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Mercury accumulation in selected plant species exposed to cement dust pollution

Mercury is a typical toxic trace metal pollutant. Bio-accumulation of mercury in plants and its entry into the food chain resulting in long-term health hazards, is of major concern. Since the beginning of the industrial era, anthropogenic activity made a substantial contribution to the mercury adulteration of the atmosphere. Increased mining, high rate of fossil fuel burning, widespread use of raw materials containing mercury in the industry are some of the sources of mercury, creating a vitiated environment.

The cement manufacturing process is one of the chief sources of mercury in the environment. The present study focuses on the analysis of accumulation levels of mercury in selected plant species around a cement factory.

The cement factory under study was Panyam Cements and Mineral Industries Ltd., located at Bugganipalli near Bethamcharla, Kurnool district, Andhra Pradesh, India. The area about ± 5 km around the factory is considered as polluted and that about ± 12 km away as control. Among the plant species encountered around the factory, *Tephrosia purpurea* and *Cassia auriculata* are abundant both in polluted and control areas, and hence were selected for experimentation. Besides, *Arachis hypogaea*, a crop plant species, common to both areas was also selected for the study.

The wild plant samples were collected at distances of 1, 2, 5 and 12 km and crop plant samples were collected at 5 and 12 km, as the crop is cultivated only from 5 km onwards. To study seasonal variations and to see the impact of wind direction on mercury accumulation, the samples were collected twice, with a gap of three months (September and January), from both the east and west directions. The plant samples were packed in air tight polythene covers and preserved in a freezer until further analysis. The mercury accumulation levels are estimated individually in the root, stem and leaf.

Wet digestion or acid digestion method was employed for quantitative analysis of mercury[1]. To 0.5 g of plant tissue (root, stem, leaf), 5:1:1 ml of HNO_3, $HClO_4$ and H_2SO_4 were added in a teflon bomb and heated on a mantle at 80°C for 7 h. The digest is diluted to 25 ml with double distilled deionized water and taken for analysis. Cold vapour atomic absorption spectrometry (CV-AAS) is adopted to analyse the plant samples[2] using a mercury analyser (MA 5800 E of ECIL) with mercury levels expressed in ng/mg.

The amounts of mercury in *Tephrosia purpurea* and *Cassia auriculata* compared with *Arachis hypogaea*, where the higher levels of mercury were noticed are shown in Table 1. This may be found to be more in the leaves than in the stem and root. However, in *Arachis hypogaea*, roots showed higher levels of mercury compared to the stem and leaves at both 5 and 12 km.

The uptake and accumulation of chemicals by plants may prove to be the most important aspect of pollution dynamics[3]. It is interesting to note that the elements like cadmium and mercury are more easily bio-accumulated than other elements[4].

The results obtained in this study reveal that the accumulation levels are not uniform, either within or among the plant species. They support the fact that many factors like the fluctuating environment (such as temperature, soil pH, soil aeration, soil moisture), the root system, availability of element in the soil, plant energy supply to all parts, etc. influence the uptake and accumulation of the metal[5]. It was observed that the root accumulated comparatively less amounts of mercury than the stem and leaf in *Tephrosia purpurea* and *Cassia auriculata*. On the other hand, *Arachis hypogaea* showed higher accumulation levels in the root. This may be partly due to plant varieties and their ability to absorb and accumulate heavy metals in their tissues[5].

Table 1. Mercury accumulation levels in plant samples

Distance (km)	Plant sample	Hg concentration mean ± SD (ng/mg) (East far the wind direction)		Hg concentration mean ± SD (ng/mg) (West against the wind direction)	
		September	January	September	January
1	T_R	0.541 ± 0.03	0.695 ± 0.05	0.500 ± 0.02	0.808 ± 0.30
	T_S	0.348 ± 0.21	0.355 ± 0.03	0.333 ± 0.02	0.720 ± 0.29
	T_L	0.330 ± 0.02	0.684 ± 0.03	0.480 ± 0.02	0.530 ± 0.24
	C_R	0.750 ± 0.02	0.660 ± 0.02	0.310 ± 0.03	0.717 ± 0.08
	C_S	0.541 ± 0.01	0.397 ± 0.07	0.500 ± 0.02	0.900 ± 0.10
	C_L	0.760 ± 0.04	0.753 ± 0.08	0.520 ± 0.03	0.742 ± 0.07
2	T_R	0.890 ± 0.23	0.832 ± 0.20	0.750 ± 0.02	0.988 ± 0.02
	T_S	0.310 ± 0.30	0.477 ± 0.10	0.340 ± 0.09	0.610 ± 0.02
	T_L	0.500 ± 0.01	0.355 ± 0.03	0.340 ± 0.09	0.754 ± 0.03
	C_R	0.500 ± 0.08	0.770 ± 0.16	0.525 ± 0.03	0.660 ± 0.08
	C_S	0.590 ± 0.11	0.770 ± 0.16	0.270 ± 0.03	0.490 ± 0.30
	C_L	0.770 ± 0.06	0.910 ± 0.11	0.610 ± 0.03	0.988 ± 0.02
5	T_R	0.586 ± 0.06	0.510 ± 0.08	0.410 ± 0.00	0.586 ± 0.70
	T_S	0.490 ± 0.29	0.390 ± 0.02	0.390 ± 0.02	0.442 ± 0.15
	T_L	0.397 ± 0.06	0.330 ± 0.02	0.330 ± 0.02	0.490 ± 0.29
	C_R	0.330 ± 0.02	0.430 ± 0.10	0.250 ± 0.10	0.397 ± 0.07
	C_S	0.310 ± 0.04	0.250 ± 0.10	0.390 ± 0.06	0.330 ± 0.02
	C_L	0.500 ± 0.08	0.510 ± 0.02	0.477 ± 0.10	0.610 ± 0.21
	A_R	1.000 ± 0.02	0.620 ± 0.32	0.741 ± 0.01	1.075 ± 0.07
	A_S	0.790 ± 0.03	0.500 ± 0.08	0.608 ± 0.09	0.982 ± 0.12
	A_L	0.260 ± 0.02	0.380 ± 0.07	0.310 ± 0.04	0.910 ± 0.11
12	T_R	0.125 ± 0.00	0.100 ± 0.07	0.100 ± 0.07	0.125 ± 0.00
	T_S	ND	ND	ND	ND
	T_L	0.100 ± 0.07	ND	0.100 ± 0.07	0.100 ± 0.07
	C_R	ND	ND	0.700 ± 0.07	ND
	C_S	ND	0.050 ± 0.00	ND	0.100 ± 0.07
	C_L	0.100 ± 0.07	0.100 ± 0.07	0.050 ± 0.00	0.125 ± 0.00
	A_R	0.191 ± 0.10	0.191 ± 0.10	0.125 ± 0.00	0.250 ± 0.10
	A_S	ND	0.050 ± 0.00	ND	0.075 ± 0.00
	A_L	0.050 ± 0.00	ND	ND	0.050 ± 0.00

Number of samples analysed: 6.
Plant species: T, *Tephrosia purpurea*; C, *Cassia auriculata*; A, *Arachis hypogaea*.
Plant parts: R, root; S, stem; L, leaf.
ND, Not detectable.

Moderate levels of mercury were found in the stems of *Cassia auriculata* and *Arachis hypogaea*, but higher accumulation levels were noticed in the stem of *Tephrosia purpurea*. This can be correlated with the transportation system through the xylem and phloem. Lateral transfer, remobilization into the phloem and transpiration intensity, significantly influence the accumulation[6]. Also, mercury mobility appears to be greater when it enters the plant through the stem or leaf[7].

It was observed that leaves of *Cassia auriculata* accumulated more mercury than its stem and root and also when compared to the other two plant species. Foliar uptake through the stomata or leaf cuticle or both, may be the principle route for its accumulation. The metal entry into plants through the leaves is more significant for pollution elements because of aerosol deposits[6]. A number of reports revealed that metal accumulation levels in plants are influenced by their distance from the source of the metal[4,8] and also seasonal effect[6,9]. But neither of these were observed in the present study.

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