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Original Research Paper

Accumulation of Some Heavy Metals in Roadside Soil Along the National Highway-8 in Rajasthan (India)

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ABSTRACT

Environmental pollution by heavy metals from automobiles has attained much attention in the recent past. The present research was conducted to study Pb and Cd level concentrations in soil along a major highway with high traffic density. Soil samples along highway were collected from 10 sites on the National Highway -8 between Kishangarh Toll to Bagru Toll in Ajmer and analysed for two heavy metals (lead and cadmium) using flame atomic absorption spectrophotometer (AAS). Physicochemical factors, believed to affect the mobility of metals in the soil of the study area, were examined such as pH, TOM, electrical conductivity, organic carbon, etc. The general decrease in concentrations of these metals with distance from the highway indicates their relation to traffic. Higher accumulations of metals have been observed in soil samples near to the highway (0-5 m) than in soil samples from sites a little farther away (5-10 m, 10-15 m). This is attributed mainly to aerial deposition of the metal particulates from motor vehicles. The values of heavy metals were compared with the results found by other investigators in various countries worldwide.

INTRODUCTION

Heavy metals are typical car exhaust pollutants and their deposition pattern is well documented in soil and vegetation. The pollution of soils by heavy metals from automobile sources is a serious environmental issue. These metals are released during different operations of the road transport such as combustion, component wear, fluid leakage and corrosion of metals. Lead, cadmium, copper and zinc are the major metal pollutants of the roadside environments and are released from fuel burning, wear out of tyres, leakage of oils, and corrosion of batteries and metallic parts such as radiators etc. (Dolan et al. 2006). The majority of the heavy metals are toxic to the living organisms and even those considered as essential can be toxic if present in excess. The heavy metals can impair important biochemical processes posing a threat to human health, plant growth and animal life (Jarup 2003, Michalke 2003, Silva et al. 2005). Studies have shown that such pollutants can be harmful to the roadside vegetation, wildlife and the neighbouring human settlements (Muskett & Jones 1980, Khan & Frankland 1983, Ndiokwere 1984, Ferretti et al. 1995, Caselles 1998, Turer & Maynard 2003). The distribution of these metals in the roadside soils is strongly but inversely correlated with the increase in the distance from road (Warren & Birch 1987, Bhatia & Choudhary 1991, Aksoy 1996). Thus, high concentration of metals, for example Pb, Cd, Zn, etc., needs to be investigated for their ecological and health implications. These metals posses bioaccumulation property and the possibility of the amount of these metals to reach critical stage and threatening human health increase the importance of this type of research. The elevated levels of Pb and Cd in urban areas are mainly attributed to automobile exhaust, particularly from leaded gasoline, motor vehicle tires and lubricant oils. A great part of metal pollutants are deposited on adjacent soil where they may be transformed and transported to other parts of the environment, for example, to vegetation. In addition to soil and vegetation function as a sink for atmospheric pollutants because of their capacity to act as efficient interceptions of airborne matter. The plants are widely used as passive biomonitors in urban environments. The tremendous increase in the number of motor vehicles is leading to increasingly high levels of some heavy metals in the urban as well as highway environment. This work consists of study of the distribution of Pb and Cd in surface soil (0-15 cm) sampled at distances from the centre of traffic flow along a highway.

STUDY AREA

The area under investigation, Ajmer, is centrally situated city of Rajasthan and lies between 26°25' to 26°29' N latitudes and 74°37' to 74°42' E longitudes. It is represented by Aravalli hill rocks, sand dunes, agricultural fields, different kind of phyto-geographical habitats, and floristic fantastic biodiversity.

The NH-8 is serving the states of Delhi, Rajasthan, Gujarat and Maharashtra. The highway originates at Delhi and ends at Mumbai. National highway-8 is one of the busiest routes in the country. It forms a part of the golden quadrangle connecting the political capital of India New Delhi with the commercial capital of India, Mumbai. National highway-8, Jaipur-Kishangarh-Ajmer, is going through the villages: Bagru, Dudu, Bandra Sindri, Kishangarh, Gegal, Gagvana and Ladpura.

Ten sites on National Highway 8 were selected for present study from Kishangarh Toll Plaza to Jaipur Toll Plaza covering major areas of the National Highway.

MATERIALS AND METHODS

Collection of samples: Samples were collected from the Jaipur-Delhi Highway No. 8 between both the Toll Booths from Kishangarh to Jaipur at an equal distance of 7 km on both sides of the road about 15 km from the nearest urban centre . Ten sites were selected for the study along this highway. At each site, three samples of soils were collected at different distance from the edge of the main road (0-5m, 5-10m, 10-15m). In each of the distance, soil samples were collected by using auger of 2-5 cm diameter in all cases; roadside soil samples were place in clean plastic bags and transported to the laboratory. The sites were particularly suitable because: (i) the traffic density is comparatively very high; (ii) there are no urban, large scale urban or industrial activities; (iii) there are no major road intersections which can cause a significant decrease in traffic density to and from Ajmer city.

Sample preparation and analysis: Soil samples were air-dried and grinded in a porcelain mortar to pass through a 2 mm sieve. About 1 g of soil was accurately weighed and transformed to a 100 mL conical flask and 5 mL of concentration HNO_3 (AR 70%) was added and kept for overnight. The flask was placed on a hot plate inside a fume hood, heated at a temperature of 70°C for 1 hour, and then kept for cooling for 30 min and then 5 mL of aqua regia, a mixture of conc. HNO_3 and $HClO_4$ (AR 70%, Merck) in a ratio of 4:1 was added and again the flask was placed on hot plate and heated at a temperature of 80°C for 2 hour. After that it was cooled for 1 hour and transferred to 100 mL volumetric flask through filtration (Whatmann 42) and the final volume was made up to the mark with double distilled water, mixed well by shaking, and let settle for at 15 hour. The resultant supernatant was analysed by flame atomic absorption spectrophotometer (FAAS, Perkin-Elmer, ANALYST 100) for total Pb and Cd. Laboratory blanks were prepared by adding 10% aqua regia to a conical flask containing none of the sample being investigated. This consisted of all components added to the matrix during digestion. All soil and blank samples were analysed for total trace metal levels. Analytical reagent-grade chemicals were employed for the preparation of all solutions. Prepared standard solutions (1000 mg/L) of metals (Pb and Cd) were used. Working solutions were prepared by diluting suitable aliquots of stock solutions with distilled water

Determination of pH and organic matter: The pH was measured using 1:2 soil, water ratio with the pH meter. Organic matters were determined using Anne method (modified Walkey-Black method).

RESULTS AND DISCUSSION

The physicochemical properties of soil at roadside agricultural sites are presented in Table 1 and Fig. 1. Maximum pH of the roadside soil was found to be 9.20 at site 6 (mean value) and minimum mean pH was observed 7.6 at site 2. The maximum electric conductance value for roadside soil was 0.81 dS/m at site 6, and the minimum EC mean value of 0.55 dS/m at site 10. The maximum mean value of organic carbon (%) was found at site 2 (1.59%), while minimum mean value of 0.38% at site 5.

In the present study, the distance from the road was served as a treatment. Therefore, heavy metals (Pb & Cd) contents in soil were measured in triplicates of three regions of each site (0-5 m, 5-10, 10-15 m). Three samples of soils were collected from particular region.

Lead: The amount of lead in roadside soil is strongly but inversely correlated with the increase in the distance from road. Table 2 and Fig. 2 show the lead content in roadside soil at different distances. At site 2, the lead concentration is highest (42.72 mg/kg) but it decreased with the increasing distance from roadside, 36.18 (5-10 m) and 30.12 (10-15 m). The high lead (Pb) concentration in all the samples could be due to the deposition from automobile exhaust, garbage disposal, discarded batteries, filling stations, motor parks and other lead bearing materials. Due to growing concerns about the problems associated with Pb, the use of leaded gasoline has been decreasing globally at an annual rate of about 7%. The maximum level of Pb in leaded gasoline has been set to be less than 0.15 g/L since July 1989, but there are still many counties that use the leaded gasoline with Pb content of about 0.4 g/L. Although the use of leaded gasoline has decreased during this time period, but the increasing number of automobiles compensated its effect on the vehicles based on lead emission. In addition, wearing down of vehicle tires can also introduce Pb to the roadside soil. Consequently, road transport is still polluting the atmosphere, soil and water near the highway.

Cadmium: Cd levels in exhaust emissions have been related to the composition of gasoline, motor oil, car tires and roadside deposition of the residues of those materials as well as traffic density. Except for few sites investigated others had Cd below the recommended 1-3 mg/kg limit given by

Table 1: Physicochemical properties of soils in roadside soils.

Site No.	pH	EC (dS/m)	Organic carbon, %
1	8.8	0.58	0.17
2	7.6	0.67	0.19
3	7.8	0.54	0.19
4	7.9	0.77	0.14
5	8.7	0.67	0.18
6	9.2	0.81	0.21
7	8.0	0.71	0.19
8	8.3	0.58	0.16
9	8.1	0.62	0.14
10	8.6	0.55	0.17

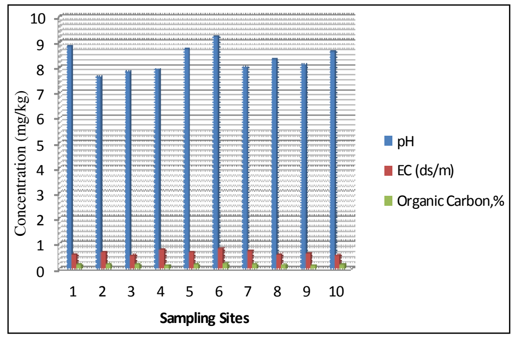

Fig. 1: Various physicochemical properties of roadside soil.

Table 2: Lead (mg/kg) in roadside agricultural soil at selected sites.

Site No.	Distance from road (m)		
	0-5m	5-10m	10-15m
1	41.72	36.18	30.12
2	39.14	33.71	26.81
3	38.10	37.22	24.76
4	40.16	36.51	29.11
5	37.82	31.86	30.86
6	36.68	29.12	31.18
7	34.64	33.78	24.58
8	41.54	35.09	32.02
9	38.54	34.31	29.42
10	35.37	35.01	26.36
Total	383.71	342.79	285.22
Mean	38.371	34.279	51.85818
Standard deviation	2.38611	2.391496	2.703293

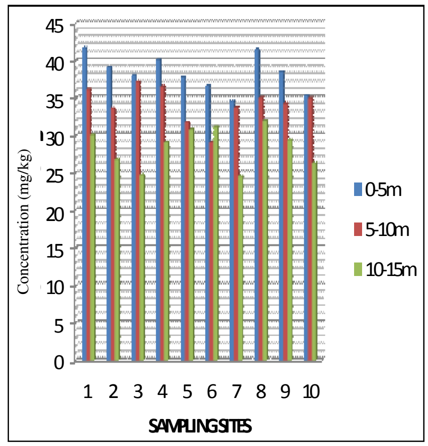

Fig. 2: Concentration of lead (mg/kg)) in roadside agricultural soil at selected sites.

Table 3: Cadmium (mg/kg) in roadside agricultural soil at selected sites.

Site No.	Distance from road (m)		
	0-5m	5-10m	10-15m
1	1.0020	0.5245	0.2002
2	0.0415	0.0212	0.0135
3	0.1042	0.1001	0.0145
4	0.0131	0.0021	0.0010
5	0.0193	0.0054	0.0021
6	0.0654	0.0302	0.0112
7	0.0158	0.0151	0.0012
8	0.0909	0.0430	0.0133
9	0.7232	0.4320	0.2030
10	2.3620	1.0043	0.6452
Total	4.4374	2.1779	1.1052
Mean	0.44374	0.21779	0.11052
Standard deviation	0.757403	0.334915	0.204431

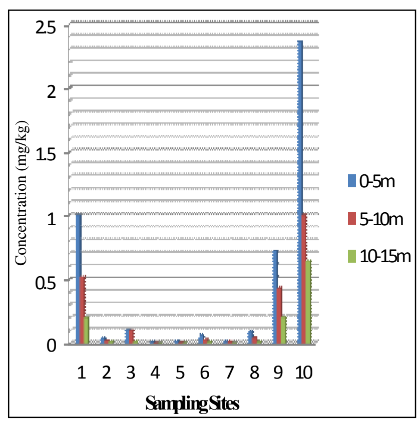

Fig. 3: Concentration of cadmium (mg/kg) in roadside agricultural soil at selected sites.

EU (Table 3, Fig. 3) Highest concentration of Cd in soil (site 10) at distance 0-5 m from road was 2.3620 mg/kg which is decreased to (about 50%) 1.0043 mg/kg (5-10 m) and 0.6452 mg/kg (10-15 m). The lowest concentration of Cd in soil (site 4) at distance 0-5 m from road was 0.0131 mg/kg which is decreased to 0.0221mg/kg at distance 5-10 m and followed by 0.0010 mg/kg at 10-15 m from road. However, the sources of Cd in the urban areas are much less well defined than those of Pb, but metal plating and tire rubber were considered the likely sources of cadmium. In the absence of any major industry in the sampling sites, the levels of cadmium could be due to lubricating oils and/or old tires that are frequently used and the rough surfaces of the roads, which increase the wearing of tires. 0-1 mg/kg of Cd in soils indicates non-contamination, 1-3 mg/kg indicates slight contamination and 3-10 mg/kg indicates a contaminated soil.

At 0-5 m from road, soil samples from site 1 and 10 contained Cd between 1-3 mg/kg, which could be considered as slightly contaminated.

CONCLUSION

From the study, following conclusions can be drawn:

1. The pollution levels along the study area as a result of vehicular emissions have not risen to a dangerous level at the moment. There is also the danger of build-up of small doses either through inhalation or absorption through skin or bioaccumulation. These can lead to unpleasant genetic and somatic consequences, most of which are due to exposure to relatively low level of concentration over a long period of time (Botkin et al. 1998). Therefore, we need to tackle the problems before they reach a critical level so as to prevent the well being of the living organisms and the environment as a whole.
2. The levels of heavy metals (Pb & Cd) contamination in soil are decreased to background levels with distance on either side of the highway. The decrease of elemental concentrations with distance from highway would indicate aerial deposition of metal particulates in road side environment from extraneous sources and not a function of soil type.
3. The concentrations of Pb, especially in soil, exhibited a larger variation with distance from the road than those of Cd.
4. The roadside environment had a significantly high content of Pb and Cd, especially Pb and the mean values of both these metals in soil were significantly different at away from the highway ($p<0.01$).
5. In terms of environmental hazards and polluted environment, it is suggested that the study on heavy metal contamination in soils and in several crops, especially those grown along the main road, should be conducted.

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