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Temporal and spatial variability of lead levels in *Salsola kali* near Razan-Hamadan highway

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ABSTRACT: The contribution to environmental pollution of heavy metals from automotive emissions has been the subject of intensive investigation in recent years. Airborne metal particulates, such as Pb, have been attributed mainly to emissions from motor vehicle exhausts. The objectives of this study were to evaluate the temporal and spatial variability of lead levels in *Salsola kali* in the vicinal soils of Razan-Hamadan highway, Iran. In both sides of the highway sampling was carried out on a transect (200-m long), in vertical direction from highway with a separation distance of 20 m, thereby providing 10 actual sampling locations for each side of highway. During 2 seasons of 2002, plant samples were taken from shoots and roots with 3 replicates. Root and shoot organs of samples separately analyzed for Pb concentration with dry ash method by atomic absorption spectroscopy. Lead levels in most of the analyzed plant samples were higher than the natural levels. Lead concentration in the plant organs was decreased exponentially with distance from the road. In both seasons the decrease constant for Pb in root organ was higher than that for shoot organ. The decrease constants for Pb in root and shoot organs of the plant were higher in spring compared to those in autumn. Lead accumulation was significantly higher in shoot organs compared to root organs. The highest lead contents may exceed 37.66 μgg^{-1} in the shoot organs of the plant in east side of the road. In both organs of the plant especially in shoot organs lead concentration in autumn compared to that in spring was relatively higher. Translocation factor for lead in the plant sampled in autumn was also higher than that for those sampled in spring. @JASEM

Lead is widely used as an intermediate for tetra-alkyl lead antiknock additives for motor fuels. This usage introduces large amount of lead into the atmosphere (Rodrigues, 1982) which accumulates in the upper layer of soil (0-5 cm) (Harrison and Laxen, 1984; Wild, 1993). This accumulation is closely related to traffic volume, vehicle type, topography and vegetation cover (Smith, 1976). High lead concentrations in roadside soils and vegetation, such as grass have been recognized by many workers (Page and Ganji, 1971; Ho and Tai, 1988; Onyari et al., 1991; Capannesi et al., 1993; Munch, 1993; Yassoglou et al., 1987); lead concentrations in soil may reach as high as 3000 ppm (Goyer, 1988).

Not only lead but also cadmium, copper and zinc are associated with the mobile sources; since they included in petrol, engines, tires, lubricant oils and galvanized parts of the vehicles (Falabi-Ardakani, 1984). The influence of the traffic load on heavy metal accumulation in topsoils and vegetation and the variability with distance are well documented (Ward et al,1977; Rodriguez and Rodriguez, 1982; Scalon, 1991). Accurate measurements of the total metal contents in polluted soils are required to assess the potential risk of these areas. However, only soluble, exchangeable and chelated metal species in the soils are the mobilc and mobilisable fractions and hence more available for plants (Kabata-Pendias, 1993). Therefore, the total amount should be complemented by the available fraction measurement trying to evaluate the most labile forms of metals (Garcia and Millan, 1998).

Our previous study in Iran has shown that lead contents in both sides of Razan-Hamadan highway soils are markedly high. The highest mean lead concentration of roadside may exceed 180μgg^{-1}, while the background concentration is less than 20 μgg^{-1}. The highest mean lead concentrations were found in soil samples taken 10 meters form roadsides. Total Pb concentration was high on east of the road rather than west of the road. Total Pb content of soil samples decreased exponentially with increase of distance from the roadsides. This decrease was more intense in soil samples taken from west roadside (Ebrahimi and Safari Sinegani, 2004).

The objectives of this study were to determine the spatial variability of lead levels in roadside *Salsola kali* as a dominant native plant in the vicinal soils of Razan-Hamadan highway Iran, and to examine seasonal variations of lead levels in this roadside plant.

MATERIALS AND METHODS

The experimental site is in Hamadan province, on the northwestern of Iran (1700 m above sea level). The regional climate is arid-cold, with annual precipitation of 322 mm. Mean daily maximum temperatures is 34.1 °C and minimum temperatures is –7.6 °C. One of the dominant native plant cover of the experimental field is *Salsola kali*. In both sides of Razan-Hamadan highway plant samples were taken on transects (200-m long), in perpendicular direction from highway with a separation distance of 20-m, therefore, providing 10 actual sampling locations for each side of highway. During the 2 seasons (autumn and spring) of 2002, samples were taken from root

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and shoot plant organs separately with 3 replicates. They were washed with distilled water, and dried at 80 °c during 24 hours. They were ground and stored in glass containers until analysis. Each sample of root or shoot organs separately analyzed for Pb concentration with dry ash method. Total Pb of samples was solved in 2N HCl and analyzed by atomic absorption on a Perkin- Elmer instrument at 283.3 nm using an air-acetylene flame (Ramos et al, 1994). All the statistical analyses were performed on the SAS 6.12 software.

RESULTS AND DISCUSSION

Tables 1 and 2 show lead levels in shoot and root organs of *Salsola kali* grown on the both sides of the highway. Generally in each location of sampling, the Pb content in shoot organs was significantly higher than the Pb content in root organs of the plant. The highest lead contents may exceed 37.66 $\mu g g^{-1}$ in the shoot organs of the plant in east side of the road. Lead levels in the analyzed plants were higher than the natural levels (0.1-0.25 ppm) (Harrison and Laxen, 1984; UNEP et al., 1988). *Salsola kali* lead levels in the east side of the highway were higher than in the west side of the highway. Ebrahimi and Safari Sinegani (2004) have reported that the highest lead concentrations were found in soil samples taken 10 meters form roadsides. Soil total and DTPA-extractable lead levels in the east side of the highway was higher than in the west side of the highway. These differences may be related to the direction of wind often breezing from southwest to northeast.

Table 1. Comparison between lead contents (mg kg^{-1}) of different organs of *Salsola kali* sampled from the west roadside in autumn.

Distance from road (m)	Mean concentration in		Std. deviation	T.F.*
	Roots	Shoots		
20	21.66 b	29 a	0.47	1.34
40	14.96 b	22.66 a	0.47	1.51
60	7.56 b	10.66 a	0.24	1.41
80	3.5 b	6.43 a	0.14	1.84
100	2.43 b	4.96 a	0.12	2.04
120	1.3 a	2.46 a	0.73	1.89
140	1.53 b	2.76 a	0.03	1.8
160	0.53 b	1.1 a	0.04	2.08
180	0.23 b	0.76 a	0.03	3.3
200	0.08 a	0.13 a	0.02	1.63

*- Translocation factor

Table 2. Comparison between lead contents (mg kg^{-1}) of different organs of *Salsola kali* sampled from the east roadside in autumn.

Distance from road (m)	Mean concentration in		Std. deviation	T.F.*
	Roots	Shoots		
20	23.33 b	37.66 a	0.97	1.61
40	21.66 b	32 a	0.62	1.48
60	10 b	15.66 a	0.47	1.57
80	7.66 b	13.66 a	0.33	1.78
100	6.33 b	12.33 a	0.33	1.95
120	2.33 a	6.66 a	0.33	2.86
140	1.33 b	3.33 a	0.33	2.5
160	0.93 b	2 a	0.2	2.15
180	0.4 b	1.66 a	0.23	4.15
200	0.1 a	1 a	0	10

*- Translocation factor

Spatial and temporal variation of lead levels in plant organs are presented in Figures 1 and 2. The lead contents in *Salsola kali* decreased exponentially with distance from the roadsides. The R^2 of all models was significantly high. Our previous study showed that total Pb content of soil samples decreased exponentially with increase of distance from the roadsides. This decrease was more intense in soil samples taken from west roadside related to the direction of wind breezing from southwest to northeast. The most remarkable influence was showed in soil, since soil tends to accumulate metals on a relatively long-term period (Ebrahimi and Safari Sinegani 2004).

The decrease constants of Pb contents in the plant were higher for root organs compared to those for shoot organs. On the other hand, for both parts of the plant, the decrease constants of Pb contents were higher in spring compared to those in autumn. The Pb decrease constant was more intense for root of the plant sampled in spring. These results may be due to the effect of wind breezing. This effect may be more intense for shoot organs sampled in autumn. Wind can displace airborne metal particulates, such as Pb, attributed mainly to emissions from motor vehicle exhausts, far from the roadsides. Airborne Pb particulate can be precipitated on plant organs and accumulated on them with passing times. So, lead content of the shoot organ of the plant sampled in autumn compared to that in spring was markedly higher. Although the temporal variability of lead content of the root (fig. 2) compared to the shoot (fig. 1) was lower, however lead levels of root organ in autumn was also higher than in spring.

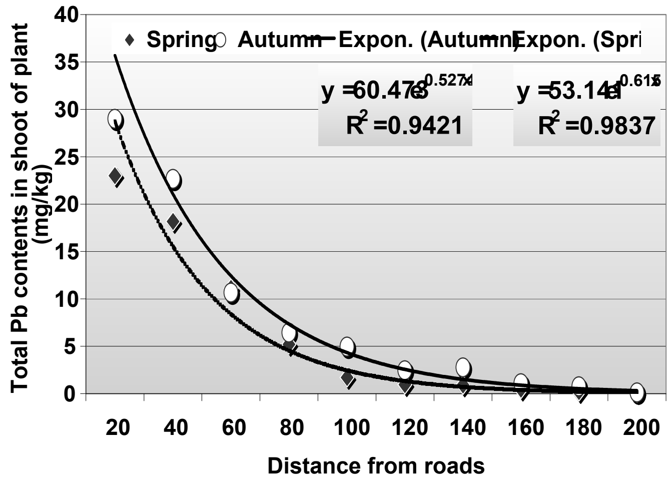

Fig 1. Decrease of lead contents in shoot of *Salsola kali* in the west roadside

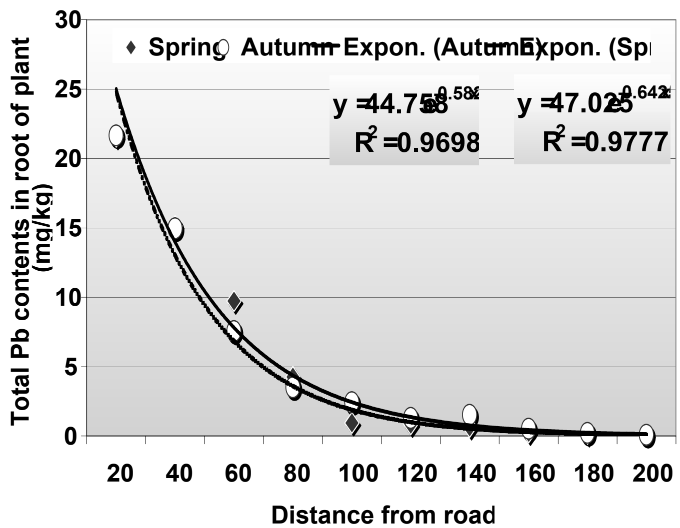

Fig 2. Decrease of lead contents in root of *Salsola kali* in the west roadside

In contrast to our finding, Othman et al. (1997) reported that lead levels in edible parts of some common vegetables grown on the roadside of Damascus city, in the wet period is higher than in the dry period, (opposite relationship to that found in soil samples). This has been related to the high humidity in the wet period which increases the adherence of particulates on plant leaves (Capannesi et al., 1993). However, the lead level in shoot organs of the plant depends not only on air humidity and rain, but on the traffic density, leaf age, leaf surface area, and leaf morphology.

Translocation factor for lead in the plant sampled in autumn was higher than that for those sampled in spring (tables 1 and 2). It increased with increasing the distance from the roadside and it was higher in long distance from the road especially in autumn.

Conclusions: Lead levels in *Salsola kali* sampled from both side of Razan-Hamadan highway have been determined in two seasons of the year. Lead levels in plant samples were relatively high in comparison to normal levels reported elsewhere in the world. These levels were influenced by several factors, namely traffic density (or road ages), season, and distance from road edge. Lead levels in plant samples in the dry period (autumn) were higher than in the wet period (spring). Concentrations were found to be higher in the shoot organs than in root organs of the plant. The decline in the relationship between lead concentration and distance from the roadside was also observed**.** Lead translocation factor increased with distance from roadside. It was higher in each distance in autumn compared to spring.

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