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Research Article

Analysis of deposition of heavy metal dust on the leaves of few selected tree species in Kanchipuram town, Tamil Nadu, India

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Abstract

Biomonitoring of heavy metals is one of the economic methods to identify and improve the quality of air. The aim of this work was to identify the concentration of nine heavy metals viz. Fe, Pb, Cu, Zn, Al, Cd, As, Cr and Mn in the ambient air deposited on the leaves of five tree species such as *Saraca asoca, Terminalia catappa, Syzygium cumini, Ficus religiosa and Pongamia glabra* collected from six sites such as Pallavarmedu (Site I), CSI hospital (Site II), Moongilmandapam (Site III), Collectrate (Site IV), Near Cancer Institute (Site V) and VellaGate (Site VI) of the Kanchipuram town of TamilNadu State, in the months of February - March 2019. Even with some differences in the concentration of nine heavy metals on the species, few were identified with significant correlation, suggesting that these pollutants were emitted from similar sources. The deposition of iron (235.53mg/kg) and aluminium (157.91mg/kg) were higher on the leaves of *S.asoca* compared with other species. The metals such as Cu, Cd, As, Pb and Cr were nil and not detected on the leaves, but Pb concentration was high (185.79 mg/kg) only on *P. glabra* at Site 2 and Cr (2.37 mg/kg) was found on the leaves of *S. asoca* at Site 1. The heavy metal dust deposited on the leaf surface was probably due to vehicular emission and other anthropogenic activities. The analysis showed that all the selected tree species acted as a biomonitor and should be grown that may help to improve the air quality of the area.

Keywords: Biomonitoring, Correlation, Deposition, Heavy metals, Species

INTRODUCTION

Heavy metals are one of the major sources of pollution in the environment due to abrupt changes in agricultural methods, rapid urbanization, industrialization and man-made activities (Kuang *et al.,* 2007; Aprile *et al*., 2010 and Liu *et al.,* 2016). These pollutants emitted into the ambient air has drastically increased and created severe health hazards to the human population and the other living components of the environment (Zouari *et al.,* 2018). Most of the heavy metals emitted into the atmosphere originate mainly from anthropogenic mobile and stationary sources compared to natural sources. Their concentration was exceeding several times greater than the original emission rate due to bio geochemical cycles. (Kula *et al.,* 2010 and Aslam *et al.,* 2012). Monitoring of heavy metals is most important to assess their distribution with time and locations and take inevitable steps to control or minimize the pollution in the environment (Yildiz *et al.,* 2010).

Monitoring of these heavy metals by equipment posed difficulties by setting an environmental station with skilled technicians and only suitable for some selected areas. Contrarily plants are greatly distributed in remote areas of which some are tolerant of various pollutants, have easy access, are cheaper to monitor and have ease in sampling identified this technique as a very effective one (Ejidike and Onianwa, 2015; Ogunkunle *et al.,* 2015 and Sharma and Uniyal, 2016). Recent investigations like *Tilia spp*. and *Pinus spp.* were used for the analysis of heavy metals in the air (Serbula *et al*., 2013) and Date palm leaves were used for biomonitoring the deposition of atmospheric heavy metal pollutants in Southwestern Iran (Naderizadeh *et* *al*., 2016) have shown that plants are considered as the effective and the best system for biomonitoring and acting as bioindicators for atmospheric pollutants especially for heavy metals. Biomonitoring by plant species has been carried out in two ways as passive monitoring and active monitoring techniques, first one is by planting or introducing the sensitive plants and the later one is using the plants existing at present in the environment (Nakazato *et al.,* 2018).

Polluted sites specifically with various metal pollutants were monitored frequently by the lower plants such as mosses and lichens due to their more accumulation ability (Jiang *et al*., 2018 and Yatawara and Dayananda 2019). Nowadays, higher plants (trees) are widely accepted in urban areas with more levels of pollution where mosses and lichens are rarely distributed (Arslan *et al.,* 2009; Khattak and Jabeen, 2012; Deepalakshmi *et al.,* 2014 and Maghakyan *et al*., 2016).

The absorption, adsorption and accumulation process on the leaves' surface are greater compared than other parts of the plants such as roots, barks and stem. Leaves are sensitive to various air pollutants that show visible changes on their surface depending upon their sensitiveness. The adsorption capacity of the pollutants on their surface or absorption inside the leaves depends upon the size and opening of stomata. The concentration of pollutants can be easily observed from the symptoms and responses shown by the plant species growing in that particular site (Mansour, 2014 and Kaur and Nagpal, 2017).

It has been reported that single species may not act as a suitable bioindicator for monitoring the heavy metal pollution worldwide. Hence, different types of species were identified and used as bioindicators (Coskun 2006). Some of the species, like mosses exhibit their sensitivity towards the single or a mixture of various pollutants (Blagnyte and Paliulis, 2010 and Terpo *et al*., 2014).

The aim of this work is to analyze the concentration of nine heavy metals as Zinc, Manganese, Lead, Iron, Copper, Chromium, Cadmium, Arsenic and Aluminium deposited on the leaf surface of the five selected tree species such as *Sarca asoca* (Ashoka), *Terminalia catappa* (Almond)*, Ficus religiosa* (Peepal)*, Pongamia glabra* (Pongam) and *Syzygium cumini* (Jamun)*,* growing at different sites of Kanchipuram town. The statistical analysis was carried out to find the significant relationship between different metals. This work was also used to identify species with higher capability to deposition of specific heavy metals on their leaves.

MATERIALS AND METHODS

Studied plant species

In the present study, five tree species were ubiquitous at all sampling sites; thus, based on easy availability following trees were shortlisted to have a representative sample from all studied sites.

1. *S. asoca* – It is an evergreen tree growing up to 9 m with existence in different parts of India. Leaves are dark green with 30 to 60cm long, rigidly sub-coriaceous and oblong.
2. *T. catappa* – It is a large tree found in tropical areas. This deciduous tree grows up to 35 m tall. The tree has broad leaves with a size of 10–14 cm width and 15–25 cm long in egg-shaped with the narrower end at the base arranged in close spirals that fall in the dry season. Their leaves are leathery and glossy dark green.
3. *F. religiosa* – It is an evergreen or deciduous tree that grows up to a height of 20m. Leaves are simple, stout, articulated, glabrous, shining, coriaceous, dark green in colour and size 7.5–10 cm long.
4. *P. glabra* – It is a fast-growing deciduous tree found up to the height of 25 m. Leaves are small, caducous, oblong, glabrous, and chartaceous. It has deep green leaflets of 5–9cm.
5. *Sy. cumini* – It is an evergreen tree up to 25 m in height. The leaves are simple, smooth, glossy, leathery and elliptic to oblong or ovate shape with 5–10 cm in length.

All the selected five species are commonly found in all sites chosen for the present work.

Study area

Kanchipuram is a temple city that is 72 km away from Chennai, the capital of Tamil Nadu. The city covers an area of 11.605 km^2 and its population as per the census carried out in 2011 was 1,64,265. Kanchipuram is located at 12.8387°N and 79.7016°E on the banks of the Vegavathi River, a tributary of the Palar river and its elevation is 83.2 m above sea level (https://en.wikipedia.org/wiki/Kanchipuram). Kanchipuram is very famous for silk weaving and many varieties of silk sarees are available. Hence it is named silk city. Nowadays, the city's population is significantly increasing in urban areas due to various reasons like it is nearer to Chennai, moderate cost of living, and many industries.

Sampling sites

The samples were collected during the months of February - March 2019 from six different sites in Kanchipuram town of Tamil Nadu in a distributed form as Industrial area, Institutional area, sensitive zone, high-density traffic area, commercial area and habitat area are given in Table 1.

Site 1, Pallavarmedu has more number of houses, large park, movement of four wheelers are less and 1.7 km from the bus stand hence it was taken as a control site, site 2 is located with CSI hospital and Government hospital, 0.35km away from the bus stand and is the route for buses to reach the outer periphery of the

Table 1. Sampling sites of the area of Kanchipuram town selected for the study.

Sampling Sites					
S1 (Control)	**S2**	**S3**	**S4**	**S5**	**S6**
Pallavarmedu	CSI hospital	Moongilmandapam	Collectorate	Near Cancer Institute	Vella Gate (WG)
Residential area	Sensitive area	Heavy traffic area	Commercial area	Institutional area	Industrial area

town. Site 3 is 0.3 km from the bus stand and the density of traffic is more since it is the main junction to enter the town. Site 4 is 2 km away from the bus stand with collector office, police training centers, Archaeological and survey department. Site 5 with Cancer Institute and Bhaktavatsalam Polytechnic College, located on the Chennai-Bangalore National highway and 4 km from the town. Site 6 with many numbers of rice mills and is located on the Arrokonam-Tirupati state highway.

Sampling

Ten leaves from all the selected five tree species such as *S. asoca*, *T. catappa*, *F. religiosa*, *P. glabra* and *Sy. cumini* were picked up at the height of 1.8m to 2.4m as per Anicic *et al*. (2011). The sampling was carried out in the month of February-March 2019 and the fresh leaves were collected in the morning from 6.00 a.m. to 8.00 a.m. It was ensured that there was no precipitation prior for more than 30 days and large amount of dust was deposited on the leaves. The leaves of these species were taken based on their easy availability for the current research work to identify the deposition of heavy metal dust on their leaf surface. These samples were stored in an airtight zip-locked polyethylene bags and taken to the laboratory for experimental analysis of the concentration of heavy metals accumulated on the surface of the leaves. The heavy metals were initially mineralized by closed vessel microwave digestion process and analyzed by using Inductively coupled mass spectrometry (ICPMS) (Galea *et al.,* 2015).

Statistical analysis

Descriptive statistical analysis was carried out for the heavy metals sampled from six sites of five species and Pearson's correlation coefficient and regression analysis was found out by using SPSS version18.0 software.

RESULTS AND DISCUSSION

The results obtained from the experimental analysis showed a widespread pattern of heavy metals in the ambient air and the deposition capacity of metals varied with samplings such as time and method of collection, sites and species. The mean, median, minimum and maximum values of six metals such as Fe, Pb, Zn, Al, Cr and Mn and that of other metals Cu, Cd and As concentrations as nil in all the selected five species are mentioned in Table 2.

The sources of the heavy metals like Pb and Zn released from traffic, wear and tear of vehicle tires and abandoned automobile parts have been described (Norouzi *et al*., 2015 and Naderizadeh *et al*., 2016). Mn in the air originated from the soil, Fe emitted into the air both from natural and anthropogenic sources (Yildiz *et al*., 2010; Ugulu *et al*., 2012 and Maghakyan *et al*., 2016). Cr originated from motor vehicles. Cu due to the combustion of coal and heavy traffic (Liu *et al*., 2017).

There was some variation in the concentration of few heavy metals in all the tree species. Fe in *S. asoca* varied between 12.73 to 235.533 mg/kg, whereas the range of 0-0, 2.39-16.58, 3.54-157.91, 0-2.37 and 0-5.61mg/kg was observed for Pb, Zn, Al, Cr and Mn, respectively. In *T. catappa* the range of the heavy metals was 4.29-40.99 mg/kg, 0-0, 0-2.09, 0-76.166, 0-0 and 0-2.76 mg/kg for Fe, Pb, Zn, Al, Cr and Mn, respectively. In *F. religiosa* the concentration of heavy metals ranged as 3.35-104.5, 0-0, 4.95-17.34, 3.96-122.5, 0-0 and 0-5.43 mg/kg for Fe, Pb, Zn, Al, Cr and Mn, respectively. In *P. glabra* the maximum and minimum values of heavy metals laid between 6.65 to 85.82 mg/kg for Fe and 0-185.79, 0-51.12, 0-108.36, 0-0, 0-4.85 mg/kg for Pb, Zn, Al, Cr and Mn, respectively. The values of heavy metals in *Sy. cumini* ranged as 14.78-51.54, 0-0, 0-3.46, 6.53-72.98, 0-0 and 0-3.54 mg/kg for Fe, Pb, Zn, Al, Cr and Mn, respectively. The mean concentration of all the six metals was in the order of Pb <Cr <Mn <Zn <Al <Fe in *S. asoca* (0 < 0.4 < 2.89 < 4.4 < 44.9 < 85.36) and *F. religiosa* (0 < 0 < 0.91< 5.08 < 26.51< 37.32), Pb <Cr <Mn <Zn <Fe <Al in *T.catappa* (0 < 0 < 0 < 0 < 11.9 < 23.9) and *Sy.cumini* (0 < 0 < 1.46 < 1.78 < 29.02 < 34.06), Cr <Mn <Zn <Al <Pb <Fe in *P. glabra* (0 < 1.17 < 9.7 < 23.06 < 30.97 < 33.5).

Tiwari *et al*. (2016) reported the heavy metals such as Cr, Cu, Cd, Ni and Pb deposited on the leaves of *S.asoca* due to high vehicular traffic in Bilaspur city, Chhattisgarh. Patel *et al*. (2015) investigated the concentration of heavy metals (Zn, Pb, Mn, Hg, Cu, Cr, Cd, Fe and As) deposited on the leaves of *F. religiosa* in the industrial city, Korba, out of which the iron (1700mg/kg) content was more due to coal burning. Agrahari *et al*. (2018) investigated the lead uptake by *F. religiosa* from nine sites in Gorakhpur city, Uttar Pra-

Table 2. Statistical analysis of heavy metals deposited on the leaves of five species from the sites.

Species	Parameters (mg/kg)	Mean	Median	Max	Min	SD
S. asoca (Ashoka)	Iron (Fe)	85.36	66.97	235.533	12.73	85.39
	Lead (Pb)	0	0	0	0	0
	Zinc (Zn)	4.4	2.59	16.58	2.39	6.23
	Aluminium (Al)	44.9	10.95	157.91	3.54	63.03
	Chromium (Cr)	0.4	0	2.37	0	0.97
	Manganese (Mn)	2.89	3.08	5.61	0	1.83
T. catappa (Almond)	Iron (Fe)	11.9	11.72	40.99	4.29	14.8
	Lead (Pb)	0	0	0	0	0
	Zinc (Zn)	0	0	2.09	0	0.85
	Aluminium (Al)	23.9	18.29	76.166	0	28.1
	Chromium (Cr)	0	0	0	0	0
	Manganese (Mn)	0	0	2.76	0	1.13
F. religiosa (Peepal)	Iron (Fe)	37.32	28.6	104.5	3.35	39.44
	Lead (Pb)	0	0	0	0	0
	Zinc (Zn)	5.08	2.48	17.34	4.95	6.89
	Aluminium (Al)	26.51	8.6	122.5	3.96	47.66
	Chromium (Cr)	0	0	0	0	0
	Manganese (Mn)	0.91	0	5.43	0	2.22
P. glabra (Pongam)	Iron (Fe)	33.5	24.87	85.82	6.65	27.32
	Lead (Pb)	30.97	0	185.79	0	75.85
	Zinc (Zn)	9.7	1.03	51.12	0	20.39
	Aluminium (Al)	23.06	8.14	108.36	0	42.02
	Chromium (Cr)	0	0	0	0	0
	Manganese (Mn)	1.17	0	4.85	0	2
Sy. cumini (Jamun)	Iron (Fe)	29.02	26.02	51.54	14.78	13.68
	Lead (Pb)	0	0	0	0	0
	Zinc (Zn)	1.78	2.35	3.46	0	1.44
	Aluminium (Al)	34.06	30.49	72.98	6.53	24.84
	Chromium (Cr)	0	0	0	0	0
	Manganese (Mn)	1.46	1.19	3.54	0	1.64

desh and they suggested that *F. religiosa* was a suitable bioindicator for the Pb in air pollution. Tak *et al*. (2019) analyzed the five heavy metals (Zn, Mn, Fe, Cr, Cu) from the dust deposited on roadside plants (*F. religiosa, F. bingolensis, Mangifera indica, Cassia fistula, Alstonia scholaris and Bauhunia variegate*) situated on the National highway of Thane, Mumbai city and concluded that the plants were planted along the roadside where the vehicular emission was high.

The present study indicated that the concentrations of heavy metals as Cu, Cd and As were below their detectable limit and the values were nil in all the experimental six sites of five species. Fe concentration was found at six sites in five species with wider variations. It was maximum on *S.asoca* at site 6, site 2 and *P. glabra* at site 1 (Fig. 1). The maximum concentration may be due to the wear and tear of the vehicles into the atmosphere. Site 2 was more polluted even though it was coming under sensitive area now it had been the major route due to one way under traffic regulation and species exposed were nearer to the road. Deposition of Al was found with higher concentration at site 2 in the leaves of *S. asoca*, *F. religiosa* and *P. glabra* at site 1 on *S.asoca* and *Sy. cumini* and at site 6 on *T. catappa* (Fig. 2). This higher value reflected the more usage of Al, fuel combustion, windblown dust from urban areas, and solid waste disposal related to its production in the mentioned sites selected for this study. Hashimoto *et al*. (1992) discussed and found that the source for Al in the air was due to human activities. Zn concentration was found high only at site 6 on *P. glabra* due to more vehicle movement, wear and tear of tires, and there was no deposition on *T. catappa* except at site 2 with minimal values (Fig. 3). The concentration of Mn was low in most of the sites and its deposition was nil on *T. catappa* and *F. religious* at all sites except at site 2 (Fig.

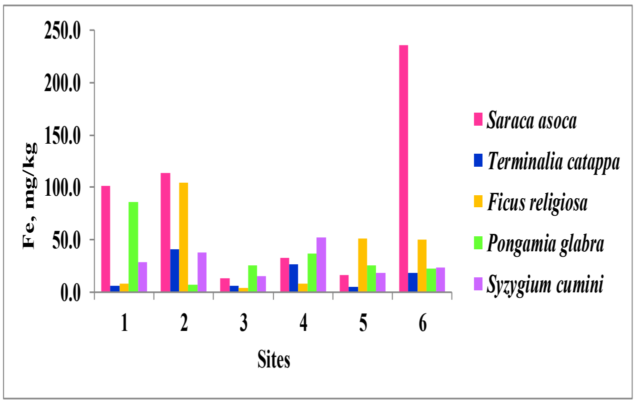

Fig. 1. *Fe concentration of the selected sites in five tree species .*

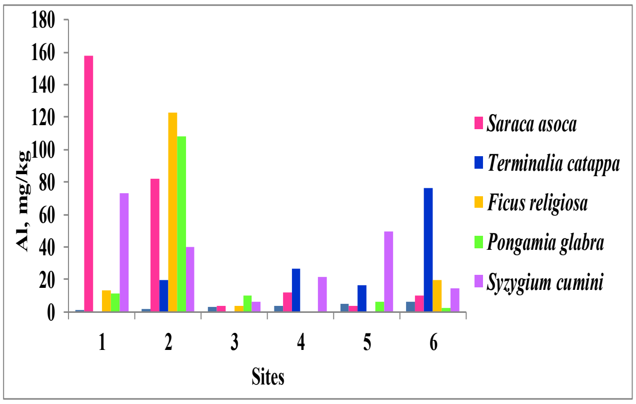

Fig. 2. *Al concentration of the selected Sites in five tree species.*

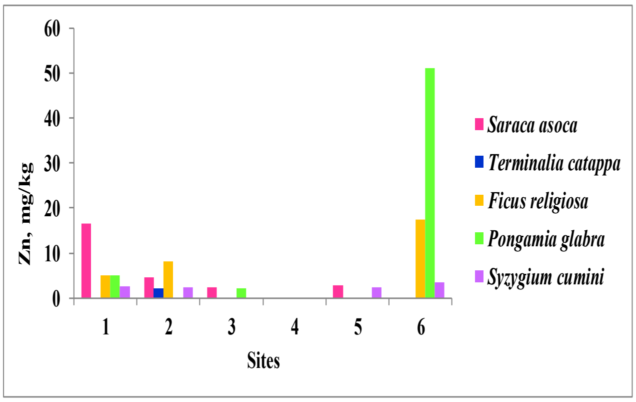

Fig. 3. *Zn concentration of the selected Sites in five tree species.*

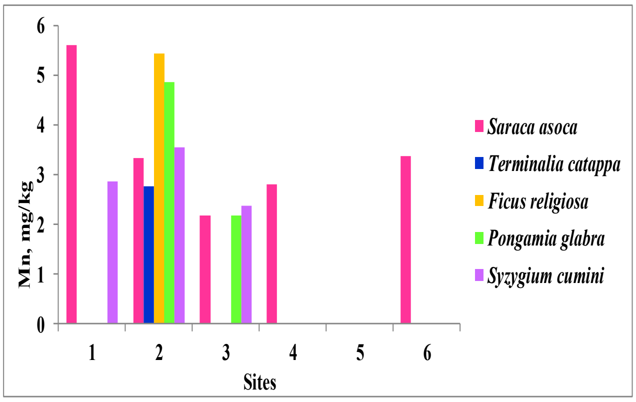

Fig. 4. *Mn concentration of the selected Sites in five tree species.*

Fig. 5. *Pb concentration of the selected Sites in five tree species.*

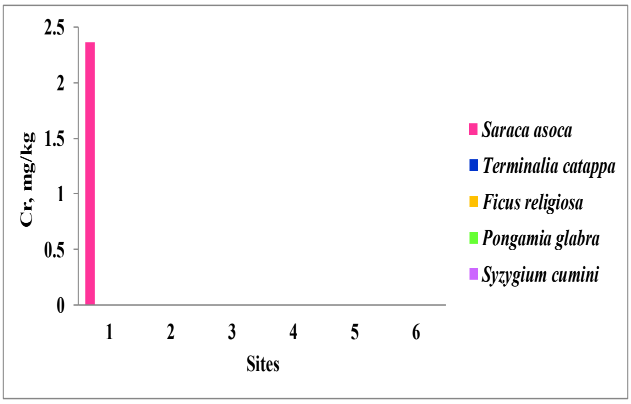

Fig. 6. *Cr concentration of the selected Sites in five tree species.*

4). Lead was deposited with a higher concentration on the leaves of only *P. glabra* in site 2 due to the congestion of vehicles and their values were nil at remaining sites and in the other four species (Fig. 5). Possible remedial measures should be taken to reduce the level of Pb in site 2 since it is coming under a sensitive zone. Like Pb, Cr was also found on *S. asoca* with lesser concentration only at site 1 (Fig. 6). Even though site 1 was considered the control site, it was also polluted with a higher amount of Fe, Al, and other metals found with minimal values due to increased anthropogenic activities and frequent movement of two-wheelers.

The correlation coefficient values (Table 3) and regression equations obtained from the analysis (Table 4 and Fig.7- Fig.11) showed the relationship between the various heavy metals selected from six sites in five species. In *S.asoca,* Fe had a minimum correlation with Zn, Al, Cr, Mn and no relation with Pb. Zn had significant correlation with Al (r=0.935) and Cr (r= 0.959), moderate correlation with Mn (r=0.659). A high correlation was found in Al with Cr (r=0.878) and Mn (r=0.794). Cr

Table 3. Correlation values of heavy metals deposited on the five species of six sites.

Species	Parameters	Fe	Pb	Zn	Al	Cr	Mn
S.asoca (Ashoka)	Fe	1	.a	0.011	0.193	0.092	0.494
	Pb		.a	.a	.a	.a	.a
	Zn			1	**0.935**	**0.959**	0.659
	Al				1	**0.878**	0.794
	Cr					1	0.730
	Mn						1
T. catappa (Almond)	Fe	1	.a	**.802**	.296	.a	**.802**
	Pb		.a	.a	.a	.a	.a
	Zn			1	-.059	.a	**1**
	Al				1	.a	-.059
	Cr					.a	.a
	Mn						1
F. religiosa (Peepal)	Fe	1	.a	.453	**.845**	.a	**.835**
	Pb		.a	.a	.a	.a	.a
	Zn			1	.364	.a	.222
	Al				1	.a	**.987**
	Cr						.a
	Mn						1
P. glabra (Pongam)	Fe	1	-.481	-.112	-.430	.a	-.544
	Pb		1	-.233	**.995**	.a	**.900**
	Zn			1	-.269	.a	-.312
	Al				1	.a	**.916**
	Cr					.a	.a
	Mn						1
Sy.cumini (Jamun)	Fe	1	.a	-.259	.047	.a	-.038
	Pb		.a	.a	.a	.a	.a
	Zn			1	.446	.a	-.003
	Al				1	.a	.323
	Cr					.a	.a
	Mn						1

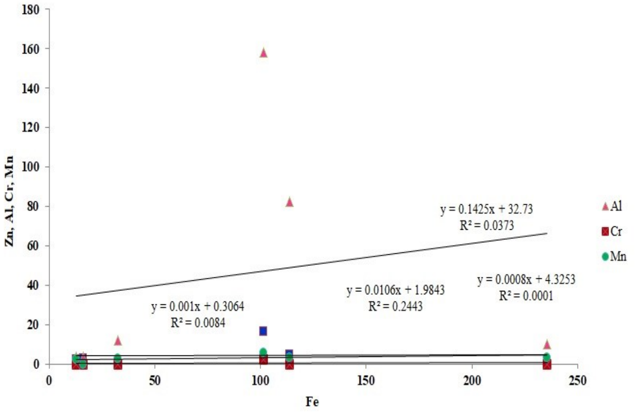

Fig. 7. *Regression equation for Fe Vs Zn, Al, Cr, Mn in S. asoca.*

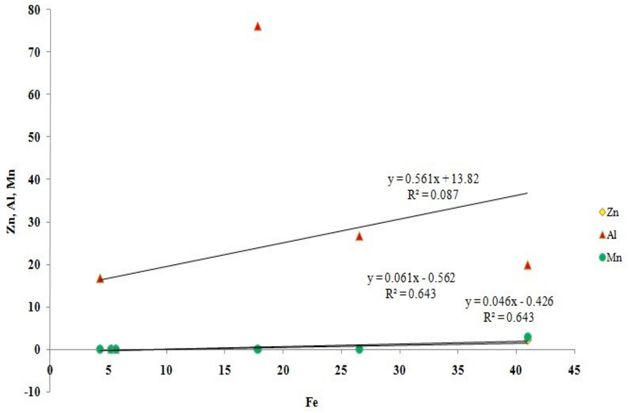

Fig. 8. *Regression equation for Fe Vs Zn, Al, Cr, Mn in T.catappa.*

was positively correlated with Mn (r=0.730) (Fig. 7). In *T. catappa* Fe was significantly correlated with Zn (r=0.802) and Mn (r=0.802), positive correlation with Al. Zn was negatively correlated with Al and Al was negatively correlated with Mn. Other metals were not correlated with any other (Fig. 8). In *F. religiosa,* Fe was significantly correlated with Al (r=0.845), Mn (r=0.835) and a positive correlation with Zn and no correlation with other metals. Zn was positively correlated with Al and Mn. Al was significantly related to Mn (r=0.987) (Fig. 9).

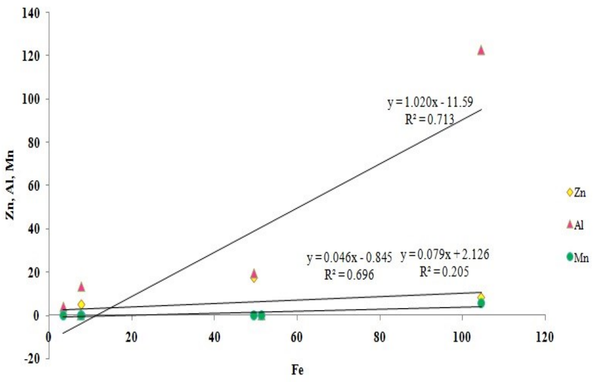

Fig. 9. *Regression equation for Fe Vs Zn, Al, Cr, Mn in F. religiosa.*

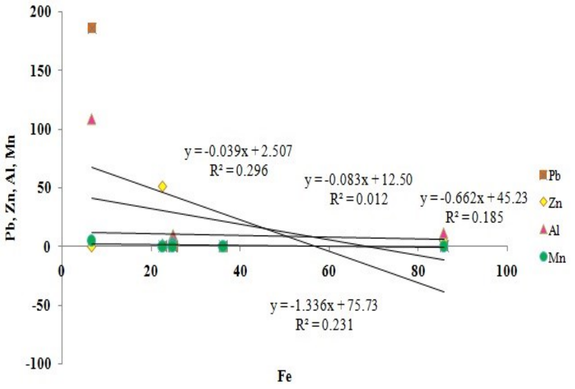

Fig. 10. *Regression equation for Fe Vs Zn, Al, Cr, Mn in P. glabra.*

Table 4. Regression equations of heavy metals depoSited on five species of six sites.

Species	Parameters	Y = ax+b	R^2
S.asoca (Ashoka)	Fe Vs Zn	Y= 0.000x+4.325	0
	Fe Vs Al	Y= 0.142x+32.73	0.037
	Fe Vs Cr	Y= 0.001x+0.306	0.008
	Fe Vs Mn	Y= 0.010x+1.984	0.244
T. catappa (Almond)	Fe Vs Zn	Y= 0.046x-0.426	0.643
	Fe Vs Al	Y= 0.561x+13.82	0.087
	Fe Vs Mn	Y= 0.061x-0.562	0.643
F. religiosa (Peepal)	Fe Vs Zn	Y= 0.079x+2.126	0.205
	Fe Vs Al	Y= 1.020x-11.59	0.713
	Fe Vs Mn	Y= 0.046x-0.845	0.696
	Fe Vs Pb	Y= -1.336x+75.73	0.231
P. glabra (Pongam)	Fe Vs Zn	Y= -0.083x+12.50	0.012
	Fe Vs Al	Y= -0.662x+45.23	0.185
	Fe Vs Mn	Y= -0.039x+2.507	0.296
Sy.cumini (Jamun)	Fe Vs Zn	Y= -(0.027x)+2.573	0.067
	Fe Vs Al	Y= 0.084x+31.59	0.002
	Fe Vs Mn	Y= -(0.004x)+1.595	0.001

In *P. glabra* Fe was negatively correlated with Pb, Zn, Al and Mn. Pb showed a significant correlation with Al (r=0.995) and Mn (r=0.900) and negatively with Zn. Al was highly related to Mn (r=0.916). There was no correlation between heavy metals and Cr (Fig. 10). In *Sy.cumini* Fe showed a negative correlation with Zn and Mn and slightly correlated with Al. Zn had a positive correlation with Al and negatively with Mn. Al had weak relation with Mn (Fig. 11). Fe, Al, Zn, Mn and Cr were positive and significantly correlated, showing that there may be a common source for their occurrence and influenced by industrial activities and dense traffic. The results obtained from the regression analysis showed a positive correlation with the metals. Liu *et al*. (2016) measured the concentration of six heavy metals such as Zn, Pb, Ni, Cu, Cr, Cd in moss samples,

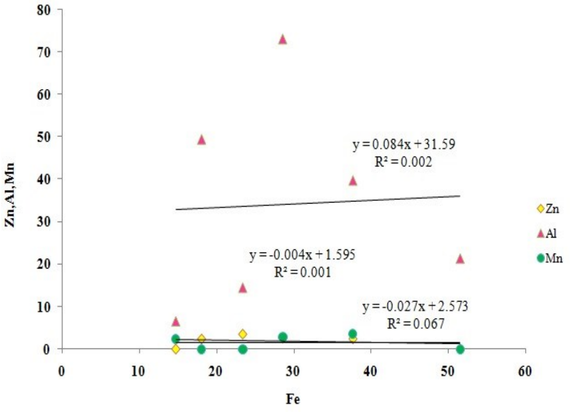

Fig. 11. *Regression equation for Fe Vs Zn, Al, Cr, Mn in Sy.cumini.*

Xuzhou city, China, identified that certain heavy metals had a significant correlation between them and suggested that these pollutants were emitted from identical sources.

Conclusion

The tree species such as *S. asoca, T. catappa, Sy. cumini, F. religiosa and P. glabra* for biomonitoring of heavy metals like Fe, Pb, Cu, Zn, Al, Cd, As, Cr and Mn in the ambient air and adopted with all selected sites indicated the significant differences in the levels of deposition of these metals. The metals such as Cu, Cd and As were below their detectable limits. Pb was only found on *P. glabra* and Cr with a minimum concentration of 2.37 mg/kg on *S. asoca*. The deposition of Fe (235.53-3.35 mg/kg) and Al (157.91-0 mg/kg) was found higher than other metals and was deposited on all the species with varying concentrations. Of all the selected tree species *S. asoca* acted as a better bio monitor for the heavy metals and other species viz. *T. catappa, Sy. cumini, F. religiosa and P. glabra* also showed a good response. Due to higher traffic and other anthropogenic activities, the deposition of pollutants was more in the sensitive areas and near industrial areas than in other selected sites. Thus, all the five tree species were good biomonitors and should be grown to maintain the green belt around the industries and improve the quality of air in the environment.

Conflict of interest

The authors declare that they have no conflict of interest.

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