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Heavy Metal Contamination of Soils along Roadsides in Port Harcourt Metropolis, Nigeria

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Since the middle of the 20th century energy generation and industrial production as well as vehicle traffic have caused a serious increase in environmental contamination by trace elements. Detailed studies of the levels of these trace metal pollutants in the environment have been reported by many researchers in order to estimate natural and man-made emissions. (Pacyna, 1984; Pacyna et. al., 1984; Nriagu and Pacyna, 1988; Daines et. al. 1970; Ihenyen, 1991, Kakulu, and Osibanjo, 1988).

Port Harcourt is a highly industrialized city of Nigeria with two petroleum refineries, one petrochemical plant and many other oil and non-oil based industries. It is the capital and major city of Rivers State, with rapid development and increasing traffic volume. Port Harcourt, however, unlike most industrial cities in developed countries, lacks good road network and efficient drainage system. It. is therefore expected to suffer from heavy metal contamination. Crops and vegetables grown along roadsides may therefore contain significant levels of heavy metals. This study aims at assessing the distribution of Cd, Cr, Cu, Ni, Pb and Zn in soils along roadsides with farming activities in and around Port Harcourt to enable the authorities to formulate pollution control measures.

MATERIALS AND METHODS

Port Harcourt lies within latitudes 4^{O} 43′ 07″ and 4^{O} 54′ N and longitudes 6^{O} 56′ 04″ and 7^{O} 03′ 20″ E with a mean annual rainfall of over 2000 mm and mean annual temperature of about 29^{O}C (NMS, 1998). The locations where samples were collected are shown in Table 1. The sampling locations were classified on the basis of motor traffic volume into high –density (> 200.000 vehicles per day), low-density (< 200,000 vehicles per day) and control (0 – 5 vehicles per day). In this study, there are eight (8) high-density areas (stations 3,4,5,6, 7,8,14 and 15), six (6) low- density areas (stations 2, 9,10, 11, 12, and 13) and three (3) control areas (stations 1, 16 and 17). Stations 1 – 15 are in the urban areas while stations 16 and 17 are in the rural areas. Soil samples were collected at 0m, 5m, 10m and 30m distances away from the road. The samples were collected into polyethylene bags and oven-dried in the laboratory at 110^{O}C for about 3 hours. The dried samples were ground to a fine dust and sieved with a 2 mm sieve. Ig of the sieved soil sample was weighed into a conical flask and digested with 10ml of 50% HCL on a hot plate until about 2 ml of acid was left. The content was filtered into a 50ml measuring cylinder and made up to the mark

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Table 1. Sampling stations.

STATION NO.	DESCRIPTION	TRAFFIC DENSITY
1.	U.S.T Teaching farm (control)	Control
2.	U.S.T. Main gate	Low
3.	Ikwerre / Agip road junction	High
4.	Ikwerre / East-West road junction	High
5.	Aba / East-West road junction	High
6.	Aba road / Kaduna St. junction	High
7.	Aba road	High
8.	Abonnema wharf road	High
9.	Ikwerre street	Low
10.	Dick Tiger street	Low
11.	Anozie street	Low
12.	Lumumba street	Low
13.	U.S.T Road E	Low
14.	Rumuokoro / East-West road	High
15.	Rumuodara/East-West road	High
16.	Bille Town (Control)	Control
17.	Idama Town (Control)	Control

with deionized water. Heavy metal concentrations were determined from the aliquot by atomic absorption spectroscopy with a PYE UNICAM SP 2900.

RESULTS AND DISCUSSION

The results showing ranges and mean concentrations of the metals are presented in Table 2. The concentrations of the heavy metals are higher at the road junctions than at the control stations. The concentrations of metals at the urban control are higher than those at the rural controls. This indicate the contributions of heavy metals by auto emissions from motor vehicles and other industrial emissions which are not available at the rural area where samples were collected. It is assumed that the amount of metals introduced from atmospheric fallout at the control stations is insignificant and is not likely to influence the result substantially. In all the stations the concentrations of Pb were higher than those of the other metals. Pb is used as an anti knock compound (tetraethyl lead) in gasoline. The combustion of gasoline globally contributes an estimated 60% of the total lead emissions from human activities such as auto exhaust (UNEP and WHO, 1988; Franz and Hadley, 1981). There are no manufacturing industries at the sampling sites. Thus the Pb concentrations in these stations are directly related with emissions from automobile activities.

The differences in levels of Ni, Cr. Cu and Zn with respect to traffic density are less clearly defined. Although Ni and Cr are often used in chrome plating of some motor vehicle parts, while Cu is a constituent of piping and other components of engine parts (Ndiokwere, 1984). Some lubricating oils also contain important Zn containing additives such as the antioxidant Zn dithiophosphate as well as in tyres of motor vehicles (Lagerweff & Specht, 1970). The distribution patterns were similar for all the metals except at stations located in residential and automobile workshop areas where high concentrations of metals, in particular Cu, Ni and Zn were found. This is as a result of identical sources of input. The concentrations of heavy metals generally decreased with increasing distance away from the road junctions. Linear regression analysis showed negative correlation ($r = -0.9577$) between metal concentrations in soil and distance. This shows that the major effect of traffic is limited to a narrow zone from the road. The scenario was different at stations 4, 8, and 12. For instance the observation at the 30 m distance at station 4 could be attributed to a short but tarred by-pass often used by vehicles. The metal distribution pattern observed at station 8 could be due to the fact that the site had been previously used as an auto garage. The situation at station 12 could be attributed to the automobile workshop, which is at the 30 m. distance. The heavy metal concentrations from high traffic density areas are higher than those from low traffic density areas. Linear regression analysis showed positive correlation ($r = 0.9162$) and t – test showed significant difference ($P < 0.05$) between the metal concentrations from high and low traffic density areas. This shows the contributions of emissions from automobiles to metal concentrations in the samples. The results obtained from soils along roadsides in Port Harcourt are differentiated according to the traffic density and compared with estimated background levels (Table 1). In general, the concentrations of all the metals at station 8; Cu, Ni, Pb at

Table 2. Heavy metal concentrations in roadside soils along different traffic density areas in port harcourt (ppm).

Metal	Heavy density	Low density	Control	Estimated Background level
Cu range	10.8 - 88.7	3.6 - 18.4	1.7 - 6.9	29
Mean	37.23 ± 15.88	11.97 ± 2.48	3.34± 1.25	
Cr range	18.7 - 95.7	3.0 - 25.6	1.1 – 7.2	88
Mean	44.24 ± 17.29	12.51 ± 3.90	3.58 ± 2.22	
Ni range	6.7 - 45.5	2.1 - 13.8	0.6 - 5.4	6
Mean	23.63 ± 8.06	7.10 ± 1.93	2.29 ± 1.90	
Pb range	15.9 - 169.5	7.5 - 39.5	1.4-10.4	83
Mean	60.63 ± 29.58	18.96 ± 4.11	4.0 ± 3.22	
Zn range	13.8 - 93.8	5.3 - 50.3	4.7 - 22.5	42
Mean	40.10 ± 15.86	27.87 ± 13.37	14.05 ± 6.03	

station 6; Cu, Ni, and Zn in stations 4 and 5; Ni and Zn in stations 3, 8 and 11 and only Ni in stations 2,13,14 and 15 exceeded their estimated background levels. However the mean concentrations of all the metals except Cu and Ni at the heavy density areas were below the background levels. The table also shows that the mean metal concentrations decreased with decreasing traffic density. Although the concentrations of most metals are highest at the heavy traffic density areas the levels of metals obtained in the low density and urban control areas indicate that in addition to auto emissions, metal parts and domestic wastes contributed to the distribution of the metals.

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