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*Article*

# Biomonitoring of toxic metals through roadside vegetation exposed to vehicular pollution in Bilaspur city

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## Abstract

The present study describes concentrations of five metals (Cd, Cu, Pb, Ni and Cr) contaminations in Bilaspur city by analysis of three roadside plants (*Calotropis procera*, *Butea monospermae* and *Saraca asoca*). Samples of leaves and topsoil were collected just before the monsoon in May 2015 and analysed for the heavy metal content. Sequences of the concentration of heavy metals deposited on leaf surface in foliar dust and those accumulated in leaf were at the same order: Pb > Cu > Cd > Ni > Cr. However, the concentrations of metals in topsoil were at order of Ni > Cu > Pb > Cd > Cr, respectively. *Calotropis procera* showed highest capacity to accumulate target heavy metals in terms of their magnitude.  Moreover, the order of accumulation of target heavy metals in different plant species studied was *Calotropis procera* > *Saraca asoca* > *Butea monospermae*. The deposition of heavy metals in plant leaves was attributed mainly due to heavy vehicular traffic. The present study clearly indicates that these plant species have biomonitoring potential and can be employed to prevent heavy metal pollution.

**Keywords** heavy metals; hazards; biomonitoring; traffic; vehicular.

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## 1 Introduction

Heavy metals play vital role in chemical as well as biological reactions in plant cells (Hashmi et al., 2007). An excess of heavy metals is proved to be harmful to the life of living beings (Anim et al., 2012; Al-Farraj et al., 2013; Meravi et al., 2013; Su et al., 2014). There are diverse sources of pollutants released into the environment such as industry, combustion of fossil fuels in vehicular traffic and energy production. Among them, vehicular traffic is the major source of pollutants, especially, heavy metals released into the atmosphere. Heavy metals are emitted from automobiles as particles of vehicular exhaust, road paint, tire dust, road construction materials, etc (Suzuki et al., 2009; Prajapati, 2012).

Trees are capable of trapping atmospheric particles, especially on their foliage (Nowak et al., 2006) and are known for reducing the high risk of respirable particulate matter (RSPM), thus preventing environment from the adverse effects (Beckett et al., 2000; WHO, 2003). Use of plants for biomonitoring purpose is a reliable way to assess the air quality without the use of expensive equipments (Markert et al., 1999). Suitability of a plant material to be used for biomonitoring purpose widely depends on their distribution throughout the region. Monitoring of heavy metals using plants is simple, cheap, and convenient method to assess air quality (Wagh et al., 2006). There are evidences where many plants accumulate trace elements at a level many times higher than contained in soil (Baker et al., 2000), which proves that the trace elements are taken up from the atmosphere.

This study aims to contribute better understanding of biomonitoring of airborne toxic metals using plants growing in roadside areas. Vehicular traffic is the major source of heavy metal pollution in urban environment. In Bilaspur city, *Calotropis procera*, *Butea monospermae*, *Saraca asoca* has a wide natural distribution since long. *Calotropis procera* has large, thick waxy leaves which enhance the scavenging and retention of airborne particulate matter (PM). Here, we report the metal deposition and accumulation potential of three plant species in Bilaspur city to assess the air quality in terms of heavy metal pollution.

## 2 Materials and Methods

### 2.1 Description of the sampling area

The Bilaspur city is situated 133 km (83 miles) north of the state capital, Raipur in the Indian state of Chhattisgarh. This city is the headquarters for South East Central Railway Zone, Bilaspur Railway Division and South Eastern Coalfields Limited. In this study, three roadside plant species were selected for assessing the suitability of species as bioindicator. *Calotropis procera*, *Butea monospermae* and *Saraca asoca* are the plants which are widely distributed in the roadside areas in Bilaspur city. Map of Bilaspur city is shown with the position of Seepat chowk, where the major source of pollution is vehicular traffic (Fig. 1).

Seepat chowk is chosen for sampling as this area is highly polluted due to continuous vehicular traffic. It is located at the centre of the city, connected to major national highway (NH111) passing through Bilaspur.

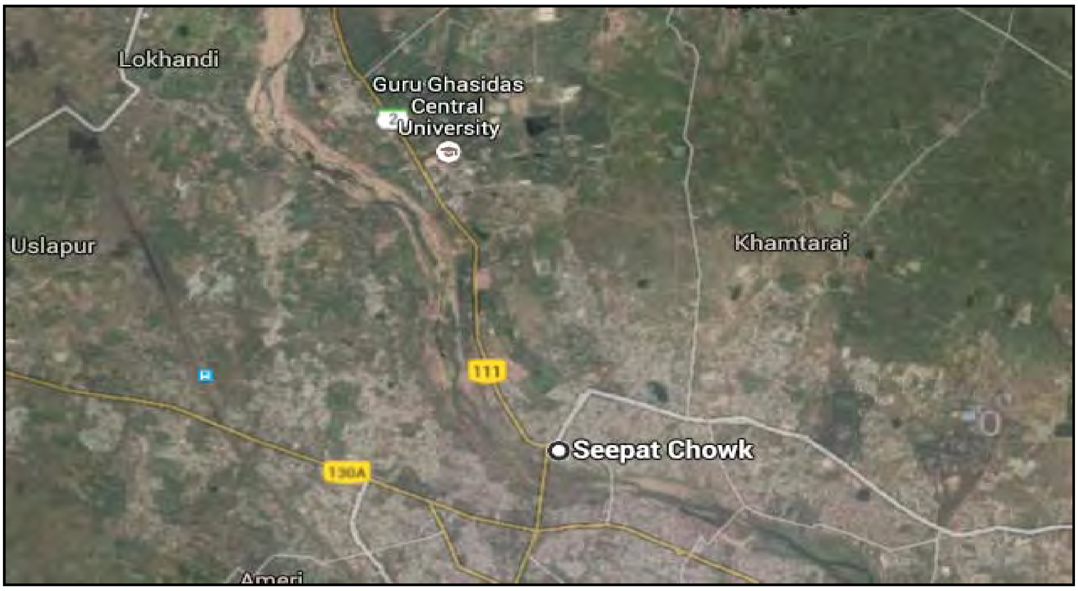

**Fig. 1** Map of Bilaspur city showing the location of study site (Near Seepat chowk: Source: Google map).

### 2.2 Sample collection and preparation

Three commonly occurring roadside plants (*Calotropis procera*, *Butea monospermae* and *Saraca asoca*) were selected. Plant species were selected on the basis of abundance and their adaptability at the selected site. An initial quantity of about 4 to 5 young leaves of per plant was collected.

Samples of plant leaves and topsoil were collected from the highly trafficked area in the month of May, 2015. Leaf samples were collected from the site in polythene bags and immediately transferred to laboratory for further analysis. After collection, dust deposited on the surface of each leaf was removed with the help of fine brush and kept in polythene bags. Further, leaf samples were washed with distilled water for the purpose of removing any left atmospheric deposition. The soil samples were taken from the topsoil using a steel hand shovel and put into plastic bags to minimize contamination. Soil and deposited dust samples were dried at room temperature for 10 days. All the leaf samples were dried in a hot air oven to a constant weight at 70º C for 48 hrs. Dried samples were manually ground and homogenized using a pestle and mortar. In the laboratory, about 0.5 gm of dried leaf, surface dust, topsoil were weighed. Three replicates of each sample were analysed. The accurately weighed samples (0.5 gm dry weight each) were placed in borosilicate beakers. 15 ml of aqua regia solution ($HNO_3$: HCl v/v 3:1) was added to each beaker and the mixture was left overnight at room temperature. Then, it was heated for 1 hr at 50º C and kept aside for cooling. After cooling, solution was filtered through a Whatman filter paper No 1. Further, the filtrate was diluted to 25 ml volume with distilled water. Standard EPA (Environmental Protection Agency) method 3050B (USEPA, 1996) was followed for digestion of samples.

### 2.3 Analytical method

All the samples were analysed for heavy metal concentrations using Graphite Furnace Atomic absorption spectrophotometer (GF-AAS). The elements were measured against a multi- element atomic absorption calibration standard solution obtained at 1000 µg/ml (999 ± 10 µg/ml); dilutions were made to cover a five point calibration. The calibration curve was used to determine unknown concentration of the element. Blank corrections were also made for true value. All concentrations were reported as µg $g^{-1.}$ The detection limit of five target metals were 0.0012 µg $g^{-1}$ (Cd), 0.003 µg $g^{-1}$ (Cu), 0.013 µg $g^{-1}$ (Pb), 0.0012 µg $g^{-1}$ (Ni), 0.0054 µg $g^{-1}$ (Cr). The precision, when expressed in terms of relative standard deviation (RSD %), was between 1- 5 % for all the metals. Accuracy for all the target metals was between 0.5 - 5 %.

## 3 Results and Discussion

### 3.1 Copper

Maximum concentration of copper was found in the foliar dust (49 ± 0.02) µg $g^{-1}$ of *Calotropis procera* (Table 1). In topsoil, maximum concentration of copper (17.4 ± 0.002) µg $g^{-1}$ was reported in *Butea monospermae*. There was positive and significant correlation ($r = 0.99$, $p < 0.01$) between concentration of metals in foliar dust with that of dust accumulated inside leaf. Similarly, there was positive and significant correlation ($r = 0.93$, $p < 0.05$) between concentration of metals in accumulated dust and topsoil. Correlation result indicates that copper metal may be transferred into leaf through both the routes, i.e, air and resuspension from topsoil (Table 2).

### 3.2 Lead

Lead is the most dominant metal of all the metals reported in the foliar dust and leaf tissue of the plants in present study in terms of its magnitude. Concentration of lead in the foliar dust ranged from 48.6 ± 0.01 µg $g^{-1}$ (*Saraca asoca*) to 53 ± 0.005 µg $g^{-1}$ (*Calotropis procera).* In case of topsoil, maximum concentration of lead (9.5 ± 0.009) µg $g^{-1}$ was reported in *Saraca asoca*. There was a positive and significant correlation ($r = 0.94$, $p < 0.01$) between concentration of metals in foliar dust and accumulated dust. However, the correlation ($r = 0.35$)

was not significant between concentration of metals in accumulated dust and topsoil. Correlation results indicate that lead was accumulated inside leaf mainly through airborne PM, while a minor fraction was partitioned from soil.

**Table 1** Concentration of metals deposited on leaf surface in foliar dust, metals accumulated in leaf, and metals in soil (µg $g^{-1}$) in different plant species.

| **Metals** | ***Calotropis procera*** | | |
|---|---|---|---|
| | **Metals in foliar dust** | **Accumulated metals in leaf** | **Metals in soil** |
| **Cd** | 34.3 ± 0.04 | 22.5 ± 0.01 | 13.7± 0.02 |
| **Cu** | 49.0 ± 0.02 | 42.0 ± 0.03 | 16.6 ± 0.08 |
| **Pb** | 53.0 ± 0.01 | 45.5 ± 0.02 | 9.00 ± 0.04 |
| **Cr** | 5.50 ± 0.06 | 3.50 ± 0.02 | 2.00 ± 0.05 |
| **Ni** | 14.5 ± 0.04 | 9.00 ± 0.01 | 13.5 ± 0.04 |
| | ***Butea monospermae*** | | |
| **Cd** | 31.8 ± 0.08 | 19.5 ± 0.01 | 4.20 ± 0.05 |
| **Cu** | 39.6 ± 0.04 | 34.6 ± 0.05 | 17.4 ± 0.02 |
| **Pb** | 49.5 ± 0.02 | 39.7 ± 0.01 | 8.00 ± 0.03 |
| **Cr** | 6.50 ± 0.09 | 4.00 ± 0.02 | 6.00 ± 0.01 |
| **Ni** | 9.50 ± 0.05 | 7.50 ± 0.09 | 5.50 ± 0.01 |
| | ***Saraca asoca*** | | |
| **Cd** | 23.5 ± 0.06 | 16.0 ± 0.03 | 7.50 ± 0.02 |
| **Cu** | 28.0 ± 0.02 | 19.0 ± 0.08 | 2.50 ± 0.01 |
| **Pb** | 48.6 ± 0.01 | 40.7 ± 0.02 | 9.50 ± 0.01 |
| **Cr** | 8.00 ± 0.01 | 7.50 ± 0.05 | 6.50 ± 0.02 |
| **Ni** | 11.0 ± 0.08 | 12.0 ± 0.06 | 41.0 ± 0.08 |

**Table 2** Correlation analysis between accumulated metals in leaf with deposited metals in foliar dust and soil (µg $g^{-1}$) across different metals.

| **S. No** | **Metals** | **Foliar dust vs. Accumulated metals** | **Accumulated metals vs. Soil** |
|---|---|---|---|
| **1** | **Cd** | 0.97** | 0.61 |
| **2** | **Cu** | 0.99** | 0.93* |
| **3** | **Pb** | 0.94** | 0.35 |
| **4** | **Cr** | 0.96** | 0.67 |
| **5** | **Ni** | 0.11 | 0.99** |

*Correlation is significant at 0.05 level.

**Correlation is significant at 0.01 level.

### 3.3 Cadmium

Concentration of cadmium in the foliar dust ranged from 23.5 ± 0.06 µg $g^{-1}$ (*Saraca asoca*) to 34.3 ± 0.04 µg $g^{-1}$ (*Calotropis procera).* In case of metals accumulated in leaf, maximum concentration of cadmium (22.5 ± 0.008) µg $g^{-1}$ was reported in *Calotropis procera*. The concentration of cadmium in topsoil (13.7 ± 0.001) µg $g^{-1}$ was found to be maximum in (*Calotropis procera*). There was a positive and significant correlation (r = 0.97, $p < 0.01$) between concentration of metals in foliar dust with that of accumulated in leaf. However, the correlation (r = 0.61) was not statistically significant between concentration of metals in accumulated dust and topsoil. Correlation results indicate that cadmium was accumulated inside leaf more actively through airborne PM compared to other sources such as topsoil.

### 3.4 Chromium

Concentration of chromium in the foliar dust ranged from 5.5 ± 0.06 µg $g^{-1}$ (*Calotropis procera*) to 8 ± 0.01 µg $g^{-1}$ (*Saraca asoca*) (Table 1). In case of topsoil, maximum concentration of chromium (6.5 ± 0.004) µg $g^{-1}$ was reported in *Saraca asoca*. *Saraca asoca* showed maximum concentration of chromium (7.5 ± 0.003) µg $g^{-1}$ accumulated in leaf. According to Correlation analysis, there was a significant and positive correlation between accumulated metals vs. foliar dust ($r = 0.96$, $p < 0.01$; Table 2). However, the correlation ($r = 0.67$) was not significant between accumulated dust and topsoil. This shows that the chromium metal accumulated inside leaf tissue was taken up mainly through airborne PM and through soil as well.

### 3.5 Nickel

Concentration of nickel in foliar dust ranged from 9.5 ± 0.05 µg $g^{-1}$ (*Butea monospermae*) to 14.5 ± 0.04 µg $g^{-1}$ (*Calotropis procera*). Highest concentration of nickel was reported in the topsoil of *Saraca asoca*. In case of accumulated metals in leaf, concentration of nickel ranged from 7.5 ± 0.09 µg $g^{-1}$ (*Butea monospermae*) to 12 ± 0.06 µg $g^{-1}$ (*Saraca asoca*). Correlation results suggests that, there was a strong and positive correlation in accumulated metals vs. soil ($r = 0.99$, $p < 0.01$). However, the correlation ($r = 0.11$) was not significant between accumulated metals and foliar dust. This shows that Nickel metal accumulated inside leaf was mainly taken up through soil.

## 4 Conclusions

Three roadside species were examined for the presence of hazardous metals in the form of deposited, accumulated dust in the leaves and topsoil of various plants. Correlation results clearly indicate that the main route of accumulation of metals (Cd, Pb and Cr) inside leaf tissue is airborne PM. Lead is the most dominant metal in the foliar dust of *Calotropis procera* in this study. Whereas, in case of topsoil, nickel is the most dominant metal in *Saraca asoca*. Among all the three species studied, *Calotropis procera* was found to have maximum accumulation potential, hence capable of minimizing the effect of toxic heavy metals released through vehicular activity. Moreover, the order of bioaccumulation potential based on the accumulation of target heavy metals in different plant species studied is *Calotropis procera* > *Saraca asoca* > *Butea monospermae.* It is concluded that *Calotropis procera* growing in roadside areas of Bilaspur city can act as a potential biomonitor for Pb, Cd, Ni, Cr and Cu. Moreover, other species (*Saraca asoca* and *Butea monospermae*) also have a considerable potential of biomonitoring and pollution control. There is a pressing need to study the species and metal interaction at diverse locations in varied environmental condition.

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## References

Al-Farraj AS, Al-Sewailem M, et al. 2013. Assessment and heavy metal behaviors of industrial waste water: A case study of Riyadh city, Saudi Arabia. Proceedings of the International Academy of Ecology and Environmental Sciences, 3(3): 266-277

Anim AK, Laar C, Osei J, et al. 2012. Trace metals quality of some herbal medicines sold in Accra, Ghana. Proceedings of the International Academy of Ecology and Environmental Sciences, 2(2): 111-117

Baker AJM, McGrath SP, Reeves RD, Smith JAC. 2000. Metal hyperaccumulator plants: a review of the ecology and physiology of a biological resource for phytoremediation of metal-polluted soils. Phytoremediation of Contaminated Soil and Water, 8: 85-107

Beckett KP, Freer-Smith PH, Taylor G. 2000. Effective tree species for local air quality management. Journal of Arboriculture, 26: 12-19

Hashmi DR, Ismail S, Shaikh GH. 2007. Assessment of the level of trace metals in commonly edible vegetables locally available in the markets of Karachi city. Pakistan Journal of Botany, 39(3): 747-751

Markert B, Wappelhorst O, Weckert V, Herpin U, Siewers U, Friese K, Breulmann G. 1999. The use of bioindicators for monitoring the heavy-metal status of the environment. Journal of Radioanalytical and Nuclear Chemistry, 240(2): 425-429

Meravi N, Prajapati SK. 2013. Effects of heavy metals/metalloids contamination of soils on micronucleus induction in Tradescantia pallida. Environmental Skeptics and Critics, 2(2): 58-62

Nowak DJ, Crane DE, Stevens JC. 2006. Air pollution removal by urban trees and shrubs in the United States. Urban Forestry and Urban Green, 4: 115-123

Prajapati SK. 2012. Biomonitoring and speciation of road dust for heavy metals using *Calotropis procera* and *Delbergia sissoo*. Environmental Skeptics and Critics, 1(4): 61-64

Su C, Zhang WJ, Jiang LQ. 2014. A review on heavy metal contamination in the soil worldwide: Situation, impact and remediation techniques. Environmental Skeptics and Critics, 3(2): 24-38

Suzuki K, Yabuki T, Ono Y. 2009. Roadside *Rhododendron pulchrum* leaves as bioindicators of heavy metal pollution in traffic areas of Okayama, Japan. Environmental monitoring and assessment, 149(1-4): 133-141

USEPA 3050B. 1996. Acid Digestion of Sludges, Solids and Soils. USA

Wagh ND, Shukla PV, Tambe SB, Ingle ST. 2006. Biological monitoring of roadside plants exposed to vehicular pollution in Jalgaon city. Journal of Environmental Biology, 37(2): 419-421

World Health Organization (WHO), 2003. Health aspects of air pollution with particulate matter, ozone and nitrogen dioxide. Report on a WHO Working Group. EUR /03/ 5042688. Regional Office for Europe, Bonn, Germany