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Biomonitoring of the Traffic Related Heavy Metal Pollution Using Roadside Plants as Possible Bioindicators During Different Seasons

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The degree of heavy metal pollution in Sargodha city was determined on different selected areas using three different plants as bioindicator. The leaf samples of *Dalbergia sissoo* Roxb., *Prosopis juliflora* L. and *Eucalyptus spp*. were collected from different sites including industrial, roadside, urban, suburban and rural in summer and winter season and analyzed for heavy metals Fe, Mn, Co and Ni concentration. These elements were detected and estimated by using atomic absorption spectrophotometer. Results of correlation analyses showed significant correlations among Fe, Mn, Co and Ni contents in leaf samples. Among these Fe was present in highest concentration in plant leaves during summer and Ni was present in lowest concentration during summer. There exist a significant correlation between these heavy metals (Fe, Mn, Co, Ni) concentration in these plant samples. Thus leaves of *Dalbergia sissoo* Roxb., *Prosopis juliflora* L. and *Eucalyptus spp*. were found to be the most suitable bioindicator of heavy metal pollution.

Key Words: Bioindicators, Pollution, Iron, Manganese, Cobalt, Nickel, Plants, Heavy metals.

INTRODUCTION

Plants are the main components of a healthy environment and the ability of some plants to absorb and accumulate xenobiotics makes them useful as indicators of environmental pollution[1]. Plants are used as bioindicators such as plant species or cultivated varieties as well as mosses and lichens appear to be much more sensitive to most environmental pollutants than man and animals[2]. The past few decades have seen an increase in the use of higher plant leaves as biomonitors of heavy metal pollution in the terrestrial environment[3,4].

Increasing the traffic density in the city day by day cause black smoke on the roads and polluted the atmosphere from the burning of gasoline, soot and smog from diesel[5]. Long-range transport of atmospheric pollutants adds to the metal load and is the main source of heavy metals in natural areas[6]. Heavy metals enter the roadside soil mainly as a result of transport work. Al, Co, Cu, Fe, Mn, Pb and Ni and other elements enter the roadside soil as a result of tire abrasion[7].

The indication provided by roadside has great significance in ecological terms particularly when environmental pollution is matter of concern[8]. The deposition of air born particulates from traffic wind and automobile exhaust on the leaves of the various roadside plants decreases the light availability for photosynthesis[9]. The declination of growth in highly polluted plants is due to decreased chlorophyll contents, leaf moisture contents, impaired gaseous exchange, clogged stomata, reduced β-carotene and vitamin and other abnormal changes in plant body[10].

Free ions of iron can be extremely extra cellular binders-siderophore storage systems and ferritins[11]. An excess of Zn leads to a significant reduction in Fe concentration in plants. According to Cakmak[12] Zn deficiency in plants increased iron concentration.

Normal Ni concentration in plants is 0.5-5 μg/g, excess of nickel is one of the important factors causing reduced growth in plants. Nickel phytotoxicity varies with concentration of nickel in soil solution as well as with the plant species. Nickel depressed shoot yield all levels except at the lowest level *viz.* 30 μg Ni/g of soil[13].

Cobalt is an essential component of several enzymes and co-enzymes. Cobalt interacts with other elements to form complexes. Toxic effects of cobalt on morphology include leaf fall, inhibition of greening (damage in plastids and chlorophyll contents), discoloured veins, premature leaf closure and reduced shoot weight[14].

Manganese concentrations in soil and in some plant species along impacted roadsides often exceeded levels known to cause toxicity. Submerged and emergent aquatic plants were sensitive bioindicators of manganese contamination[15].

Mesquite (*Prosopis juliflora* L.) is a deciduous that tolerates extreme temperature and considered as a good absorbant of dust on roadsides and used as an emulsifying agent[16]. Shisham (*Dalbergia sissoo* Roxb.) is a large deciduous tree with a loose spreading crown. It is facing severe threat of Die back, due to the unidentified causes[17]. But yet, if the major specie that is grown on our roadsides and it is worldwide considered as an important bioindicator and some is the cause with *Eucalyptus species*. Some *Eucalyptus species* were introduced in Pakistan in early 20th century and had been widely planted in all parts of the country[18].

Due to increasing level of pollution that is the result of rapidly increased number of automobiles in the city, it is necessary to investigate the fate and effects of metals in components of ecosystems is of great importance. Therefore the present study was planned to: 1) Investigate the impact of traffic pollution upon the road side plants; 2) To find out the degree to which the plant under study can tolerate the high level of pollution.

EXPERIMENTAL

Plant samples were taken from different sampling sites in Sargodha city during December 2008 and May 2009. These sites include urban, suburban, industrial, roadside and rural. Preferred industrial and roadside sites for sampling were the most crowded and polluted parts of the city.

About 200 g of well developed leaves of *Dalbergia sissoo*, *Prosopis juliflora* and *Eucalyptus species* were selected and collected. Leaf samples were washed thoroughly with distilled water to remove dust particles from leaf surfaces and then leaf samples were oven-dried for 24 h. And then dried leaf samples were converted into fine powder after crushing. The dried material (0.1 g) was digested with sulfuric acid and hydrogen peroxide according to the method of Wolf[19].

Concentrations of the heavy metals (Fe, Mn, Ni and Co) were analyzed in plant samples by an atomic absorption spectrophotometer (Model # AA. 6300 SHIMADZU 'Japan' AAS flame type).

All the concentrations reported are in µg/g and refer to dry weights. A statistical treatment of the data was carried out using the XLSTAT software.

RESULTS AND DISCUSSION

Table-1 explain the comparison of means of iron concentration in roadside plants collected from different areas during winter. The highest value was observed in industrial site in Eucalyptus 362.01 ± 139.78 and the lowest value was observed in *Dalbergia sissoo* Roxb. 77.57 ± 130.09 in suburban. Table-2 explain the comparison of means of Iron concentration in roadside plants collected from different areas during summer. The highest value of iron was observed in *Eucalyptus* 1077.21 ± 821.18 in urban site and the lowest value was observed in case of *Prosopus juliflora* L. 334.26 ± 36.00 in rural site. According to Ross[20] criteria the value of Zn in contaminated plants is in range of 100-400 µg g^{-1} and result of our fall in this range. Similar studies of Zaidi *et al.*[21] showed that Zn and Fe were most abundant in roadside plants of Quetta. The amount of Fe was found to be maximum *i.e.* 705.45 ± 455.325.

The data regarding the comparison of means of nickel concentration in roadside plants collected from different areas during winter are presented in Table-3. In suburban site the highest value was observed in *Dalbergia sissoo* Roxb. 179.71 ± 15.79 and the lowest value were observed in *Dalbergia sissoo* Roxb. 99.92 ± 6.65 in rural site. Also the comparison of means of nickel concentration in roadside plants collected from different areas during summer are given in Table-4. The highest value of Ni was determined in roadside site in case of *Prosopus juliflora* L. 69.73 ± 28.74 and the lowest value was in case of *Prosopus juliflora* L. 29.46 ± 3.37 in rural site. Normal Ni in plants is 0.5-5 µg g^{-1}. In our study it was179.71 ± 15.79 (D.S. suburban) to 66.44 ± 54.67 (Euc industrial) in winter and it was 69.73 ± 28.74 (P.J. roadside) to 29.46 ± 3.37 (P.J. rural). Ni emissions are accounted by oil combustion. The mean value of Ni was 2.398 ± 1.435 µg g^{-1} in Quetta roadside plant[21]. These values are far less than our values, it mean that our values lie in toxic range. The reason for reduction in Ni levels in summer maybe due to rainfall during summer. These are the reverse of the results of Zaidi *et al.*[21].

TABLE-1
COMPARISON OF MEANS OF Fe CONC. (µg/g DRY wt) IN LEAVES OF ROADSIDE PLANTS DURING WINTER

	D.S.	Euc	P.J.
Urban	165.27 ± 191.96	238.98 ± 63.16	154.50 ± 124.56
Suburban	77.57 ± 130.09	190.40 ± 83.46	85.89 ± 67.13
Industrial	217.33 ± 101.61	362.01 ± 139.78	265.64 ± 23.80
Roadside	277.63 ± 249.57	280.74 ± 45.32	177.09 ± 117.53
Rural	184.37 ± 61.23	153.73 ± 46.00	203.27 ± 37.50

D.S.: *Dalbergia sissoo* Roxb.; Euc: *Eucalyptus sp.*; P.J.: *Prosopis juliflora* L.

TABLE-2
COMPARISON OF MEANS OF Fe CONC. (µg/g dry wt) IN LEAVES OF ROADSIDE PLANTS DURING SUMMER

	D.S.	Euc.	P.J.
Urban	470.43 ± 497.69	1077.21 ± 821.18	783.73 ± 245.76
Sub urban	467.33 ± 79.68	424.41 ± 71.15	814.89 ± 46.55
Industrial	381.983 ± 245.76	736.80 ± 97.57	413.39 ± 90.38
Roadside	473.15 ± 129.80	411.75 ± 325.78	550.68 ± 178.68
Rural	578.35 ± 174.45	454.36 ± 89.93	334.26 ± 36.00

D.S.: *Dalbergia sissoo* Roxb.; Euc: *Eucalyptus sp.*; P.J.: *Prosopis juliflora* L.

TABLE-3
COMPARISON OF MEANS OF Ni CONC. (µg/g dry wt) IN LEAVES OF ROADSIDE PLANTS DURING WINTER

	D.S.	Euc.	P.J.
Urban	169.03 ± 21.84	148.85 ± 27.19	133.71 ± 51.43
Suburban	179.71 ± 15.79	174.45 ± 20.38	175.44 ± 17.23
Industrial	178.96 ± 13.89	66.44 ± 54.67	115.38 ± 51.95
Roadside	123.75 ± 44.72	94.40 ± 38.18	95.51 ± 72.50
Rural	99.92 ± 6.65	101.74 ± 9.88	103.81 ± 36.42

D.S.: *Dalbergia sissoo* Roxb.; Euc: *Eucalyptus sp.*; P.J.: *Prosopis juliflora* L.

Table-5 data pertaining the comparison of means of manganese concentration in roadside plants collected from different areas during winter. The highest value was observed in *Dalbergia sissoo* Roxb. 410.75 ± 121.37 in roadside site and the lowest value was observed in *Prosopis juliflora* L.

49.87 ± 112.94 in rural site. Table-6 reveals the comparison of means of Mn concentration in roadside plants collected from different areas during summer. Among the areas, the highest concentration were observed in industrial site in *Eucalyptus* 319.76 ± 48.01 followed by urban, roadside then suburban and then rural. The lowest value 70.70 ± 182.73 was observed in rural site. According to Swaileh *et al*.[22] the concentrations of heavy metal roadside plants were as Fe-730, Mn-140 and Ni-4.87. According to Suzuki *et al*.[23] roadside rhododendron leaves have 7.00 ± 0.90-22.22 ± 3.3 Cu, 0.60 ± 0.20-12.65 ± 2.23 Pb, 0.97 ± 0.20-3.5 ± 0.16 Ni and 51.84 ± 2.76-160.46 ± 12.20 Zn in mg kg^{-1}. Ni, Fe, Mn, Zn and Pb were high during summer in leaves of roadside plants than in winter and similar observation were made by Zaidi *et al*.[21] in Quetta.

TABLE-4
COMPARISON OF MEANS OF Ni CONC. (µg/g dry wt) IN LEAVES OF ROADSIDE PLANTS DURING SUMMER

	D.S.	Euc.	P.J.
Urban	54.24 ± 25.28	55.42 ± 31.81	45.01 ± 33.38
Suburban	37.18 ± 38.55	50.51 ± 36.75	36.90 ± 8.98
Industrial	63.73 ± 34.37	65.48 ± 31.54	68.65 ± 30.92
Roadside	46.20 ± 40.00	44.63 ± 14.77	69.73 ± 28.74
Rural	33.01 ± 4.35	37.47 ± 2.45	29.46 ± 3.37

D.S.: *Dalbergia sissoo* Roxb.; Euc: *Eucalyptus sp.*; P.J.: *Prosopis juliflora* L.

TABLE-5
COMPARISON OF MEANS OF Mn CONC. (µg/g dry wt) IN LEAVES OF ROADSIDE PLANTS DURING WINTER

	D.S.	Euc.	P.J.
Urban	208.15 ± 137.28	153.05 ± 136.31	191.54 ± 138.03
Suburban	77.57 ± 130.09	85.89 ± 67.13	190.40 ± 83.46
Industrial	402.55 ± 168.33	283.18 ± 15.01	225.16 ± 71.75
Roadside	410.75 ± 121.37	260.13 ± 41.06	147.19 ± 96.25
Rural	104.91 ± 168.49	92.43 ± 32.66	49.87 ± 112.94

D.S.: *Dalbergia sissoo* Roxb.; Euc: *Eucalyptus sp.*; P.J.: *Prosopis juliflora* L.

TABLE-6
COMPARISON OF MEANS OF Mn CONC. (µg/g dry wt) IN LEAVES OF ROADSIDE PLANTS DURING SUMMER

	D.S.	Euc.	P.J.
Urban	295.88 ± 148.03	184.86 ± 99.31	239.26 ± 84.69
Suburban	189.49 ± 315.48	146.50 ± 5.10	210.78 ± 31.31
Industrial	276.57 ± 17.73	319.76 ± 48.01	267.98 ± 112.20
Roadside	198.01 ± 95.08	193.04 ± 90.66	182.32 ± 118.22
Rural	175.56 ± 18.16	70.70 ± 182.73	128.61 ± 182.96

D.S.: *Dalbergia sissoo* Roxb.; Euc: *Eucalyptus sp.*; P.J.: *Prosopis juliflora* L.

The comparison of means of cobalt concentration in roadside plants collected from different areas during winter is given in Table-7. The highest value was observed in *Prosopis juliflora* L. 256.99 ± 159.56 in roadside and the lowest value was observed in *Dalbergia sissoo* Roxb. 82.34 ± 48.83 in urban site. Table-8 represents the comparison of means of cobalt concentration in roadside plants collected from different areas during summer. The maximum level of Co concentration, among the areas, were observed in roadside plant in *Eucalyptus* 99.81 ± 27.62 and followed by urban, industrial site then suburban and then rural site. The lowest concentration 38.98 ± 11.21 was found in rural site. The higher concentration of Co, Ni and As, in roadside leaves could not be caused by root absorption of trees from the soil, but was most attributed to foliar uptake of trace elements from ariel sources[24]. Primarily result from local atmospheric dust deposition caused by traffic activities.

TABLE-7
COMPARISON OF MEANS OF Co CONC. (µg/g dry wt) IN LEAVES OF ROADSIDE PLANTS DURING WINTER

	D.S.	Euc.	P.J.
Urban	82.34 ± 48.83	194.79 ± 80.52	151.12 ± 35.95
Suburban	103.52 ± 7.83	179.08 ± 93.45	108.83 ± 50.93
Industrial	123.93 ± 198.66	251.60 ± 19.13	221.37 ± 161.29
Roadside	194.70 ± 61.34	218.08 ± 74.45	256.99 ± 159.56
Rural	101.45 ± 14.51	114.10 ± 11.37	176.45 ± 44.83

D.S.: *Dalbergia sissoo* Roxb.; Euc: *Eucalyptus sp.*; P.J.: *Prosopis juliflora* L.

TABLE-8
COMPARISON OF MEANS OF Co CONC. (µg/g dry wt) IN LEAVES OF ROADSIDE PLANTS DURING SUMMER

	D.S.	Euc.	P.J.
Urban	67.20 ± 33.57	80.02 ± 35.47	73.92 ± 47.38
Suburban	77.31 ± 3.58	81.25 ± 16.76	78.81 ± 5.97
Industrial	63.33 ± 12.54	44.24 ± 36.29	58.95 ± 29.44
Roadside	81.89 ± 44.21	99.81 ± 27.62	88.71 ± 47.52
Rural	42.01 ± 23.25	38.98 ± 11.21	63.46 ± 11.41

D.S.: *Dalbergia sissoo* Roxb.; Euc: *Eucalyptus sp.*; P.J.: *Prosopis juliflora* L.

Leaves collected during summer were heavily polluted, while those collected during winter had lesser concentration of all the elements. This could be attributed to the winter rainfall which washed away the pollutants from the leaves. Concentration of all the elements analyzed varies from one location to the other. The amount of Fe was found to be maximum amongst all the elements present and that of Ni was found to be minimum. The order of concentration of metals in different three plants from different sites was as follows:

$$Fe > Mn > Co > Ni$$

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