

Alstonia scholaris R. Br. and *Cassia siamea* Lamk as possible biomonitors of lead and cadmium in the polluted environment of Karachi city, Pakistan

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Summary

The leaves of *Alstonia scholaris* and *Cassia siamea* were investigated as possible biomonitors of heavy metal pollution in polluted environment of Karachi city. Concentration of heavy metals (lead and cadmium) was determined in unwashed leaves of *A. scholaris* and *C. siamea* collected from a wide range of different sites of the city. Difference between lead and cadmium content varied according to the metal pollutant levels at the sites. The leaves of *A. scholaris* and *C. siamea* growing along the busy roads of the city showed significantly higher concentration of Pb and Cd. The concentration of Pb and Cd in leaves was found quite high at M.A. Jinnah road as compared to Shahrah-e-Faisal, Nazimabad, Gulshan-e-Iqbal and Karachi University Campus. Higher level of Pb and Cd in leaves of *A. scholaris* might be due microrugosity of its surface area that is available for exposure to any pollutant. Low vehicular traffic activities at the campus showed lowest Pb and Cd contents in leaves of both the species. A comparison of leaf analyses gave a reasonably reliable measure of the total aerial fallout of heavy metals at the study area. The highest pollution levels of Pb (95 mg kg⁻¹) and Cd (2.96 mg kg⁻¹) was found in samples of *A. scholaris* at M.A. Jinnah road. Similarly, *C. siamea* also showed high levels of lead (89 mg kg⁻¹) and cadmium (1.76 mg kg⁻¹) at the same point. In this study, *A. scholaris* was found a useful biomonitor of Pb and Cd as compared to *C. siamea*.

Introduction

Pakistan is a developing country and situated on the shores of the Arabian sea. Major cities like Karachi, Lahore, Faisalabad and Hyderabad are suffering by environment related problems due to constant increase in population growth, automobile activities, solid refuse and domestic fuel burning and industrial activities. Transportation activities are considered as the main cause of air pollution. In addition to health, its impact on plant growth and metal contents is also reported. The common effects are alterations in metabolism, chlorophyll disintegration, photosynthesis, morphological and anatomical characters, foliar necrosis, leaf fall, seed quantity and quality, growth and yield reduction. Less production of fruits, flowers and modification in amino acids were investigated in some roadside plants (AHMED and QADIR, 1975; ISMAIL and AHMED, 1984; BHATTI and IQBAL, 1988).

Pollution of heavy metals is a worldwide problem. The concentration of heavy metals particularly lead and cadmium has increased alarmingly in the environment since the last two decade. Emission of Pb from petrol driven motor vehicles in Karachi was estimated to be about 125 tons per annum in 1989 (BEG, 1990). High level of heavy metals (Pb and Cd) were investigated in the leaves of *Eucalyptus* sp., *Ficus bengalensis*, *F. religiosa* and *Guaiacum officinale* from various polluted areas of Karachi city (KHALID et al., 1996). *Rhododendron* leaves were collected from different road site in Bergen, Norway and analyzed for Pb and Cd. Pb levels were found to be highly correlated with traffic density, and rhododendron leaves appear to be excellent bioindicators of roadside Pb pollution (HOL et al., 1997).

Trees in cities face a severe stressful growing environment due to various types of pollutant and environmental degradation. Use of higher plant leaves as a biomonitor of heavy metal pollution in the terrestrial environment has been conducted by AKSOY and SAHLN (1999) and ALFANI et al. (1996). Uptake and accumulation of elements in plants may follow two different paths, i.e., the root system and the foliar surface SAWIDIS et al. (2001). HAMPP (1974) found *Acer platanoides* as an indicator of the traffic caused Pb pollution in the city limits of Munich, when the air borne Pb on the leaves of trees and hedges in an urban environment increased with high traffic densities. Contamination of vegetation by airborne lead, cadmium, copper and nickel in urban areas is mainly by aerial deposition from motor vehicle exhaust (AKSOY and OZTURK, 1996; BRUIN, 1990; KOVACS et al., 1981; KRISHNAYYA and BEDI, 1986; NYANGZBABO and ICHIKUNI, 1986; OTHMAN et al., 1997; SEAWARD and MASHOUR, 1991; SHAMS and BEG, 2000; WARD et al., 1977; WOLTERBEEK, 2002; ZHANG et al., 2008). High level of Pb was found in sweet corn plants (WARD et al., 1975), roadside plants and crops (ALBASEL and COTTENIE, 1985) along the highways. Considerable higher levels of Pb, Cu and Zn have been recorded in soil of some stands, where *Suaeda fruticosa* and *Salsola baryosma* occurred. Trace metals have been associated with *Prosopis juliflora* along the super highways (IQBAL et al., 1998). Leaded gasoline is the primary source of Pb exposure in cities in most developing countries. It accounts for 80-90% of airborne Pb pollution in large cities in which it is still used (LOVEI, 1999).

Alstonia scholaris (Linn.) R. Br. (Apocynaceae), commonly known as Dita bark tree is a beautiful evergreen tree with a tall stem and dark green shiny leaves in whorls of 4 to 10. It exudes milky juice on cutting. *A. scholaris* is an evergreen tree with white, strongly perfumed flowers and is cultivated in Pakistan as an ornamental (NAZIMUDDIN and QAISER, 1983). It is found in tropical Australia, Africa, India to Indonesia and cultivated in Pakistan for ornamental purposes.

Cassia siamea Lam. (Leguminosae) commonly known as Kasood tree, is a moderate sized, well-shaped evergreen tree with a dense crown. It is native to South India. This tree is largely planted for ornamental purposes. The tree grows fairly rapidly, and is easy to cultivate. The aim of the present study was to investigate the levels of Pb and Cd in leaves of *A. scholaris* and *C. siamea* in Karachi city as possible biomonitors of heavy metals.

Materials and methods

Site description

Karachi is situated on the coast along the Arabian Sea at a latitude of 24° 48' N and longitude of 66° 55' E. The soil is calcareous, marine in origin and belongs to upper tertiary period. Moving away from the coast, the ground rises gently forming a large plain to the north and east on which the city is built. The city is between 1.5 and 37 m above sea level. CHAUDHRY (1961) has characterized the climate of Karachi as subtropical maritime desert. Average wind velocity is 12 m s⁻¹ during June and July and 3.5 m s⁻¹ from January

to March. During the southwest monsoon season winds blow from sea towards the coast, whereas during the northeast monsoon their direction is reversed. Therefore, pollutants are pushed inland during the southwest monsoon season and are blown out to sea during the northeast monsoons (UNEP, 1992).

The hot and humid rainy season, which is variable, lasts from June to September. Minimum rainfall (1 mm) is in the month of October whereas, the maximum rainfall (85 mm) occurs in the month of July. The winter season is very short lasting from middle of November to middle of February. The rest of the months constitute the summer, autumn and spring seasons. Temperature is mild with no frost. Dew formation is quite common and the relative humidity is high. The climatic conditions at the control site (Karachi University Campus) are not different from other sites of the city.

Selection of sites

The site in urban area is disturbed mainly by autovehicular activities, includes all main traffic network (Fig. 1; Tab. 1). Karachi University is relatively a clean area.

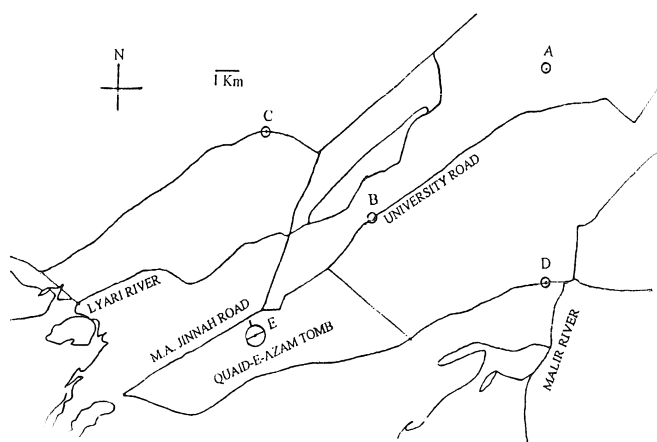


Fig. 1: Map of the study area (A = Karachi University, B = Gulshan-e-Iqbal, C = Nazimabad, D = Shahrahe-Faisal, E = M.A. Jinnah Road).

Tab. 1: Estimated Emission of Pollutant from vehicles in Pakistan, 1996, 1997 and 2000), tons $\times 10^3$.

Pollutants	1996	1997	2000	Source
CO	6000	6500	8000	Qureshi (2000)
HC	1250	1340	1650	
Nox	440	460	540	
SO ₂	69	72	85	
PM ¹⁰	125	135	160	
Total No. of Vehicles	3276000	3515000	4291000	

A. Karachi University Campus: Karachi University Campus is situated at the outskirts of the city. This site is relatively free from the autovehicular activities as compared to other sites of the city. Karachi University Campus is clean and 20 km away from Quaid-e-Azam tomb, the main city centre.

B. Gulshan-e-Iqbal: Gulshan-e-Iqbal is located about 8 km North East of the Quaid-e-Azam tomb. This place is comparatively open with low traffic. However, traffic congestion in the morning hours is common due to trade activities at old vegetable and fruit market.

C. Nazimabad: Nazimabad handles a large traffic volume, moving from north to west of the city. This site is about 10 km away from the North of Quaid-e-Azam tomb.

D. Shahrah-e-Faisal: Shahrah-e-Faisal has many multistoreyed buildings. This site is 15 km from the Eastern site of the Quaid-e-Azam tomb and heavily influenced by traffic activities.

E. M.A. Jinnah Road: This site is the most congested site along the Quaid-e-Azam tomb. Traffic from Gulshan-e-Iqbal, Nazimabad, Liaquatabad and Shahrah-e-Faisal passes through this road. Multi-storyed buildings are common at this site. The slow movement of traffic starts building up toxic pollutants in the area.

Sample collection and analysis of heavy metals in leaf samples

The leaf samples of common roadside trees like *A. scholaris* and *C. siamea* with uniform growth and stem diameter at breast height were chosen from each site. The samples affected by traffic were obtained from the edge of the road at a distance of 1 meter. Twenty-five fresh leaf samples of three individuals of each species were randomly collected from each area at two-meter height throughout the plant canopy to give representative average sample.

The contents of Pb and Cd in the foliage of roadside plants collected from different areas of the city were analyzed. Unwashed leaf samples were oven dried at 80 °C for 24 hours and made in powdered form. Half of a gram powdered leaf sample was taken in 100 mL Pyrex beaker and 10 mL concentrated nitric acid was added. The beaker was partially covered with watch glass to avoid any loss of acid. Later, the beaker was kept on the hot plate in fume chamber for digestion. The sample was digested till a clear solution obtained. The watch glass was removed from the top of the beaker and heating continued till the volume of content was reduced to 1-2 ml. Evaporation was allowed but not to dryness. Later, the content was cooled down. The content was dissolved in 0.1 N HCl, filtered through Whatman filter paper No. 44 and the volume was made up to 50 mL in volumetric flask. Digested plant material solution was analyzed for metal contents on the atomic absorption spectrophotometer (Perkin Elmer 3100) using appropriate cathode. A series of standard solutions for each element in the range of absorbance noted for unknown samples were simultaneously run on atomic absorption spectrophotometer. The calibration curves obtained for absorbance versus concentration data were statistically analyzed using fitting of straight line by least square method. Three replicates were used in this analysis. Concentration of elements is expressed as $\mu\text{g/g}$ of dried samples. All reagents were of analytical grade and all glassware's were carefully cleaned with double distilled water and later rinsed with deionized water. The analyses of Pb and Cd were performed at wavelengths 283.3 nm and 228.8 nm, respectively.

To confirm the validity of data, a comparison from control and between the means of treatment was done by Duncan's multiple range test. The data were statistically analyzed by analysis of variance techniques on personnel computer software package, CO-Stat version 3.

Results

The analysis showed high levels of Pb and Cd in the leaves of *Alstonia scholaris* and *Cassia siamea* collected from the polluted as compared to less polluted sites of the city (Fig. 2, 3; Tab. 3, 4). A significant ($P < 0.05$) difference was found in Pb content in the leaves collected from the polluted and less polluted areas. The values were found higher in the city environment than at Karachi University Campus (Tab. 3). Higher Pb content (95 mg kg^{-1}) was found in

Lead Contents

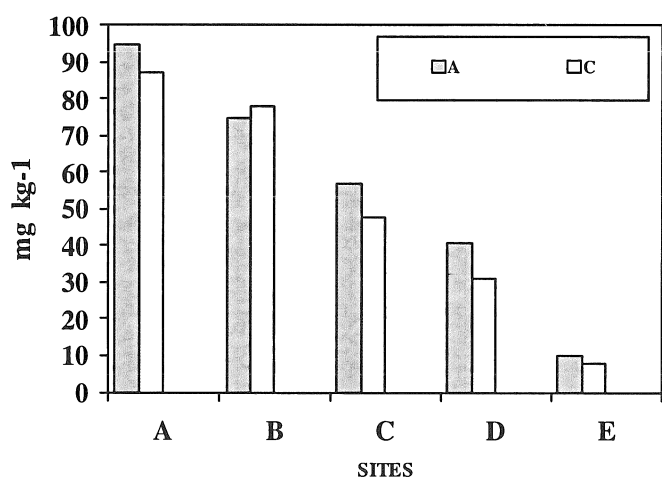


Fig. 2: Level of lead (mg kg⁻¹) in the foliage of (A) *A. scholaris* and (C) *C. siamea*. Sites A = M.A. Jinnah Road, B = Shahrah-e-Faisal, C = Nazimabad, D = Gulshan-e-Iqbal, E = Karachi University Campus.

Cadmium Contents

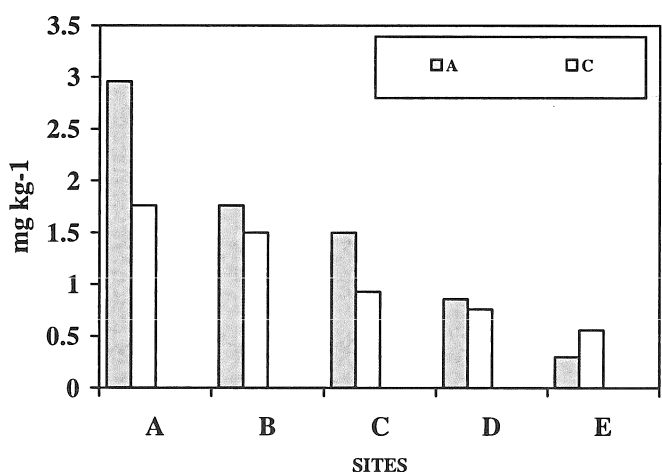


Fig. 3: Level of cadmium (mg kg⁻¹) in the foliage of (A) *A. scholaris* and (C) *C. siamea*. Sites A = M.A. Jinnah Road, B = Shahrah-e-Faisal, C = Nazimabad, D = Gulshan-e-Iqbal, E = Karachi University Campus.

A. scholaris at M.A. Jinnah Road, while the minimum (10 mg kg⁻¹) was recorded at Karachi University Campus. At Shahrah-e-Faisal, the concentration of Pb was significantly (P<0.05) higher (75 mg kg⁻¹) as compared to control. An average level of Pb (57 mg kg⁻¹) content was recorded in the leaves of *A. scholaris* from Nazimabad site, while low concentration of Pb (41 mg kg⁻¹) was found in the leaves of same species collected from Gulshan-e-Iqbal (Fig. 2).

Cd analysis in leaves of *A. scholaris* showed low levels as compared to Pb (Tab. 4). The leaves of *A. scholaris* showed high level of Cd in samples collected from the city area as compared to Karachi University Campus. Cd level in leaves of all the species were found in the range of 0.30-2.96 mg kg⁻¹. The highest level of Cd (2.96 mg kg⁻¹) was found in the leaves of *A. scholaris* growing at M.A. Jinnah Road. The level of Cd in the leaves of *A. scholaris* collected from

Tab. 3: Concentration of lead in the foliage of different plants.

Name of Species	Sites	Pb (mg kg ⁻¹)
<i>Alstonia scholaris</i>	E	*95.00±2.88 a
	D	75.00±3.46 b
	C	57.00±4.04 c
	B	41.00±2.88 d
	A	10.00±2.88 e
L.S.D. p<0.05		10.3
<i>Cassia siamea</i>	E	87.00±1.52 a
	D	78.00±2.64 b
	C	48.00±1.52 c
	B	31.00±4.61 d
	A	8.00±1.15 e
L.S.D. p<0.05		7.8

Symbol used: Sites A = Karachi University Campus, B = Gulshan-e-Iqbal, C = Nazimabad, D = Shahrah-e-Faisal, E = M.A. Jinnah Road. Statistical significance determined by analysis of variance. Number followed by the same letters in the same column are not significantly (p<0.05) different, according to Duncan's Multiple Range Test. * Mean ± Standard Error.

Tab. 4: Concentration of cadmium in the foliage of different plants.

Name of Species	Sites	Cd (mg kg ⁻¹)
<i>Alstonia scholaris</i>	E	*2.96±0.057 a
	D	1.76±0.057 b
	C	1.50±0.288 c
	B	0.86±0.115 d
	A	0.30±0.230 e
L.S.D. p<0.05		0.600
<i>Cassia siamea</i>	E	1.76±0.057 a
	D	1.50±0.034 ab
	C	0.93±0.132 abc
	B	0.76±0.577 bc
	A	0.56±0.150 c
L.S.D. p<0.05		0.866

Symbol used: Sites A = Karachi University Campus, B = Gulshan-e-Iqbal, C = Nazimabad, D = Shahrah-e-Faisal, E = M.A. Jinnah Road. Statistical significance determined by analysis of variance. Number followed by the same letters in the same column are not significantly (p<0.05) different, according to Duncan's Multiple Range Test. * Mean ± Standard Error.

Shahrah-e-Faisal, Nazimabad and Gulshan-e-Iqbal, were 1.76 mg kg⁻¹, 1.50 mg kg⁻¹ and 0.86 mg kg⁻¹, respectively (Fig. 3).

The analysis also showed high levels of Pb and Cd in the leaves of *C. siamea* collected from the polluted as compared to less polluted sites of the city (Fig. 2, 3). The values were found higher in the city environment than at Karachi University Campus. A significant (p<0.05) difference was found in Pb content in the leaves collected from the polluted and less polluted areas. The level of lead in the leaves of *C. siamea* was found high at M.A. Jinnah Road (87 mg kg⁻¹), followed by Shahrah-e-Faisal (78 mg kg⁻¹), Nazimabad (48 mg kg⁻¹), and Gulshan-e-Iqbal (31 mg kg⁻¹), respectively (Fig. 2). Lowest level of lead (8 mg kg⁻¹) was recorded in the foliage of *C. siamea* growing at Karachi University Campus. Cd analysis in leaves of *C. siamea* showed low levels as compared to lead (Fig. 2). The leaves

sample of *C. siamea* showed high level of Cd in samples collected from the city area as compared to Karachi University Campus. High amount of Cd (1.76 mg kg^{-1}) in the leaves of *C. siamea* was found at M.A. Jinnah Road, while the lowest Cd (0.56 mg kg^{-1}) was recorded at Karachi University Campus. Levels of Cd in the leaves were 1.50, 0.93 and 0.76 mg kg^{-1} in samples collected from Shahrah-e-Faisal, Nazimabad and Gulshan-e-Iqbal sites, respectively.

Discussion

Emissions from automobile contribute most to air pollution problems. Trees growth performance in cities are under widespread pressure of autovehicular emission. In plant organs, the leaf is the most sensitive part to be affected by air pollutants. The sensitivity rests on the fact that the major portions of important physiological processes are concentrated in the leaf. Therefore, the leaf at its various stages of development, serves as a good indicator to air pollutants. Pollutants derived from the autoemission can directly affect the foliage of plants by entering the leaf, destroying individual cells, and reducing the plant ability to produce biomass. It is found that the plants growing close to the busy road of the city are good accumulator of pollutant released from auto emission. A major and increasing impact upon the environment is that of roads and their associated vehicular traffic (ANGOLD, 1997). Studies have been conducted to find plants and microorganisms with potential capacity to remove heavy metals from soil and aqueous solutions (SOARES et al., 2008).

The results of the present study testify this grave situation facing for trees growing at the polluted sites. Trees are dying as a result of prolonged exposure of exhaust emission especially at M.A. Jinnah Road. The concentrations of heavy metals in the leaves of *A. scholaris* was significantly higher at the polluted environment of city as compared to clean area.

C. siamea plants growing at two different sites (polluted and non-polluted) on two important roads of Agra city (India) exhibited significant differences in their flowering phenology and floral morphology. The flowering in plants growing at polluted site was delayed and there was a marked reduction in flowering density, flowering period, size of floral parts, pollen fertility, fruit, seed-set and concluded that these changes were found to be closely associated with the extent of air pollution caused mainly by significant in the number of automobiles CHAUHAN et al. (2004). The metal accumulation potential and growth performance of ornamentally, economically and medicinally important non-nodulated leguminous plant, *Cassia siamea* Lamk, having potential to establish on degraded lands (KUMAR et al., 2000).

In urban areas, vehicular emissions and dust resuspension associated to road traffic become the most important manmade source (PEREIRA et al., 2007). For the last 40 years road transport emissions were considered to be the principal source of Pb in the urban environment (GEORGE et al., 2007). Atmospheric contamination is of major importance as it allows a multidirectional transfer over great distances. The present findings helps us in understanding of how the leaves of tree species accumulates atmospheric contaminants and to what extent a routine use of plant materials may be conceived for atmospheric contamination monitoring. For this purpose, we compared the levels of heavy metals (Pb and Cd) deposited on the surface of the leaves of plants growing in the different polluted sites of the city. A comparative study of the capabilities of *A. scholaris* and *C. siamea* tree leaves as a biomonitor of atmospheric heavy metal pollution is reported. Results of this study support that leaves of both tree species can be used for air pollution monitoring in urban sites, where severe environmental conditions are resulting due to automobile activities. Pb is a natural element which can be found in the Earth's crust but also in the biosphere and is one of the most

studied contaminants (among heavy metals). The tree species chosen for this study *A. scholaris* and *C. siamea* are very common species in Karachi. In a preliminary study, it was shown that phenology, periodicity and biomass production of both species significantly affected due to automobile activities. These atmospheric pollutants play an important part in growth and development of plants growing in the polluted environment, hence the urgent need to lessen them quantitatively. Therefore, the quantification of such contaminants has come to a priority issues for the betterment of the environment. Therefore, the estimation of the atmospheric contaminating is necessary for understanding the current level of pollutant in the environment. It might be helpful in understanding the current level of available pollutant in order to raise the alarm about excessive atmospheric contaminants levels increasing due to automobile activities. Overall, the results reported here demonstrate that leaves of both tree served as a good bioindicator and can be used in elemental air pollution monitoring studies in urban sites. The use of plants as a complementary tool to traditional (instrumental) methods of studying atmospheric pollution from anthropogenic and natural sources became an established technique in the past 30-40 years because of the development of powerful analytical techniques (BERLIZOV et al., 2007). A comprehensive review on the use of plants for air-monitoring purposes was given by (NIMIS, 1990; MULGREW and WILLIAMS, 2000). In present investigation, a comparative study of the capabilities of *A. scholaris* and *C. siamea* tree leaves as a biomonitor of atmospheric heavy metal pollution is recorded. Results of this study support that leaves of both tree species can be used for air pollution monitoring in urban sites, where severe environmental conditions are resulting due to automobile activities. In conclusion, the present study brings out the clear picture about the levels of trace metals present in the biological material collected from the different site of the city. The dominant metals in local atmosphere Pb and Cd exhibited significant contributions. The relatively higher levels of both metals are indicative of the fact that the local atmosphere is undergoing to an alarming situation for the plant health due to automobile activities. It is high time to evolve an air pollution abatement strategy to ward off people against the hazardous effects arising from elevated trace metal levels (SHAH and SHAHEEN, 2007). Heavy metals from vehicular emissions have continuously added to the pool of contaminants in the environment (HASHISHO and EL-FADEL, 2004; HARRISON et al., 1981; WONG and TAM, 1978). Modern civilization introduces a wide range of pollutants to the atmosphere through various activities (EL-HASAN et al., 2002). Traffic emissions on roads are the main cause of heavy metal accumulation on the surrounding environment including vegetation, which might have an ecological effect on them. CASSELLES (1998) found that some heavy metals such as Pb decrease in the leaves of plants with increasing distance from the road. High Pb concentrations that were attributed to vehicle emission sources were reported in Amman City center (JARADAT et al., 1999). Metal contamination from automobile activities sources is an important environmental concern in Pakistan. Thus, the monitoring of airborne metals in the urban environment has become an essential part of environmental planning and control programs in many parts of the world (LEE et al., 2005). Biomonitoring is a technique using organisms or biomaterials to obtain (quantitative) information on certain characteristics of the biosphere (WOLTERBEEK, 2002). The use of plant materials as a bio-indicators study is an easy to collect, cheaper, and have higher concentrations than air and rainwater (HUHN et al., 1995; KUIK, 1994; MARANON and SASTRE, 1991; VAZQUEZ et al., 1994; WALKENHORST et al., 1993). The result could be used as preliminary baseline data for trace elements concentrations in the ecosystems for future assessment and monitoring. Environment friendly organization in public and governmental sectors, environment management worker, policy-

makers, scientists, educators and researcher are providing informative data on the biomonitoring of various types of pollutants. It is based on the sampling and analysis of the materials collected from the contaminated site. Plant, soil, water and air samples are most commonly measured. This technique helps in investigating the level of contamination of pollutants in any given environment. The results of these measurements provide information and guide about the current level of pollutants in the environment.

Higher plants may be used as biomonitors for the assessment of atmospheric heavy metal pollution by means of their bioaccumulative properties (TOMASEVI et al., 2004).

Plant materials such as tree bark, tree rings and leaves of higher plants have been used to detect the deposition, accumulation and distribution of metal pollution for many years (AKSOY and SAHLN, 1999; SAWIDIS et al., 1995). To study airborne dust particles deposited in the polluted areas, the most suitable method is leaf collection (FREER-SMITH et al., 1997). It is logical to conclude that heavy metals, which are discharged into the atmosphere through motor vehicles exhaust, are deposited on and penetrate into leaves. Pb is one of the best known heavy trace elements, with a long history of toxicity. Its exposure is becoming a great concern because of its toxic nature, wide spread occurrence and long life in biological system. The Pb content in this study was found in the range of 8-95 mg kg⁻¹ with great differences among sites and plant species. In the present study the concentration of Pb in leaves sample of *A. scholaris* was found high at polluted site as compared to Karachi University Campus. This high level of Pb at the polluted site might be due to presence of high Pb additive compounds used in petrol. A complete monitoring data on both metals is sparse. However, it should be noted that Pb content of petrol are quite high (1.5-2.0 mg kg⁻¹), which are above the guideline of World Health Organization (0.5-1.0 mg kg⁻¹) (UNEP, 1992). Air borne Pb is closely associated with the density and congestion of motor vehicle traffic. It is therefore not surprising to see that Pb concentrations in the leaf of trees growing at M.A. Jinnah Road was quite high as compared to leaf samples collected from other less polluted sites (Shahrah-e-Faisal, Nazimabad, Gulshan-e-Iqbal and Karachi University Campus) of the city. Accumulation and deposition of metals on the surface of leaves can increase the metal concentrations. The higher level of Pb in the leaf of *A. scholaris* (95 mg kg⁻¹) was recorded at M.A. Jinnah road as compared to *C. siamea* (89 mg kg⁻¹), which might be due to the large surface area that is available for exposure to any pollutant. AKSOY et al., (2000) found high level of Pb (15.98-177 mg kg⁻¹) in unwashed leaves sample of *Robinia pseudo-acacia* growing along roadside of Kayseri city, Turkey. High concentration of Pb in leaves sample of *C. siamea* was also found at similar site (M.A. Jinnah Road) where the traffic density was highest as compared to Karachi University Campus. The amount of Pb potentially available to plants in any given locality obviously depends on the density of vehicles. Low vehicular traffic activities at the campus showed lowest Pb contents for *A. scholaris* and *C. siamea*.

Cd level in the air is also an important component leading to the problems of environmental pollution. Cd is a transitional metal and is a relatively volatile element. It reacts readily with non-oxidizing acids, releasing hydrogen and giving the divalent ions. Cd in the form of cadmium sulfate is available in the environment and geochemically is quite mobile in soil, water and thus freely taken up by plants. Cd is also one of the metals highly dispersed by human activities (KABATA-PENDIAS and DUDKA, 1990). LAGERWERFF and SPECHT (1970) have suggested that Cd is found in lubricating oils as a part of many additives. The concentration of Cd in leaf samples collected from M.A. Jinnah Road, Shahrah-e-Faisal, Nazimabad, Gulshan-e-Iqbal and Karachi University Campus showed similar distribution as found for Pb. The data emphasized that motor vehicles traffic load is a major cause of high level of Cd content in

leaf samples of *A. scholaris* collected from the polluted areas of the city. The flow of traffic at M.A. Jinnah Road near Quaid-e-Azam tomb is quite slow due to presence of traffic signals. The area is rather congested with the result that pollutants emitted from the motor vehicles remained suspended in the atmosphere for some time and ultimately deposited on the surface of leaves. Level of Cd was found in the range of 0.30-2.96 mg kg⁻¹. Maximum level of Cd (2.96 mg kg⁻¹) was found at M.A. Jinnah road, which is highly polluted sites of the city. Similarly, AKSOY and SAHLN (1999) investigated high level of Cd (1.38 mg kg⁻¹) in unwashed leaves of *Eleagnus angustifolia* collected from the crowded parts of city center in Kayseri (Turkey). ARA et al. (1996) had also found Cd content in the leaves of *Ficus religiosa* (0.036 mg kg⁻¹) and *Eucalyptus* sp. (0.033 mg kg⁻¹) from some other polluted area of the city.

These results indicate those metal aerosols after deposition on the leaf surface of a species is responsible for increase in the level of Pb and Cd at the city area as compared to Karachi University Campus. An enhancement of Pb was found in roadside soil and vegetation due to combustion of leaded petrol by automobile exhaust in Baghdad city (KHALID et al., 1981). Moreover, in the present study it was observed that *A. scholaris* leaf sample collected from the polluted sites also showed a tendency of higher concentration of Cd. YOUSAFZAI (1991) found the level of Cd (0.2-4.5 mg kg⁻¹) in the street dust of metropolitan city of Karachi and concluded that Pb in roadside dust of Karachi city was mostly attributed to leaded gasoline from vehicular traffic. KARTAL et al. (1992) studied Pb, Ni, Cd and Zn pollution of traffic in Kayseri (Turkey) and found direct correlation between the number of cars and the heavy metals.

Overall study for Pb and Cd accumulation and their levels in foliage of roadside plants reveals that plants growing in the polluted city environment are badly affected by autoemission. However, *A. scholaris* was found a good accumulator of Pb and Cd which could resist the polluted environment of the city to some extent. The results indicate that automobile activities have contaminated excessively with heavy metals. *A. scholaris* and *C. siamea* may be a good indicator of the metal level predominantly Pb and Cd. These elements get into the environment in the largest quantities due to poorly maintained vehicles, and reach higher levels in the immediate environment. High level of Pb and Cd concentration suggests that traffic is a significant source of both metal deposition in the city. The different levels of Pb and Cd in the foliage of *A. scholaris* and *C. siamea* have been investigated from different sites of the city. The pattern of Pb and Cd deposition shows that concentrations decrease with the intensity of pollutant level on the road. KINGSTON et al. (1998) observed that vegetation sited close to the motorway results indicate that different tree species have different propensities for the capture and retention of Pb. High Pb concentration in air and soil in urban areas has been attributed to increasing number of automobiles, especially leaded petrol (HEINZE et al., 1998). Concern over the potential ecotoxicological hazards posed by elevated levels of metals in the environment has prompted a search to find reliable, low cost methods of assessing the extent of metal contamination at local environment and the exposure risk to both plants and animals. One avenue of research has been to identify organisms that could potentially be utilized as biological monitors for estimating levels of metal pollution. In present days, exposure to toxic metals like Pb in daily life increased marginally (MUMTAZ et al., 1999; WILLIAM and ALTAF, 1989). In densely populated urban area of Karachi with more than 10 million population surviving with a mean concentration of 2990 mg kg⁻¹ Pb in street dust and annual addition of 28, 447 kg of Pb in the environment (YOUSUFZAI, 1991). Pb is a widely distributed and non-biodegradable toxic metal in the environment. It has been added to petrol since the 1920s as an anti-knocking agent, to improve fuel efficiency and to reduce wear on vehicle engines. Leaded petrol has caused more environmental Pb exposure

than any other source (LANDRIGAN, 2002). Cd is also a cumulative toxic agent and its half life in blood is estimated to be 2-3 months (WILLIAM, 1988), smoking, tobacco chewing, as pigment in plastics, electric batteries and as an anticorrosive use of Cd are the source of Cd exposure to human (FIBERG et al., 1986; WHO, 1996). The concentrations of Pb, and Cd were analyzed in surface deposit of *A. scholaris* and *C. siamea* leaves from different sites of the urban area of Karachi, exposed to different degrees of automobile pollution. These included major roads with heavy traffic loads. The Pb and Cd content were significantly higher ($P < 0.05$) in leaves from roadside sites than in leaves from campus. A correlation between leaf size was found Pb and Cd content, thus suggesting that trace metal contents of leaves directly depend on atmospheric depositions and size of the leaves. Moreover, metal accumulation was high at the polluted site and was comparable at control and polluted sites. There has been a continuing interest in the biomonitoring of heavy metal content in roadside trees. Therefore, it is suggested that plantations of plant species having larger leaf surface area like *A. scholaris* should be planted along the busy roads of the city. No doubt, national efforts to deal with this increasing problem are under way in many major cities, but such efforts must be strengthened. There is also a need for enforcement of regulations to control environmental pollution. Public participation, non-governmental organization and civic agencies of the government require a collective approach towards this solution. Continuous air monitoring for one or more pollutants is an absolute necessity for completing a diagnosis of pollutant level in the air, water and soil environment. More importantly, a network of monitoring stations throughout the country would be helpful to measure the current pollutant level. Accumulation of air monitoring data will provide the criteria needed for establishing air quality standards. Considerable recovery in the environment quality is possible if the heavy reliance on the automobile discouraged.

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