Most of the commercial vehicles are not properly maintained.

2.2 Collection and preparation of soil samples

Soils samples were collected within the study area from roadsides. At each sampling point, soil samples were collected at depths of 0cm, 10cm and 20cm and at distances of 0.2m, 1.5m and 3.0m from the edge of the road pavement, using a stainless-steel trowel and they were stored in plastic bags. The samples collected above were air dried for 3 days. The dried samples were sieved using a 2mm plastic sieve to remove gravel – sized materials and dead woods. It was homogenized with mortar and pestle.

2.3 Digestion and analysis of sample

Wet digestion method was used in which a small portion of the dried sample, about 0.5g was weighed, placed in clean digestion flask and placed on heating block inside fume cupboard. Before heating, 15ml of concentrated trioxonitrate V acid (HNO_3) and 5ml of Perchloric acid ($HClO_4$) was added to the sample in the flask, the solution was then heated up for about one-hour. When the solution was nearing dryness, another acid was added in ratio 3:1 and heated up until the solution became colourless. The solution was allowed to cool for about 15 minutes at room temperature. The solution was then filtered using Whatman No 1 filter paper to remove the soil residue. The filtrate was then made up to a volume of 100ml, using deionized water. The solution was transferred into sample bottle for heavy metal analysis. The procedure was repeated for all the samples.

The concentration of heavy metals in the samples were analysed using Atomic Absorption Spectrophotometer (AAS), Buck Scientific model 210 VGP at the Ladoke Akintola University of Technology, Ogbomoso Central Research Laboratory. The following heavy metals were analysed; Lead (Pb), Zinc (Zn), Copper (Cu), Cadmium (Cd) and Nickel (Ni).

3.0 Results and Discussion

The results of the laboratory analyses conducted on the digested soil samples in order to determine the concentration of heavy metals in the soil, show that the concentration of Pb, Zn, Cu, Ni and Cd range from 9.1 to 253 µg/g, 6.4 to 215 µg/g, 1.08 to 88µg/g, 0.32 to 88.7 µg/g, and 0 to 3.99 µg/g respectively. The Tables 1 to 9 show that the concentration gradient of the heavy metals in roadside soil was in order Pb>Zn>Cu>Ni>Cd and this order is consistent with findings at motor-parks and along the road side in Ibadan (Onianwa et al.,2001 and Olajire and Ayodele,1997).

The metals can be from various sources apart from automobiles but in this study, it is highly suspected to be from automobile because there are no industries within the study location. Therefore, the Pb can be from leaded gasoline although it has been banned but there are reliable pieces of information that some of the imported gasoline that escaped Government scrutinizing still contain some amount of Lead. It can also come from bearing wear, lubricating oil, batteries and so on. The Zn is suspected to be from the use of Zincoxide and Zinc diethyl or dimethyl Carbonate in vulcanization of motor tyre (Largerwerff and Specht, 1970). The Zn can also be from lubricating motor oil, tire wear, brake emissions and corrosion of galvanised parts. The Cu can be from engine parts, bearing wear and brake emission. Ni can be from diesel fuel and gasoline, lubricating oil and brake emission. The Cd can be from fuel burning, tyre wear and batteries.

All these metals have been found to be hazardous to human, animals and plants. They have a lot of far reaching implications, such as, neurological impairment in children, hypertension in adults, abortion and potential damage to fetus in pregnant women, affect some organs such as kidney and liver, Itai-itai byo (Lumbago pain) and so on.

A comparison of the concentration of the heavy metals in the road side soils with Canadian Soil Quality for protection of environmental and Human Health (CCME,2004) revealed that the concentration of the heavy metals were below the permissible limits in the environment with the exceptions of some few locations which are above these limits. Those soil samples with the high concentration of the heavy metals pose serious environmental threat to human, animals and plants around the area and therefore require closer monitoring and some remediation and preventive programme.

Table 1: Descriptive Statistic of Heavy Metal Concentration (μg/g) in Roadside Soil along Federal Roads at Sampling distance of 0.2m

Sampling depth (m)	*Paramter*	*Pb*	*Cu*	*Zn*	*Ni*	*Cd*
0	Mean ± SD	154.67 ± 118.56	49.43 ± 15.21	124.71 ± 37.54	27.40 ± 8.04	2.19 ± 1.32
	Range	19.2-397.00	28.4-74.00	65.4-171	16.2-38.2	0.0-3.99
10	Mean ± SD	121.65 ± 92.79	32.95 ± 9.04	83.22 ± 27.82	18.9 ± 4.53	1.29 ± 0.90
	Range	36.7-325	17.8-46.9	39.2-126	12.7-24.7	0.0-2.4
20	Mean ± SD	75.16 ± 50.11	22.81 ± 8.27	52.41 ± 28.32	12.55 ± 3.10	0.83 ± 0.84
	Range	24.3-173	12.9-36.0	18.5-105	8.6-16.1	0.0-2.2

Table 2: Descriptive Statistic of Heavy Metal Concentration (μg/g) in Roadside Soil along Federal Roads at Sampling distance of 1.5m

Sampling depth (m)	*Paramter*	*Pb*	*Cu*	*Zn*	*Ni*	*Cd*
0	Mean ± SD	115.03 ± 72.84	33.28 ± 11.00	85.6 ± 35.66	19.14 ± 3.99	1.08 ± 0.68
	Range	44.0-268	16.8-53.8	39-132	13.9-25.4	0.11-2.27
10	Mean ± SD	65.13 ± 27.11	25.45 ± 12.89	59.13 ± 29.93	12.97 ± 3.99	0.38 ± 0.54
	Range	26.8-116	9.76-47.6	24.3-101	7.2-17.8	0.0-1.21
20	Mean ± SD	40.64 ± 17.88	27.62 ± 27.40	42.9 ± 22.29	12.79 ± 3.70	0.36 ± 0.50
	Range	17.6-72	6.23-88.0	15.1-78	4.8-17.2	0.0-1.1

Table 3: Descriptive Statistic of Heavy Metal Concentration (μg/g) in Roadside Soil along Federal Roads at Sampling distance of 3.0m

Sampling depth (m)	*Parameter*	*Pb*	*Cu*	*Zn*	*Ni*	*Cd*
0	Mean ± SD	73.56 ± 71	27.5 ± 12.95	51.23 ± 17.71	13.06 ± 3.77	0.46 ± 0.46
	Range	13.3-241	10.6-49.3	29.8-76.2	9.21-18.8	0-1.08
10	Mean ± SD	64.25 ± 63.23	20.12 ± 13.05	34.63 ± 13.33	10.78 ± 5.68	0.12 ± 0.25
	Range	17.3-216	6.42-48.7	18.8-54.6	5.5-22.6	0-0.71
20	Mean ± SD	33.1 ± 16.92	13.89 ± 8.31	25.99 ± 12.46	6.63 ± 4.52	0.13 ± 0.28
	Range	11.8-64.6	4.19-30.4	12.3-49.3	2.3-15.2	0.0-0.8

Table 4: Descriptive Statistic of Heavy Metal Concentration (μg/g) in Roadside Soil along State Roads at Sampling distance of 0.2m

Sampling depth (m)	*Parameter*	*Pb*	*Cu*	*Zn*	*Ni*	*Cd*
0	Mean ± SD	138.2 ± 21.25	45.44 ± 7.54	150.4 ± 42.48	23.83 ± 3.07	2.22 ± 1.51
	Range	117-167	34-53.6	107-215	20.7-27.2	0-3.99
10	Mean ± SD	90.0 ± 22.75	27.94 ± 5.38	103.68 ± 36.81	16.02 ± 3.27	1.00 ± 0.91
	Range	67.5-121	19.8-33.1	64.9-152	12.5-19.2	0.0-1.92
20	Mean ± SD	61.54 ± 15.91	22.32 ± 6.29	67.34 ± 21.43	9.36 ± 1.88	0.30 ± 0.61
	Range	47.3-81.8	14.6-31.2	48.4-96.3	7.4-12.3	0.0-1.4

Table 5: Descriptive Statistic of Heavy Metal Concentration (μg/g) in Roadside Soil along State Roads at Sampling distance of 1.5m

Sampling depth (m)	*Parameter*	*Pb*	*Cu*	*Zn*	*Ni*	*Cd*
0	Mean ± SD	95.62 ± 21.42	28.82 ± 5.13	99.88 ± 29.93	16.96 ± 2.34	0.74 ± 0.93
	Range	79-128	23.8-37.5	69.4-138	14.5-19.6	0-1.9
10	Mean ± SD	62.42 ± 17.62	20.12 ± 6.70	70.2 ± 29.35	11.36 ± 2.26	0.314 ± 0.52
	Range	49.1-92.1	16.3-32.0	44.6-116.0	9.1-14.3	0.0-1.2
20	Mean ± SD	48.7 ± 20.52	11.94 ± 1.96	45.8 ± 22.21	10.66 ± 8.87	0.46 ± 0.55
	Range	32.1-83.6	9.6-14.6	27.1-79.0	5.3-26.4	0.0-1.3

Table 6: Descriptive Statistic of Heavy Metal Concentration (μg/g) in Roadside Soil along State Roads at Sampling distance of 3.0m

Sampling depth (m)	*Parameter*	*Pb*	*Cu*	*Zn*	*Ni*	*Cd*
0	Mean ± SD	60.66 ± 12.90	20.62 ± 4.88	67.38 ± 22.91	9.57 ± 6.54	0.22 ± 0.44
	Range	48-82	15.6-28.44	43.3-96.5	0.32-18.1	0-1.01
10	Mean ± SD	45.04 ± 23.25	13.04 ± 2.48	44.36 ± 29.89	8.27 ± 5.30	0.15 ± 0.34
	Range	29.6-86.0	9.9-16.8	9.3-87.0	3.9-17.2	0.0-0.77
20	Mean ± SD	26.64 ± 12.11	10.58 ± 4.47	33.4 ± 17.84	5.26 ± 4.07	0.05 ± 0.09
	Range	14.8-45.7	7.1-17.6	17.2-62.3	2.1-12	0.0-0.21

Table 7: Descriptive Statistic of Heavy Metal Concentration (µg/g) in Roadside Soil along Local Roads at Sampling distance of 0.2m

Sampling depth (m)	*Parameter*	*Pb*	*Cu*	*Zn*	*Ni*	*Cd*
0	Mean ± SD	110.6 ± 28.66	35.57 ± 17.0	104.26 ± 31.84	23.99 ± 6.98	1.12 ± 1.38
	Range	76-162	15.25-74.0	64-163	14.7-37.0	0-3.61
10	Mean ± SD	70.98 ± 19.47	23.68 ± 11.49	64.33 ± 19.83	13.81 ± 3.86	0.26 ± 0.64
	Range	43.2-105	9.2-51.8	41.5-108	8.2-19.9	0.0-2.2
20	Mean ± SD	46.52 ± 11.84	15.53 ± 8.59	40.33 ± 14.77	15.7 ± 23.14	0.34 ± 0.56
	Range	32.2-68.3	6.0-36.3	12-67.8	6-88.7	0.0-1.42

Table 8: Descriptive Statistic of Heavy Metal Concentration (µg/g) in Roadside Soil along Local Roads at Sampling distance of 1.5m

Sampling depth (m)	*Parameter*	*Pb*	*Cu*	*Zn*	*Ni*	*Cd*
0	Mean ± SD	67.86 ± 20.73	24.03 ± 13.07	67.54 ± 27.79	14.4 ± 4.68	0.61 ± 0.81
	Range	37.8-107	8.21-53	24.1-105	6.9-22.4	0- 2.31
10	Mean ± SD	45.94 ± 13.24	16.59 ± 9.09	45.65 ± 18.72	9.33 ± 2.86	0.22 ± 0.412
	Range	28.1-71.8	5.7-37.1	19.6-73.5	5.3-15.68	0.0-1.13
20	Mean ± SD	30.09 ± 10.14	10.57 ± 6.24	30.37 ± 11.96	5.96 ± 2.21	0.18 ± 0.27
	Range	12.7- 43.4	3.9-24.9	13-46.5	2.9-9.9	0.0-0.9

Table 9: Descriptive Statistic of Heavy Metal Concentration (µg/g) in Roadside Soil along Local Roads at Sampling distance of 3.0m

Sampling depth (m)	*Parameter*	*Pb*	*Cu*	*Zn*	*Ni*	*Cd*
0	Mean ± SD	41.47 ± 17.49	16.20 ± 7.65	45.8 ± 19.58	11.00 ± 5.00	0.21 ± 0.37
	Range	20.7-86.5	4.25-27.3	15.5-76	5.3-21.9	0-1.16
10	Mean ± SD	26.29 ± 11.08	9.90 ± 4.86	28.6 ± 11.65	6.83 ± 3.29	0.0 ± 0.0
	Range	12.4-52.6	2.7-17.1	10.8-48.2	2.8-13.3	0.0-0.0
20	Mean ± SD	17.09 ± 8.11	6.56 ± 3.68	18.35 ± 8.54	4.37 ± 2.17	0.04 ± 0.12
	Range	9.1-38.4	1.08-12.3	6.4-34.2	1.6-8.7	0.0-0.42

The plots of the heavy metals concentrations with sampling depth at various sampling distance from the edge of the road show that the concentrations of the heavy metals decrease with increase in sampling depth except for a few locationswhich show some deviations from these trends. These deviations suggest some other possible sources of heavy metals or a rearrangement of the soil profile as a result of the frequency of laying and repairing of fiber optics by the various telecommunications service providers in Nigeria. The later reason is likely to be the cause because the deviation in trends only account for 1.33 percent of the 375 trends. Also, plots for the relationship between the heavy metals concentrations and sampling distance reveal that the heavy metals are mostly from automobiles. However, some trends in three locations show some deviations and they only account for 1.06 percent of the 375 trends which is very negligible. These patterns are similar to the findings of Ramakrishnaiah and Somashekar (2002) and Olajire and Ayodele(1996).

4.0 Conclusion

The concentration of the heavy metals was found to be above the permissible international standards especially at the surface and this poses serious health challenge to humans, animals and plants within the study area. The concentration of the heavy metals decrease with increase in sampling depth and distance from the edge of the road pavement. This indicates that most of the heavy metals were from activities from the road. It also indicates that there is less geoaccumulation of the heavy metals in the roadside soil (they possibly leached to nearby streams or rivers).

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