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MULTIVARIATE ANALYSIS OF SELECTED ROADSIDE PLANTS (*DALBERGIA SISSOO* AND *CANNABIS SATIVA*) FOR LEAD POLLUTION MONITORING

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Abstract

The indication provided by roadside has great significance in ecological terms particularly when environmental pollution is matter of concern. Soil and plant (*Dalbergia sissoo* and *Cannabis sativa*) samples from ten locations along Islamabad Highway were analyzed for lead (Pb) concentration (mg kg^{-1}) using atomic absorption spectrometry. The locations were further divided into site A and site B for spatial difference of Pb concentration. The data were subjected to multivariate analysis to examine the relationship between distance and Pb concentration in plants. A strong correlation was observed for the concentration Pb in soil and plants. In addition, the highest and lowest values of Pb concentration in both the soil and plants were found at the same location. The results show that Pb concentration in soil decreases with increasing distance from roadside as the Pb concentration in site A sample of one location declined in site B samples of the same location. This indicated that road traffic may be the key source of Pb present in soil and plants of this area. Furthermore, values of Pb concentration in soil and *C. sativa* correlated more than *D. sissoo* and soil. So *Cannabis sativa* can be used as a good choice species to biomonitor of Pb in this area.

Introduction

Our environment is the entire web of geological, hydrological, atmospheric, biological and anthropogenic interactions that characterize the relationship between life and the planet earth. Soil pollution with heavy metals, such as cadmium, lead, chromium, copper, etc., is a problem of concern. Long-range transport of atmospheric pollutants adds to the metal load and is the main source of heavy metals in natural areas (European Environmental Agency, 1995). The effects of heavy metals on the environment and human health have been widely studied (Fergusson, 1990). One of these metals which has hazardous health effects is lead (Rowchowdhury and Gautum, 1995; Shen *et al*., 1996; Nriagu *et al*., 1996; Al-Saleh *et al*., 1996; Kim *et al*., 1996; El-Zohairy *et al*., 1996; Shannon and Graef, 1996).

Lead is a naturally occurring, non-biodegradable element generally found in all the components of environment. It is most likely to be present in concentrations that endanger human health and its effects include blood enzyme changes, anemia, loss of appetite, hyperactivity and neurological disorders (Ormrod, 1984). Besides posing an immediate health risk through inhalation, lead from vehicular emissions can also accumulate in soils and plants and enter into the food chain (Khandekar *et al*., 1984 and Duggan, 1980).

Lead emissions are associated with the use of lead compounds in gasoline as antiknock agents (Suzuki *et al*., 2008). Lead is available to plants from soil and aerosol sources. The leaves of *Robinia pseudo-acacia* L. (Fabaceae) were evaluated as a

biomonitor of heavy metal contamination in Denizli city, Turkey by (Celik *et al*., 2005). Concentrations of Fe, Zn, Pb, Cu, Mn and Cd were determined in leaves and soils collected from different sites. According to them, the degree of heavy metal concentration in the leaves is proportional to urbanization.

Monitoring of atmospheric lead from the *Dalbergia sissoo* tree was undertaken at Lucknow, India by (Singh *et al.*, 2002). Highway localities show higher lead concentrations as compared to urban localities. The lead accumulated by the leaves of different species of roadside plants in Karachi, Pakistan was measured in a study by (Shams and Beg, 2000). *Nerium oleander*, *Guaiacum officinale*, *Ficus bengalensis and F. virens* were selected for the study. A statistically significant correlation was found between the number of passing petrol driven vehicles and the lead concentration in the leaves at different designated sites. Maximum lead accumulated by the leaves was noted as 3.12 ± 1.09 ppm.

The present study was aimed to look into the pollution levels of Pb in soil, *Dalbergia sissoo* and *Cannabis sativa* on Islamabad highway and to assess the effect of distance and the location on the metal contents in road soils and plants. This study was also intended to assess whether *D. sissoo* and *C. sativa* are useful as a bioindicator of soil heavy metal pollution originating from traffic.

Materials and Methods

Islamabad is accessible from two main arterials: the Islamabad Highway, which is the actual area under study links to the (historic) Grand Trunk Road, and the Kashmir Highway. The present study was conducted along Islamabad highway. Soil and plant (*Dalbergia sissoo, Cannabis sativa*) samples were collected in March-May 2008 from ten different sites on both sides of Islamabad Highway, Islamabad, Pakistan. Because of its uneven topography, in this area the flat lands rarely extend more than five meters from the roads. Therefore, in each location two distances named as A and B points were selected for sampling: the first one Site A was at edge of the road and the second one Site B was five meters away from the first point. Soil pH was determined by using glass electrode pH meter, Thermo Orion (Model 410 A +) in 1:5 soil–water extract. EC is measured with the EC pocket meter (Conductivity -^{o}C meter, Cyberscan 500 Con). The concentration of Pb (mg kg^{-1}) in plants and soil were determined after acid digestion. The acids used were: aqua regia for soil and HNO_3-$HCl0_4$–H_2SO_4 for plants digestion (Eaton, 1995).

Results

In the study area soil pH was observed in the range from pH 7.47 to pH 9.30. The normal pH range for productive soil is from 6.5 to 8.4 (WHO, 1996). Among the studied soil, relatively higher pH was recorded in only two soil samples (location No.3, Site B and location No.7, Site A) whereas on all other points pH was within the normal range The maximum EC i.e., 490 µS/cm is recorded in soil sample of location No. 4, Site B while the minimum EC i.e. 66.4 µS/cm is observed in Location No. 10, Site B. Concentration of lead in the soil of study area varies from 2.28 mg/kg (location No.7, Site B) to 4.99 mg kg^{-1} (location No. 1, Site A). Concentration of Pb in Control sample was recorded to be 0.94 mg kg^{-1} (Table 1). The average soil Pb concentration in the study area is 3.72 mg kg^{-1}. Lead concentration in most of the soil samples of study area was higher than the permissible limits of World Health Organization (3mg/l) (Table 2) Comparatively almost all the samples collected from Site A showed higher soil Pb concentration. The main reason for high Pb content in soil of this area is the emission from road traffic.

Table 1. Lead concentration in roadside soil (mg kg^{-1}).

S. No.	Location	Sampling Site	Pb Concentration (mg kg^{-1})
1.	Koral Chowk	A	4.9946
		B	2.8542
2.	Judicial Colony	A	3.8116
		B	3.5845
3.	Wild Life Park	A	4.0933
		B	3.5719
4.	Loi Bher	A	3.2753
		B	3.6028
5.	Bahria Town	A	3.9953
		B	3.6346
6.	Sawan Garden	A	4.2793
		B	3.6928
7.	Jinnah Garden	A	3.7774
		B	2.2884
8.	Sihala	A	4.2983
		B	3.9668
9.	DHA	A	3.6904
		B	3.5649
10.	Rawat	A	3.9989
		B	3.5763
11.	Control sample		0.9434

Table 2. Comparison of permissible soil heavy metal concentration (mg kg^{-1}).

Element	WHO permissible concentration in soil (1996)	Present study (mean values)	
		Roadside soil	Control soil
Pb	3.00	3.72758	0.9434

Concentration of Pb in *C. sativa* in the study area varies from 1.8 mg kg^{-1} (location No. 4, Site B) to 4.09 mg kg^{-1} (location No. 1, Site A). Concentration of Pb in Control sample was recorded to be 0.71 mg kg^{-1} (Table 3.). The average Pb concentration in *C. sativa* in the study area is 3.6935 mg kg^{-1}. Lead concentration in most of the plant samples of study area was higher than the values mentioned in other literature. The mean Pb concentration in *C. sativa* also exceeded the normal level of Pb in plants (3ppm) as given by Allen (1989). Comparatively almost all the samples collected from Site A which was directly at the border of road showed higher Pb lead concentration than Site B samples.

Concentration of Pb in *D. sissoo* leaves in the study area varies from 1.05 mg kg^{-1} (location No.3, Site B) to 3.92 mg kg^{-1} (location No. 1, Site A). Concentration of Pb in Control sample was recorded to be 0.8156 mg/kg (Table 3.). The average Pb concentration in *D. sissoo leaves* in the study area was 2.41 mg kg^{-1}. According to Singh *et al*., (2002) the lead concentration in *D. sissoo* leaves in India ranges between 2.1-12.3 μg/g. Most of the plant samples collected from Site A showed higher Pb concentration in their tissues than Site B. The comparison between Pb concentration for soil and both the plant species is presented in Fig. 1 which shows that *C. sativa* had the higher mean Pb concentration than *D. sissoo* and indicating that it had the ability to accumulate lead.

Table 3. Lead concentration in roadside plants (mg kg^{-1}).

S. No.	Location	Sampling site	*C. sativa* (mg kg^{-1})	*D. sissoo* (mg kg^{-1})
1.	Koral Chowk	A	4.0957	3.9253
		B	3.9782	2.3378
2.	Judicial Colony	A	2.8422	3.4778
		B	1.9681	1.4882
3.	Wild Life Park	A	3.2456	2.8141
		B	2.1357	1.0518
4.	Loi Bher	A	2.6356	2.2856
		B	1.842	1.2266
5.	Bahria Town	A	2.8156	2.325
		B	2.2554	1.2828
6.	Sawan Garden	A	3.3618	3.0998
		B	2.5895	2.3909
7.	Jinnah Garden	A	3.113	2.9071
		B	3.1355	2.5553
8.	Sihala	A	3.0705	2.7954
		B	3.0712	2.6765
9.	DHA	A	3.2441	2.3529
		B	2.5451	1.7365
10.	Rawat	A	3.6843	2.5451
		B	2.9869	2.9593
11.	Control sample		0.7154	0.8156

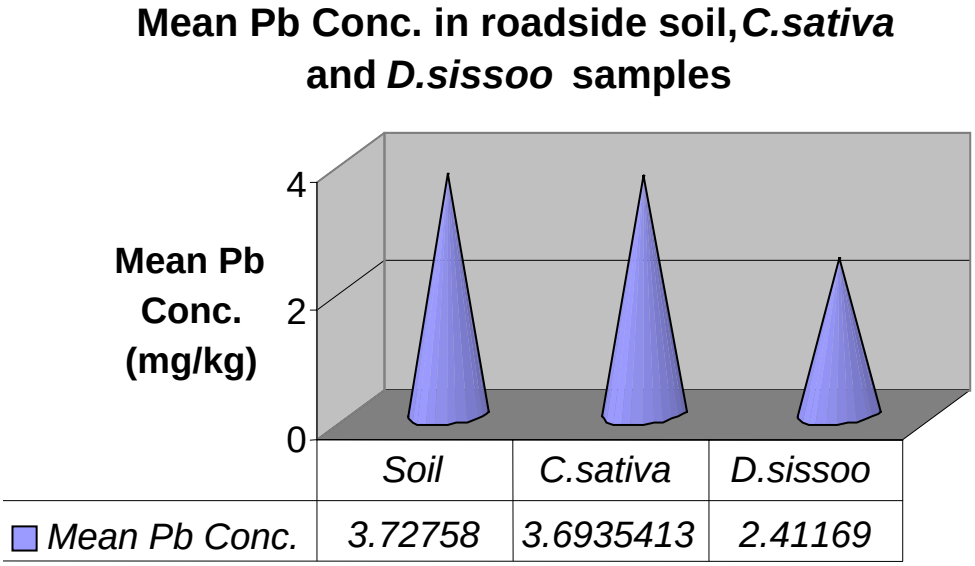

Fig. 1. Mean lead (Pb) concentration (mg kg^{-1}) in roadside soil and plants.

Results of Principal Components Analysis (PCA) showed the pattern of Pb concentration distribution in *C. sativa* and *D. sissoo* in site A and site B samples. Similarly Fig. 2 showed the symbol attribute plot diagram indicating Pb concentration in *C. sativa* at site A samples. The highest Pb concentration is found out to be 4.10 mg kg^{-1} at location 1 whereas the lowest Pb concentration is 2.64 mg/kg at Location 4. The highest Pb concentration is indicated by the biggest plot in the graph whereas the lowest Pb

concentration is indicated by the smallest plot. Results given in Fig. 3 showed the symbol attribute plot diagram indicating Pb concentration in *C. sativa* site B samples. The highest Pb concentration is found out to be 3.98 mg kg^{-1} at location 1 whereas the lowest Pb concentration is 1.84 mg kg^{-1} at location 4. Generally, the Site A plant samples have higher Pb content than Site B plant samples. Figs. 4 and 5 showed the symbol attribute plot diagram indicating Pb concentration in *D. sissoo* site A samples. The highest Pb concentration is found out to be 3.93 mg/kg at location 1 whereas the lowest Pb concentration is 2.29 mg kg^{-1} at location 4. Similarly in *D. sissoo* site B samples, the highest Pb concentration is found out to be 2.959 mg kg^{-1} at location 10 whereas the lowest Pb concentration is 1.052 mg kg^{-1} at location 3.

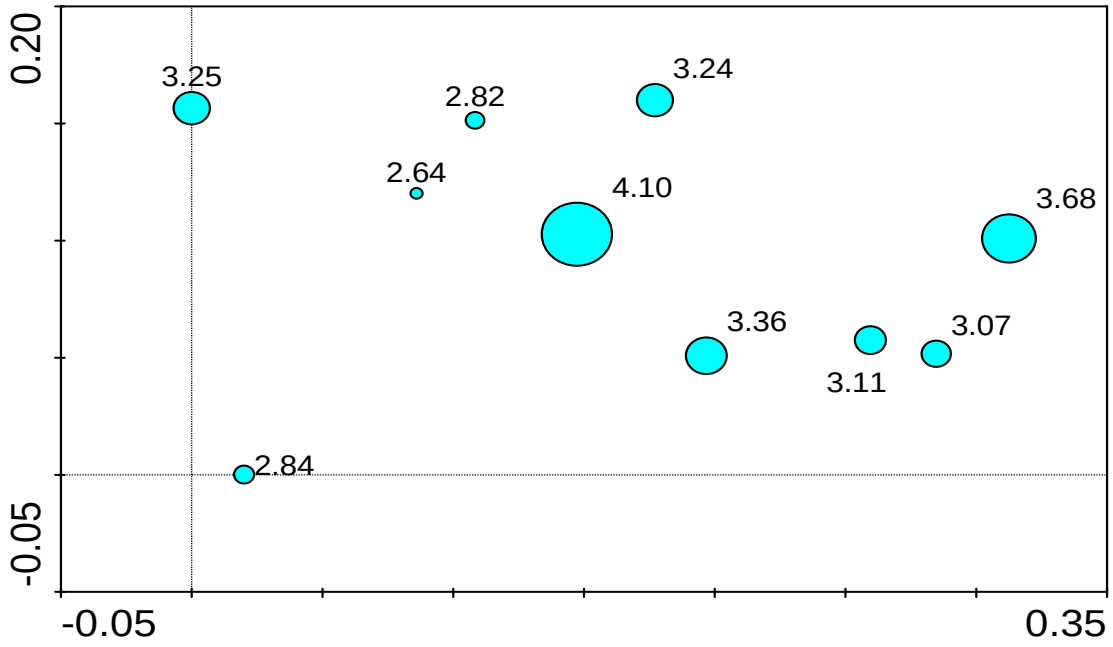

Fig. 2. Symbol attribute plot diagram showing Pb concentration in *C. sativa* Site A.

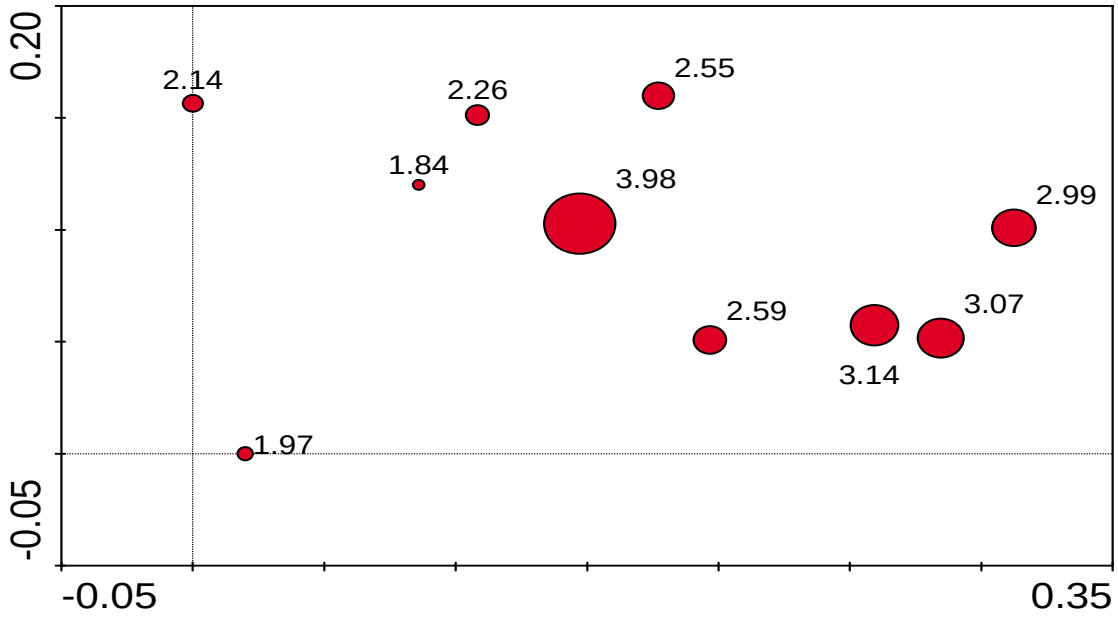

Fig. 3. Symbol attribute plot diagram Showing Pb concentration in *C. sativa* Site B.

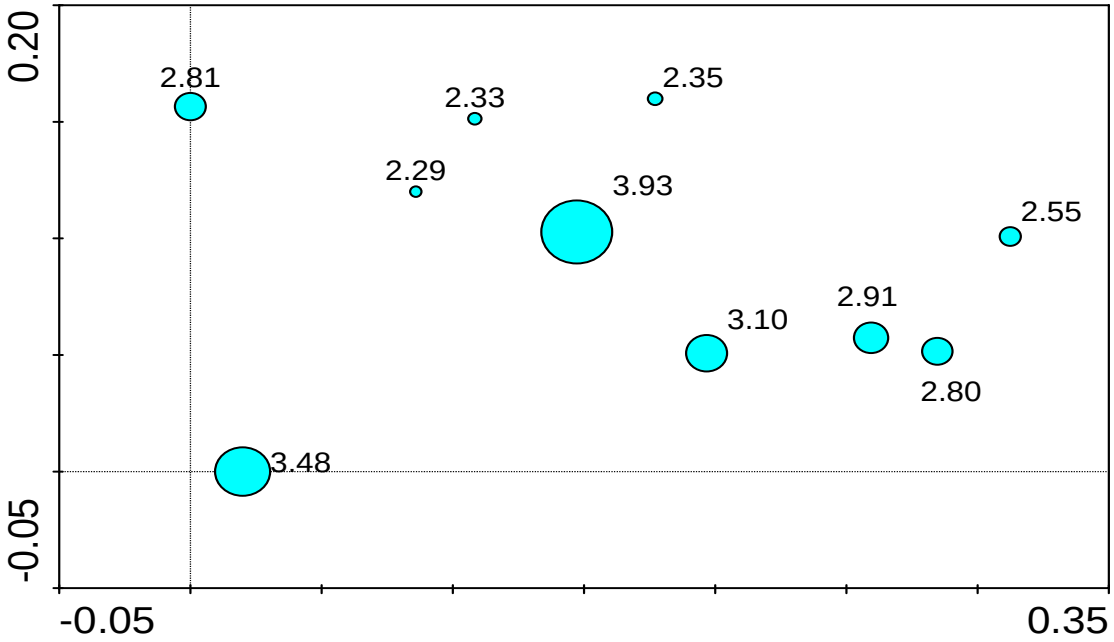

Fig. 4. Symbol attribute plot diagram Showing Pb concentration in *D. sissoo* Site A.

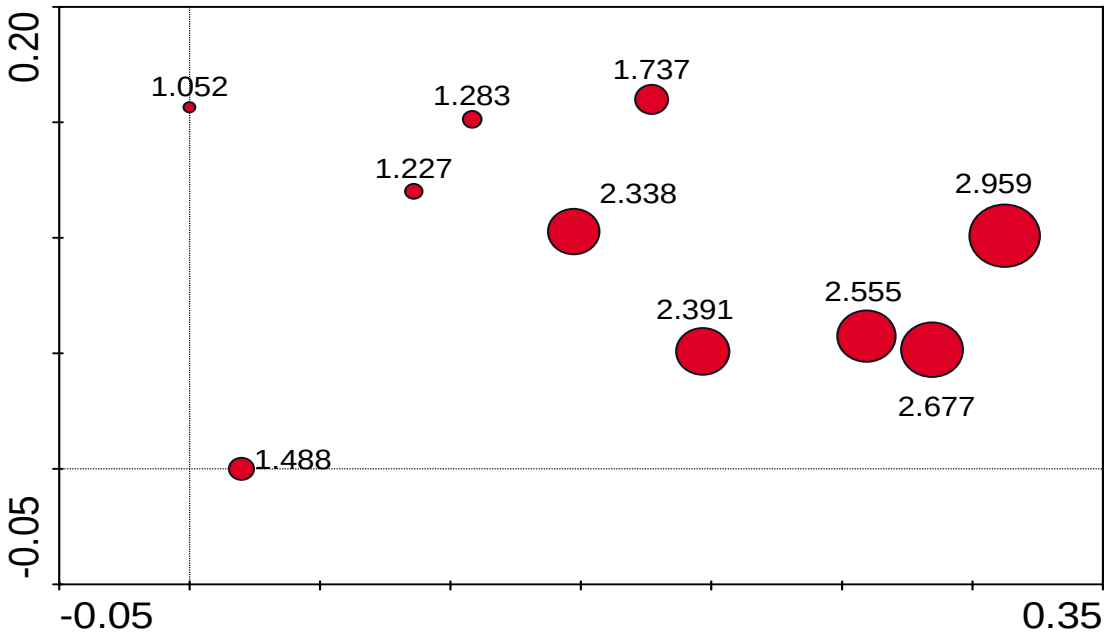

Fig. 5. Symbol attribute plot diagram Showing Pb concentration in *D. sissoo* Site B.

Discussion

From toxicological perspective, the bioavailability of metal pollutant in soil is important and at the same the nutrient availability is crucial for the growth of vegetation in the area. Soil pH is a one simple and direct measure of the overall chemical condition of soils. It is commonly recognized that at pH 6.5 nutrient availability to plants is at highest and toxicity at a lowest (Harris *et al.*, 1996). In our work, pH in soil of the study area is ranging from 7.47 to 9.30. The normal pH range for productive soil is from 6.5 to 8.4 (WHO, 1996). High pH of soil generally can affect plant growth and nutrient availability (Williams, 2003). The heavy traffic on the road emits smoke containing

heavy metals like Pb that are ultimately deposited into the soil. Therefore higher concentration of heavy metals in soil increases its pH, and with the increase in soil pH, the fertility of soil is affected. In general Pb is a major pollutant of the roadside environment. There is a general agreement that combustion of gasoline containing lead is a major source of Pb pollution.

The amount of lead in the roadside soils is strongly but inversely correlated with increase in distance from the road. Akbar *et al*., (2003) calculated a sharp decrease in lead concentration from border zone to verge zone in the Sahiwal Distric, Punjab, Pakistan. In the present study also, a distinct gradient with a pronounced decrease in the lead content from the border zone i.e., site A, to the verge zone i.e. site B, has been observed. The mean soil Pb concentration of the study area was 3.72 mg kg^{-1} which is higher than the WHO permissible limits of Pb in soil (3mg/l). The roadside soils have been reported to have usually higher lead content because of the vehicular exhaust.

The average Pb concentration in *C. sativa* in the study area was 3.69 mg kg^{-1}. Lead concentration in most of the plant samples of study area is higher than the values mentioned in other literature. According to Shams and Beg (2000), the maximum Pb accumulated by roadside plants was noted to be 3.12 ppm. The mean Pb concentration in *C. sativa* also exceeded the normal level of Pb in plants (3ppm) as given by Allen (1989).

The average Pb concentration in *D. sissoo* leaves in the study area was 2.411 mg kg^{-1} and all the samples collected from site A which was directly at the border of road showed higher Pb Content than site B samples which was five metres away from site A. Various studies have shown heavy contamination of roadside soils and vegetation with lead concentration declining steeply with distance from the road (Little, 1995) as was seen in the present study. The rate of lead deposition to the ground is very much dependent upon the presence and nature of vegetation. The rate of deposition of lead on grass is about four times greater than on bare soil (Little & Wiffen, 1978). In the present study area the most dominating species was *Cynodon dactylon* justifying the high lead deposition in the area. The distribution of lead in the soil is very characteristic, with a steep decline in lead concentration with increasing distance from the road.

As long as lead remains in petrol, levels of lead in soils will continue to increase and zone of heavy metal contamination will gradually widen away from the roads. Ward *et al.,* (1977) calculated a sharp increase in lead concentration in the roadside soils with heavy metals. In the present study the lead concentration recorded was quite higher than national environmental quality standard range i.e. 0.5 μg g^{-1}. High Lead concentration in soil will affect the health of the residents as well as surrounding communities. These may also affect the soil fertility. Besides the burning of vehicular fuel, the emissions from brick kilns in the surrounding area are also contributing heavy metals into the environment.

The plant samples collected from Koral Chowk have high Pb content as compared to other locations. The soil samples collected from Koral Chowk also have higher Pb concentration. This study indicates that the plant samples under study can be used as bioindicators in future studies. Especially the Pb concentration in *C. sativa* was recorded higher than *D. sissoo* which indicates that *C. sativa* can be used as an indicator species. For lead pollution and bioindicator *D. sissoo* is already used as a bioindicator by Singh *et al*., (2002).

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