Article

Heavy metal speciation of soil and *Calotropis procera* from thermal power plant area

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Abstract
Present study was conducted near to a super thermal power plant for the speciation of heavy metals/metalloids contamination of soil and estimation of concentration factor for plant parts (CFPP) of *Calotropis procera.* The heavy metals selected for speciation in soil and plant parts were Pb, Fe, Cr, Cd, Zn, Ni, V, Co, Mo and Cu and were estimated using AAS-7000(Shimadzu). Reason for selecting the present plant was its abundance in the area vicinity of the power plant. Presence of these heavy metals/metalloids can be attributed to the coal used for combustion from which they are volatised and after condensation are associated to the fly ass. The plant *Calotropis procera* growing in the area accumulates these metals/metalloids do a significant extent and thus can be used for the plantation in the fly ash dykes so as to minimise the contamination of soil and ambient air with these metals/metalloids.

Keywords speciation; thermal power plant; fly ash; soil contamination.

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1 Introduction

The power generation in India mainly comes from thermal power plants and coal is used for the combustion processes. The fly ash emitted from the power plants are important source of heavy metals/metalloids because the metals/metalloids are volatized during the process of combustion and after condensation gets incorporated with the fly ash. Heavy metals in the environment interact with water and sediment/soil samples of geological origin and subsequently influence various processes occurring in soil and plants (Sayadi and Sayyed, 2011; Prajapati, 2012; Ediagbonya et al., 2013). Heavy metals are classified among the most dangerous groups of anthropogenic environmental pollutants due to their toxicity and persistence in the environment. Presence of heavy metals in the road-side and particulate matter in the ambient air is serious and has adverse human health effect. Particulate matter has been widely studied in recent years due to its potential health impact and the need for its control. Links between asthma attacks and coughs to particulates have also been reported (Freer-Smith et al., 1997). Studies indicate that finer PM has the strongest health effects (Schwartz et al., 1996; Borja-

Aburto et al., 1998). Vehicular traffic, industrial processes, and fossil fuel stations are primary sources of airborne particulate matter (Beckett et al., 1998), which is responsible for contamination of urban areas (Janssen et al., 1997; Monaci et al., 2000; Fernandez et al., 2001). In aerosols, magnetite is associated with other heavy metals, such as zinc, cadmium, and chrome (Georgeaud et al., 1997). There are references that plants capture trace elements and can be used as biomonitors (Oliva and Valdes, 2003; Oliva and Rautio, 2004; Marañó, T. and Murillo, 2006). Keane et al. compared the metal content (Cd, Cr, Cu, Fe, Mn, Ni, Pb, and Zn) in dandelion leaves with the PM_{10} levels.

Higher plants function as biomonitors of aerial metal contamination due to their accumulation properties. Vehicle derived particulates were monitored using magnetic properties of leaf dust and it has been established that they are particularly dangerous to human health (Prajapati et al., 2006). Prajapati and Tripathi (2007) have biomonitored the trace metals present in PM_{10} using leaves of *Saraca indica* and *Lantana camara*. Present study was conducted in Bilaspur district (C.G.) near to a super thermal power plant (NTPC, Sipat) of India which is facing nuisances of air problems. The *Calotropis procera* which are growing abundantly in the area were selected for the estimation of concentration factor for plant parts (CFPP) parts for various heavy metals/metalloids.

2 Materials and Methods

Soil sample and plant material of *Calotropis procera* were taken from the vicinity of a super thermal power plant (NTPC, Sipat) located at 22°07' N and 82°16' 43 E with a capacity of 2980 MW. The soil sample and plant materials were immediately kept in polybags after collection. Dust were removed from the different plant parts with the help of distilled water and fine brushes and marked for identification. The soil sample and different plant parts were digested in aqua regia for the estimation of heavy metals/metalloids. The heavy metals/metalloids concentrations were measured with the help of atomic absorption spectrophotometer (AAS) model: AA 7000, SHIMADZU and the standard was prepared using standard metal solution of Inorganic Ventures.

3 Results

The analysis of soil and plants part for the estimation of heavy metals/metalloids concentration is given in Table 1. It is clear from the table that out of the ten metals analysed Fe was having maximum concentration and Cd least concentration in soil. Mo was not detected in the soil sample. The concentration of different metals/metalloids in different plant parts can also be observed from the Table 1. For different metals/metalloids different plants have different capacity for accumulation. The concentrations of metals/metalloids in plant parts are less as compared to the soil except for Cd where the leaf is having higher concentration than the soil.

Table 1 Heavy metals/metalloids concentration (µg g^{-1}) of soil and different plants parts of *Calotropis proccera*,

	Pb	Fe	Cr	Cd	Zn	Ni	V	Mo	Co	Cu
Soil	2.82	34.26	1.23	0.05	4.65	0.14	3.98	*n.d*	1.01	2.62
Fruit	0.29	18.64	0.91	0.04	1.05	0.01	*n.d*	*n.d*	*n.d*	*n.d*
Leaf	0.29	14.38	*n.d.*	0.06	0.78	*n.d.*	0.64	*n.d*	0.01	*n.d*
Flower	0.3	9.72	0.48	0.04	3.15	0.01	1.5	*n.d*	*n.d*	*n.d*

n.d.- not detectible (< 0.01 ppm)

Concentration factor for plant parts (CFPP) for different metals/metalloids is shown in Fig. 1. Concentration factor for plant parts (CFPP) are calculated as follows:

$$CFPP = \frac{concentration\ in\ plant\ part}{concentration\ in\ soil}$$

Fig. 1 clearly depicts that CFPP for Cd is maximum (1.2) and nil for Cu and Mo. The CFPP for Pb is almost same for every plant parts while maximum variation can be observed for V. The variations in CFPP for different metals/metalloids may be due to different roles played by them in plant physiology and the affinity of the plant for these metals/metalloids.

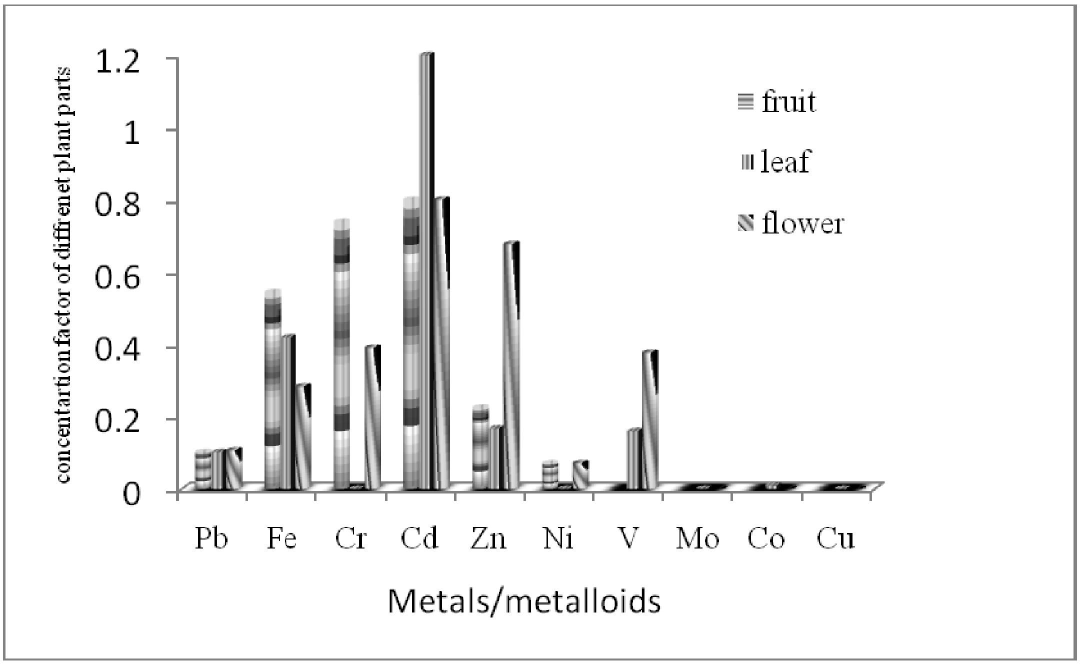

Fig. 1 Concentration factor for plant parts (CFPP) for different metals/metalloids.

4 Discussion

Present study was undertaken near to a super thermal power plant utilising high quality of coal. The fly ash emitted from the thermal power plant is the main cause for the presence of heavy metals/metalloids in the surroundings. The elements Pb, Fe, Cr, Cd, Zn, Ni, V, Co and Cu are volatile to a significant level during the process of combustion in the plant and are associated with the fly ash after condensation. Another source of these metals/metalloids is fly ash dykes located in the vicinity of the plants from where the fly ash contaminated with these metals/metalloids may come along with winds or during storms. The plant *Calotropis procera* growing in the area accumulates these metals/metalloids do a significant extent and thus can be used for the plantation in the fly ash dykes so as to minimize the contamination of soil and ambient air with these metals/metalloids. Different parts of the plants viz. leaf; flower and fruit accumulate the metals/metalloids to varying ratios depending upon the CFPP. The plant *Calotropis procera* growing in the area is healthy and thus can be used for plantation in the surroundings of a thermal power plant.

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