Heavy metal contamination in Plants and Soils

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ABSTRACT

Concentration of Fe, Mn, Zn, Cu, Pb, Cd and Cr were measured in tree species such as Azardirachta indica, Pongamia glabra and Delonix regia and soil samples at the depths 0-20cm and 20-40cm respectively. The mean heavy metals concentrations were found to be below the normal range and also the critical concentration in soil. Bio accumulation coefficient for all the heavy metal and for all the three selected plant species at residential site was found to be less compared to traffic and industrial sites. The geo accumulation index for Fe, Mn and Cr was found to be 0 <I geo ≤ 2 belongs to class 2 that is moderately polluted. The geo accumulation index for Cd was found to be 3 < Igeo ≤ 4 belongs to class 4 that is strongly polluted .Enrichment factor for Cu and Cd shows moderate enrichment in the soil at depth (0 - 20 cm) and (20 - 40 cm) respectively. Enrichment factor for plant shows Pb and Cd are more enriched in the plants. Factor analysis was done to identify the source of heavy metals. Pearson correlation matrix performed to find the degree of association between heavy metals and confirmed by cluster analysis. The study of SEM and X – ray diffraction pattern provides information about morphology and particle size of the heavy metals present in the samples. Uptake patterns of metals into leaves and soils were found to be the same in all the sampling species could be indifferently used as bio - monitors.

INTRODUCTION

It has been observed that plants are far more sensitive to pollution than animals and man are therefore, used as indicators. Attempts have been made to develop certain plant strains, which can be specially used for predicting a particular pollution and can be extensively used in bioassay techniques [1]. Leaf is the plant part, which is most sensitive to pollution. The pollution indicator value of the leaf has been exploited by a large number of workers. On the basis of their responses to pollutants under field and laboratory conditions, plants have been classified into sensitive and tolerant ones. Other sources of heavy metal contamination associated with agricultural soil are sewage sludge, fertilizers and pesticides [2,3]. The Concentration of heavy metals in soils is influenced by variation in their texture, composition, reduction /oxidation reactions, adsorption /desorption and physical transport or sorting in addition to anthropogenic metal input [4-6].

Heavy metals are considered as soil contaminates due to their widespread occurrence, acute and chronic toxicity [7, 8]. Thus, the contamination of agricultural soils with heavy metals has always been considered a critical challenge in scientific community .Due to their cumulative behavior and toxicity, they have a potential hazardous effect not only on vegetation but also on human health and also trees in cities are more prone to heavy metal pollution due to pervasive pressure of auto vehicular emissions [9, 8]. Among heavy metals, lead and cadmium toxicity has become important due to their constant increase in the environment. The high sensitivity of plants towards some pollutants means that a great variety of plants can be used as bio indicators of heavy metals pollution in soil. Wenzel and Jockwer [10], Namiesnik and Wardenisk [11], Chandhari and Gajghate [12], Witting and Markert [13] and Sarala et al., [3] worked on the basic criteria for selection of species as a bioindictor .The major criteria are species should be represented in large numbers all over the monitoring area, have a wide geographical range, be possible to differentiate between airborne and soil-borne heavy metals, be easy to sample and there should be no identification problems. *Azardirachta indica, Pongamia glabra and Delonix regia were selected for this study as the plants that are the most common roadside in most of the areas of Dindigul town and can serve as bio indicators of heavy metal pollution. The aim of this study was to evaluate the potential risk of pollution in the urban soil of Dindigul town and also use plants bio monitors.*

THE STUDY AREA DESCRIPTION AND SAMPLE COLLECTION
1. Monitoring Town Dindigul
The study area is located in the southern part of India, close to Kodaganal river basis, mainly in hard rock terrain. The area is known for its leather industries. It lies between 10° 13'44" – 10°26'47" N latitude and 77 °55'08" – 78 °01'24" E longitude.

2. Selection of Sampling Species
Azadirachta indica, Pongamia glabra and Delonix regia samples were collected at different sites. The pattern of sampling collection was depended on the presence of both chosen plants at the same sampling site as well as the demand to select sampling sites located at different distances around and from the industrial complex .One control site for each species was established at about 5 km from the study area .Since it was impossible to find a common control where both species grew. Control site were selected according to local authority information because they have meteorology similar to the other sampling sites, they are far from the influence of the industrial focuses and they have quite low traffic level. Therefore in each transect three species were collected. Leaf samples of Azadirachta indica, Pongamia glabra and Delonix regia together with soils in the immediate vicinity of the plants were collected according to the protocol used by Rossini Oliva and Mingorance [14]. Fig.1 shows the picture of plants selected for studies.

3. Sampling Procedure
Six samples were collected from (Oct 2011 to Feb 2012) each site at random to cover the entire sampling area. Large stone and plant materials were removed, and the samples were dried for three days at 60oC and Sieved through #60 nylon mesh. To determine the mobility of heavy metals, six core samples were collected between 0-20cm and 20-40 cm depth using a core extractor of 2.5 cm diameter. Composite samples of respective depths were prepared, air dried for days and sieved through a 1-mm nylon mesh. The samples were stored in polyethylene bags then treated and analyzed separately.

4. Sample Preparation and Analysis (Heavy Metals)
500 g of each air dried composite sample was ground separately to pass through a 2 mm sieve. About 5 gm of the homogenized sample from each group was ground into fine powder using agate mortar and pestle and further dried in hot air oven at 70 0 C for 72 hrs to constant weights (ISO 1995). Exactly 1g from each of these finely ground soil samples were weighed out using an electronic balance into properly cleaned 250 ml glass beakers.

Digestion was performed by adding 12 ml of aqua regia (3:1,v/v, concentrated HCl to concentration HNO3) into the beaker covered with watch glasses on a hot plate for 3h at 110 °C. After

evaporation to near dryness carefully, the sample was diluted with 20 ml of 2% (v/v with water) nitric acid and transferred into a 100ml volumetric flask after filtering through Whatman no:42 filter paper and diluted to 100ml with double distilled water [15, 16] and used for chemical analyses. Heavy metal analysis was carried out with the atomic absorption spectrophotometer. Quantization of Fe, Mn, Zn, Cu, Pb, Cr and Cd was carried out using standard solutions in the same acid matrix. A reagents blank for soil was also prepared by carrying out the whole extraction procedure, but without samples.

SAMPLE COLLECTION AND ANALYSIS
The morphology and particle size of the individual heavy metals were examined by scanning electron microscopy (SEM) and X-ray diffraction studies. The X-ray diffraction pattern about particles were analyzed using multivariate techniques (Hierarchical cluster analysis, Principal factor analysis) to determine the principal components of metals .The analysis was performed using JSM-6390 Scanning microscope (JOEL) equipped with a thin window oxford instruments and XRD (Shimadzu-6000). Samples were collected randomly and analyzed.

RESULTS AND DISCUSSION
The data presented in the table-1 reveals an average concentration of different heavy metals in the urban soil of Dindigul town. At depth (0-20 cm) the Iron concentration in the soil varied from 8.57 mg kg-1 to 11.15 mg kg-1. The major source identified for Fe was due to stacking of over burden dump and fugitive emission. At depth (20-40 cm) Fe content of the soil varies from 6.84 mg kg-1 to 9.10 mg kg-1. Manganese found in the range of 11.52 mg kg-1 to 19.20 mg kg-1 at depth (0-20 cm) and 9.64 mg kg-1 to 17.52 mg kg-1 at depth (20-40 cm).Critical Manganese concentration in soil is rather high 1500-3000 mg kg-1, while Critical concentration in plants is in the range of 300-500 mg kg-1 [17]. The Zinc content in the soil varied from 1.97 mg kg-1 to 2.96 mg kg-1 at depth (0-20 cm) and 1.25 mg kg-1 to 2.96 mg kg-1 at depth (20-40 cm) respectively. Copper found in the range of 3.29 mg kg-1 to 9.15 mg kg-1 at depth (0-20 cm) 2.73 to 9.15 mg kg-1 at depth (20-40 cm) respectively.

The Lead found in the range of 0.76 mg kg-1 to 0.952 mg kg-1 at depth (0-40 cm) and 0.48mg kg-1 to 0.860 mg kg-1 at depth (20-40 cm) respectively. The presence of Pb coming from the emission of vehicles as well as its presence in the soils polluted with wastes from different operations. The Cadmium concentration found in the soil at the depth (0-20 cm) was found to be 0.028 mg kg-1 to 0.16 mg kg-1 and at the depth (20-40 cm) 0.016 mg kg-1 to 0.84 mg kg-1 respectively. Chromium is found in soil in the range of 1.08 mg kg-1 to 4.68 mg kg-1 at depth (0-20 cm) and 0.92 mg kg-1 to 2.56 mg kg-1 at the depth (20-40 cm) respectively**.**

It is shown in the table-2 and 2 a, the Iron content was found to be in the range of 214.8 mg kg-1 to 352.22 mg kg-1, 194.0 to 290.75 mg kg-1 and 231.7 mg kg-1 to375.75mg kg-1 respectively for *Azadirachta indica, Pongamia glabra and Delonix regia. Iron is not considered a toxic heavy metal, because of its function in a number of normal physiological processes in plants [18].*

The manganese content was found to be in the range of 25.53 mg kg-1 t 62.12 mg kg-1, 36.20 to 51.88 mg kg-1 and 31.5 mg kg-1 to 85.32 mg kg-1 respectively for *Azadirachta indica, Pongamia glabra and Delonix regia. Mn plays a significant role in carbon dioxide assimilation and nitrogen metabolism [19].*

The Zinc content was found to be in the range of 17.68 mg kg-1 to 43.25 mg kg-1, 13.97 to 74.75 mg kg-1 and 20.52 mg kg-1 to 39.32mg kg-1 respectively for *Azadirachta indica, Pongamia glabra and Delonix regia .Zn concentration in the plants is generally considered to be around 80-100 μg gm*-1 [20]. and value below 15 μg gm-1 is regarded as a sign of deficiency. All the three species were not found to be deficient. The Copper content was found to be in the range of 10.17mg kg-1 to 25.08 mg kg-1, 8.41 to 17.42 mg kg-1 and 14.72 mg kg-1 to 42.03 mg kg-1 respectively for *Azadirachta indica, Pongamia glabra and Delonix regia*

.Although the concentration of Cu in the polluted area is more than the un- polluted area, however it is well below critical level in plants [21].

The Lead content was found to be in the range of 2.45 mg kg-1 to 53.57 mg kg-1, 1.26 to 48.4 mg kg-1 and 2.08 mg kg-1 to 42.33 mg kg-1 respectively for *Azadirachta indica, Pongamia glabra and Delonix regia. Pb toxicity in plants is in the range of 10 μg gm*-1 - 20 μg gm-1 [22]. All the species had level of Pb above the toxic range for the plants. Cadmium content was found to be in the range of 0.024 mg kg-1 to 3.50 mg kg-1, 0.054 to 4.57 mg kg-1 and 0.033.mg kg-1 to 1.6mg kg-1 respectively for *Azadirachta indica, Pongamia glabra and Delonix regia. Concentration in plants or the lowest level of Cd which can cause yield reduction is between 5-30 mg kg*-1. Surprisingly very minimum Cd was detected in plant samples. This may be due to a very low level (Below detection limit) of Cd in the available soil for plant growth [23]. Cd is considered highly toxic to plants in the range of 5 μg gm-1 to 10 μg gm-1 [22]. In all the species, Cd content was found to be under the normal limit. Chromium content was found to be in the range of 0 mg kg-1 to 1.17 mg kg-1, 0 to 1.95 mg kg-1 and 0 mg kg-1 to 1.94 mg kg-1 respectively for *Azadirachta indica, Pongamia glabra and Delonix regia. An elevated concentration between 5-30 mg kg*-1 is considered critical for plants and could cause yield reduction [19].The concentration level of Cr is well below the critical level and hence acceptable.

1. Bioaccumulation Coefficient
The ratio between plant and soil concentrations is an index of element soil-plant transfer that may favor the understanding of the plant uptake characteristics [24]. **Bioaccumulation coefficient greater than one indicates that the plants enrich these elements [25] and a ratio at around 1 indicates a rather in different behavior of the plant towards these elements (indicator), [25].**

Bioaccumulation coefficient that expresses the ratio of metal concentration in plants to its concentration soil.

$$MR = M_{plant / M soil} \text{ ------------- (1)}$$

Bioaccumulation **coefficient for Iron varies between 25.20 to 34.79, 20.49 to 26.74 and 27.36 to 33.65 at depth (0-20 cm) and 31.58 to 4.41, 23.80 to 32.81 and 334.28 to 41.23 at depth (20-40 cm) for** *Azadirachta indica, Pongamia glabra and Delonix regia respectively. The Bioaccumulation Coefficient of Manganese varies between 1.32 to 5.43, 2.01 to 4.04 and 1.62 to 6.22 at depth (0-20 cm) and 1.44 to 6.48, 2.20 to 4.85 and 1.778.08 at depth (20-40 cm) Azadirachta indica, Pongamia glabra and Delonix regia respectively. The Bioaccumulation Co-efficient for Zinc varies between 9.34 to17.91, 6.57 to 13.58 and 9.054 to 15.04 at depth (0-20cm) and 14.48 to 22.08, 11.36 to 36.80 and 10.72 to 18.54 at depth (20-40 cm) for Azadirachta indica, Pongamia glabra and Delonix regia respectively. The Bio accumulation Coefficient for Copper varies between 1.93 to 3.22, 1.49 to 2.68 and 3.52 to 4.62 at depth (0-20 cm) and 1.99 to 3.88, 1.53 to 3.22 and 3.62 to 5.57 at depth (20-40 cm) for Azadirachta indica, Pongamia glabra and Delonix regia respectively. The Bio accumulation Coefficient for Lead varies between 3.68 to 58.08, 1.71 to 52.45 and 2.5 to 46.38 at depth (0-20 cm) and 1.99 to 3.88, 1.53 to 3.22 and 3.62 to 5.57 at depth (20-40 cm) for Azadirachta indica, Pongamia glabra and Delonix regia respectively. The Bioaccumulation Coefficient for Cadmium varies between 1.071 to 33.77, 0.714 to 40.351 and 1.88 to 45.83 at depth (0-20 cm) and 1.88 to 45.83, 1.25to 54.76 and 1.88 to 19.52 at depth (20-40 cm) for Azadirachta indica, Pongamia glabra and Delonix regia respectively. The Bioaccumulation Coefficient for Chromium varies between 0 to 0.55, 0 to 0.74 at depth (0-20 cm) and at depth (20-40 cm) for Azadirachta indica, Pongamia glabra and Delonix regia respectively.*

2. Geo Accumulation Index
The assessment of soil or sediment enrichment can be carried out in many ways. The most common one is the index of geo accumulation [25]. In this work, the geo accumulation index (I geo) have been applied to assess heavy metals (Fe, Mn, Zn, Cu, Pb,

Cd and Cr) distribution and contamination in the soil samples in the Dindigul Town.

The index of geo accumulation index (I_{geo}) was originally used with bottom sediment by Muller [26]. It is computed by the following equation.

Igeo = log 2 (Cn / 1.5 Bn)...... (2)

Where, C_n is the measured concentration of the element in the tested sediment (soil) and B_n is the geochemical background value of the element in fossil argillaceous sediment (average shale). The constant 1.5 is introduced to minimize the effect of possible variation in the background values which may be attributed to litho logic variations in the sediment [27] gave the following interpretation for the geo accumulation index:

I_{geo} < 0 = practically unpolluted; 0 < I_{geo} < 1 = unpolluted to moderated polluted; 1 < I_{geo} < 2 = moderately polluted, 2 < I_{geo} < 3 = moderately to strongly polluted; 3 < I_{geo} < 4 = strongly polluted; 4 < I_{geo} < 5 = strongly to extremely polluted and I_{geo} > 5 = extremely polluted.

Geo accumulation index for Fe, Mn, Zn ,Cu, Pb, Cd and Cr at different depth and at different sampling sites are given in table 4.The geo accumulation index varies from 0.161 to 0.541 ,-0.697 to 1.325 ,1.309 to 1.896 ,0.015 to 1.49 ,1.341 to 1.647,2.222 to 4.737 and -0.078 to 2.037 for Fe, Mn, Zn ,Cu Pb Cd and Cr at depth(0-20 cm) and similarly geo accumulation index varies from -0.164 to 0.247 ,-0.431 to -1.1700, 0.653 to 1.653 ,-0.254 to 1.418, 0.678 to 1.56 , 1.415 to 3.807 and -0.2937 to 2.681 for Fe, Mn, Zn ,Cu, Pb, Cd and Cr at depth (20-40 cm) respectively.

The geo accumulation index for Fe, Mn and Cr was found to be 0 < I_{geo} <=1 belongs class 1 that is from unpolluted to moderately polluted at depth (0-20cm) and (20-40 cm) respectively. The geo accumulation index for Zn, Cu and Pb was found to be 1 < I_{geo} <= 2 belongs to class 2 that is moderately polluted. The geo accumulation index for Cd was found to be 3 < I_{geo} < = 4 belongs to class 4 that is strongly polluted.

3. Enrichment Factor
Element enrichment factor, evaluated using the local background values, was used to establish which elements were relatively enriched in the different samples. Due to the inconsistency relating to the EF values cutoff to differentiate depleted and enriched samples ,we decided to use EF > 2 to consider sample enrichment.

Enrichment Factor (EF soil), relative abundance of a chemical element is a soil compared to the relative abundance respect to local control site.

EF control = $(M/A_1)_{Soil} / (M / A_1)_{control}$-   (3)

A1 - reference element.

Enrichment factor of plant (EF plant), calculated as

EF = $M_{plant} / M_{control}$ -------(4)

The Enrichment Factor at depth (0-20 cm) and (20-40 cm) for Mn, Zn Pb and Cr were found to be EF < 2 which indicates the depletion to minerals. Enrichment by heavy metals such as Cu and Cd were found to be 2 ≤ EF <5 moderate enrichment. Heavy metals such as Mn, Zn, Pb and Cr were not enriched but Cu and Cd are moderately enriched in the soil at various depths (0-20 cm and 20-40 cm).

Enrichment Factor of plant (EF plant) calculated,

EF= $M_{plant} / M_{control}$

The Enrichment Factor of the heavy metal for Fe (EF < 2), Zn and Cu (2 < EF ≤5) moderate enrichment, Pb 5 ≤ EF <20 significant,Cd (EF > 40) extremely high enrichment for *Azadirachta indica.For*

Pongamiaglabra .The enrichment factor for Fe, Mn and Cu (EF < 2), indicating depletion to mineral enrichment, Zn (2 ≤ EF <5) moderate enrichment, Pb(20 ≤ EF <40) very high enrichment .For Delonix regia Fe,Zn Cu (EF < 2) depletion to mineral enrichment , Mn(2 ≤ EF <= 5) moderate enrichment, Pb and Cd (EF > 40) extremely enriched. It is understood by the EF Pb and Cd are more enriched in the plants . **It is shown in fig 2,3 and 4.**

4. Pollution Source Identification
Factor analysis was applied to assist in the identification of the sources of the heavy metals. According to the Kaiser criterion, the first two components with Eigen values larger than 1.0 have dominant influences. The two principal components contribute 99.25% of the total variance in the samples. The initial Eigen value of the first factor is the largest 16.476, accounting for 91.53% of the total variance, which suggests the existence of one dominant emission source or a group of emission sources of some elements. The two principal component analyses are shown by in Fig (2).

Road traffic emission contains not only vehicles exhaust but also tire end brake wear and resuspended dust Factor 1 also represents the high score of chromium, which indicate the urban soil of Dindigul which is leather industrialized town, contaminated with the same. The factor F2 is characterized by (Cu =1.589), (Fe = 1.107), (Pb = -1.282), (Cd =-1.492) and (Zn = -0.639). The association between these element can be seen in the loading plot (fig – 5).Copper has relatively high loading in F2 (Cu = +1.589). The high loading for these five elements also confirm their strong positive relationship. The result suggests that the concentration of these metals originate from the influence of road traffic. This result also suggest that other elements with high loading in F1 might be also contributed by resuspension of local soil particles provoked by vehicle activities.

5. Cluster Analysis
Cluster analysis was performed on the basis of information assessed from principal component analysis. Three main clusters can be distinguished in the dendrogram obtained from cluster analysis in fig-6. The lower the value on the distance cluster, the more significant is the association. Pb, Cu, and Zn form a cluster (1) which suggests that the association between these elements is very significant and their sources are similar. Cluster 1 includes Pb, Cu and Zn which were identified as contaminants derived from anthropogenic sources. These findings confirm the results of correlation matrix. Cluster 2 contains Cr and Cd which form a distinct cluster showing that they are from similar sources that is due to industrial activity and vehicular output. Cluster 3 contains Fe and Mn which are attributed of a main origin from road traffic emission. It has revealed that the elevated concentration of the metals could be related to land based point source discharge related to rapid urbanization.

6. Correlation Matrix
According to the values of pearson correlation coefficient, a significant positive correlation (P < 0.01) exists between Fe vs Zn(r = +0.957, P < 0.01), Cu(r = -0.803, p < 0.01), Pb (r = +0.883), p < 0.01), Cd (r = +0.705, P<0.01), weak correlation with Cr(r = +0.435, r < 0.01) and negative correlation with Mn (r = -0.384, P < 0.01). Manganese shows negative and significant correlation with Zn (r = -0.449, P < 0.01), Cu(r = -0.8333, p < 0.01), Pb(r = -0.615, p < 0.01), Cd (r = -0.509, p < 0.01) but insignificant positive correlation with Cr (r = +0.044, r < 0.01). Zinc shows positive and significant correlation with cu(r = 0.851, p < 0.01), Pb (r = +0.879, P = 0.01), Cd (r = +0.637, p = 0.01) and weak correlation with Cr(r = +0.327, p < 0.01). The significant and positive correlation exist between Cu and Pb (r = +0.861, p < 0.01) and Cd (r = 0.676, p < 0.01) and insignificant correlation with Cr(r = +0.232, P < 0.001). Pb shows positive and significant correlation with Cd (r = +0.750, p < 0.01) and insignificant correlation exist between Pb and Cr (r = +0.265, p < 0.01) and Cd and Cr(r = +0.296, p < 0.01). The strong correlations among elements indicate their common origin. The significant positive correlation among Fe, Zn, Cd, Pb and Cu indicate their similar sources that are anthropogenic sources.

7. Morphology studies

7.1. Scanning Electron Microscope and XRD analysis of the samples

The SEM analysis of soil and plants collected from different sites are given in fig 7and 8 respectively. The SEM analysis of individual particles deposited on soils showed that the 50-60% belong to a class of fine particles singly or gathered in agglomerates of various shapes. These particles were distributed with higher density on the soil of fine particles, mainly of anthropogenic origin, were often observed which may affect the physiological characteristics of soils. According to their morphology and chemical composition investigated by the SEM metal rich particles were frequently observed. From the energy dispersive spectrum sample revealed that the concentration of Mn > Fe > Cu > Zn at control site, similarly Mn > Fe > Cu > Zn > Pb and Mn > Fe > Cu >Zn for traffic and tannery sites respectively, which is in accordance with the mean concentration evaluated by Atomic Absorption Spectroscopy. X-Ray diffraction studies used to calculate the particle size of the heavy metal present in the samples. Fig- 9 and 10 shows the peaks obtained in the study of X-Ray diffraction for soil and plants collected from different sites. Particle size of the metal present in the soil and the plants collected from different sites are calculated using Bragg's equation. Particle size values are given in table-3.

$$n\lambda = 2d\sin\theta \text{ ----------(5)}$$

λ – Wavelength of the X-ray
d – Interplanar spacing
θ – Diffraction angle
n – 0, 1, 2, 3……

CONCLUSION

The mean heavy metals concentration as Fe, Mn, Zn, Cu, Pb, Cd and Cr were found to be below the normal range and also below the critical level. The mean heavy metals concentration for Fe in *Azardirachta indica, Pongamia glabra and Delonix regia were found to be greater than the critical range 50-20mg/kg.The mean concentration of Mn, Zn Cu , Pb, Cd and Cr for all the three species were found to be below the critical level* Mn(400-1000 mg kg^{-1}), Zn (100-400 mg kg^{-1}),Cu(20-100 mg kg^{-1}), Pb (30-300 mg kg^{-1}), Cd(5-30 mg kg^{-1}) and Cr(5-30 mg kg^{-1}). Bioaccumulation coefficient in these plant species indicates that these plant species accumulate the heavy metals and there is more transfer of heavy metal from soil to plant . Geo accumulation index Fe, Mn, Cu and Pb were found to be moderately enriched in the soil .The enrichment factor for all the heavy metals expect Cu and Cd at depth (0-20 cm and 20-40 cm) were found to be depletion to minerals but Cu and Cd shows the moderate enrichment. The results of geo accumulation index are in accordance with enrichment factor. According to the values of Pearson correlation matrix which indicate the significant positive correlation among Fe, Zn, Cd, Pb and Cu. It shows the similar sources that are anthropogenic sources .The energy dispersive spectrum results showed the mean concentration of heavy metals were in the order Mn > Fe > Cu > Zn which is similar with Atomic absorption spectroscopy analysis. SEM Analysis result confirmed the presence of heavy metals and revealed the concentration of urbanization to the recorded concentration. It was concluded that SEM and XRD technique were a useful technique for characterizing and identifying heavy metal pollution. The present study emphasizes the need to continue to monitor concentration of toxic heavy metals such as Pb, Cd, Fe, Mn and Cr in soil and plant located near traffic and industrial area in order to detect their toxicity on time.

Table-1
Heavy metal concentration in soil samples with normal and critical range

Heavy metals	Normal range(mg/kg)*	Critical soil concentration (mg/kg)**	Average concentration soil mg/kg						Back ground mg/kg
			Residential		Traffic		Industrial		
			0-20cm	20-40cm	0-20cm	20-40cm	0-20cm	20-40cm	
Fe	-	50mg/kg	8.57	6.84	10.28	8.85	11.15	9.10	5.11
Mn	20-10000	1500-3000	19.20	17.52	11.52	9.64	14.65	10.56	15.84
Zn	1-900	70-400	1.97	1.25	2.54	2.06	2.96	2.50	0.53
Cu	2-250	60-125	3.29	2.73	8.38	8.15	9.15	8.70	2.17
Pb	2-30	100-400	0.76	0.48	0.94	0.885	0.952	0.860	0.2
Cd	0.01-2.0	3-8	0.028	0.016	0.16	0.073	0.114	0.084	0.004
Cr	-	50-200	1.08	0.92	1.32	0.93	4.68	2.56	0.76

Table-2
Heavy metal concentration in commonly grown trees at selected sites with normal and critical range

Family Name	Sampling Sites		Heavy Metals (mg/kg)						
			Fe	Mn	Zn	Cu	Pb	Cd	Cr
		Normal	30-300	50-500	27-100	5-30	5-10	0.05-0.2	0.1-0.5
		Critical	50-200	400-1000	100-400	20-100	30-300	5-30	5-30
Azardirachta Indica	Residential		216	25.3	18.4	10.6	2.8	0.03	0
	Traffic		357.6	62.5	45.5	16.2	54.6	2.16	0.73
	Industrial		310.8	54	36.2	25.0	32.4	3.85	1.02
Pongamia glabra	Residential		194.8	35.6	14.2	8.8	1.3	0.02	0
	Traffic		210.6	46.5	75.8	12.5	49.3	2.28	0.98
	Industrial		298.2	51.2	40.2	18.6	36.5	4.60	1.86
Delonix regia	Residential		234.5	31.0	21.0	15.2	1.9	0.03	0
	Traffic		318.4	71.6	38.2	29.5	43.6	1.25	1.25
	Industrial		375.2	85.3	26.8	41.0	29.4	1.64	1.93

Table – 3
Particle size of metals calculated from X-Ray diffraction pattern

Name of the plant and soil from different sites	Particle size of the metal in A°
Control Soil	3.30525
Tannery Soil	2.43293
Traffic Soil	3.28574
Control Azardirachta indica	4.22695
Tannery Azardirachta indica	4.20222
Traffic Azardirachta indica	4.29985
control Delonix regia	4.01002
Tannery Delonix regia	4.16551
Traffic Delonix regia	4.20521
Control Pongamia glabra	4.20714
Tannery Pongamia glabra	4.20233
Traffic Pongamia glabra	4.11087

Azadirachta indica   *Pongamia glabra*   *Delonix regia*

Fig-1 Pictures of collected plants
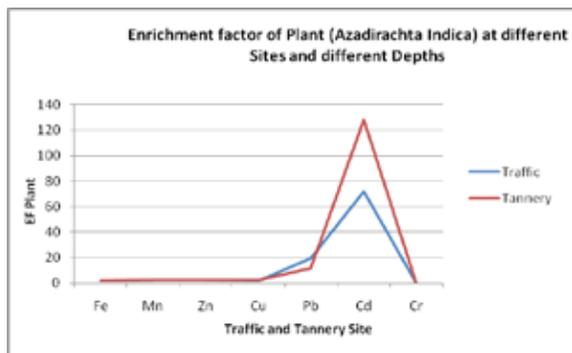
Fig – 2 Enrichment Factor of plant (Azardirachta Indica) at different sites and different depths
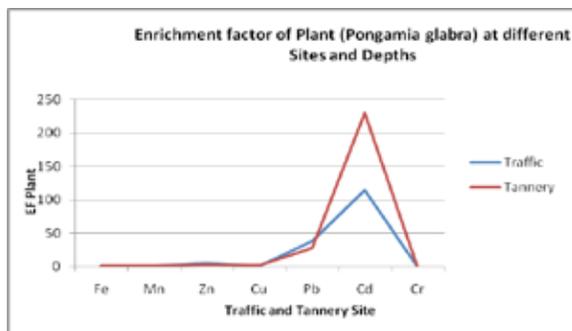
Fig – 3 Enrichment Factor of plant (Pongamia glabra) at different sites and different depths
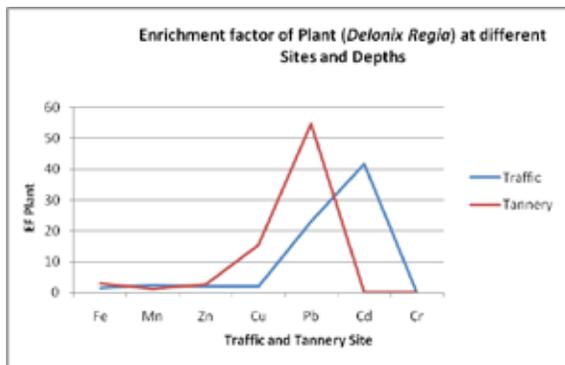
Fig – 4 Enrichment Factor of plant (Delonix regia) at different sites and different depths
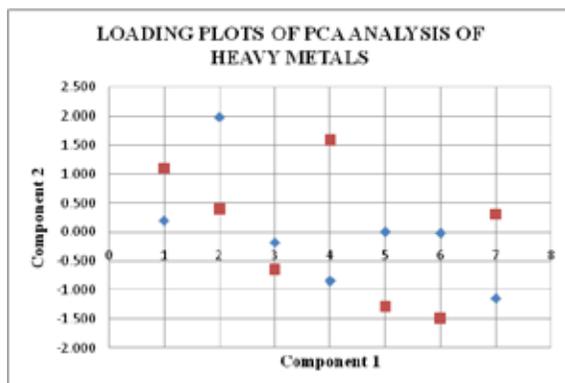
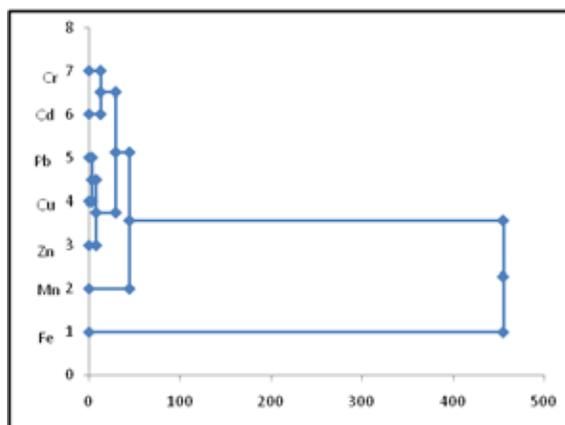**Fig – 5 loading Plot of Principal component analysis of heavy metals**

Fig -6 Cluster Analyses of the samples collected from polluted and control sites

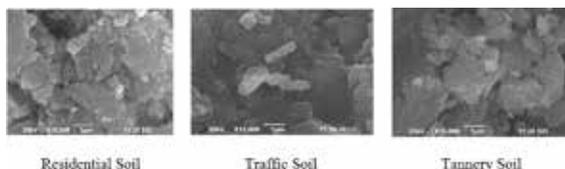Residential Soil   Traffic Soil   Tannery Soil

Fig – 7 SEM Representation of soil collected from Residential Soil, Traffic Soil and Tannery Soil
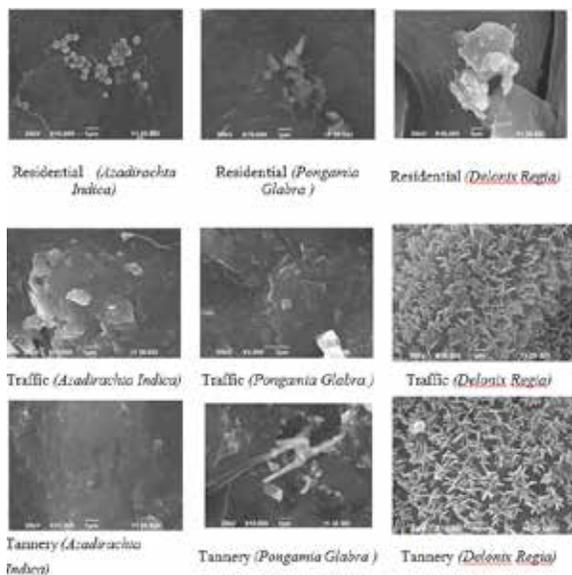
Fig – 8 SEM Representation of plants collected from Residential Sites, Traffic Sites and Tannery Sites
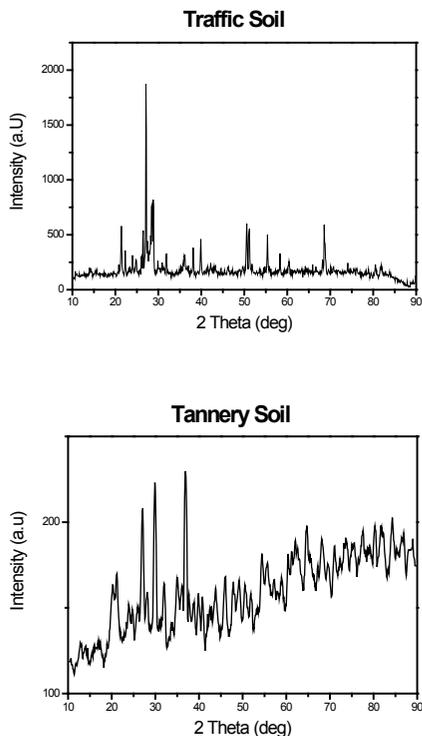

Fig – 9 XRD pattern of soil collected from control, traffic and tannery sites.
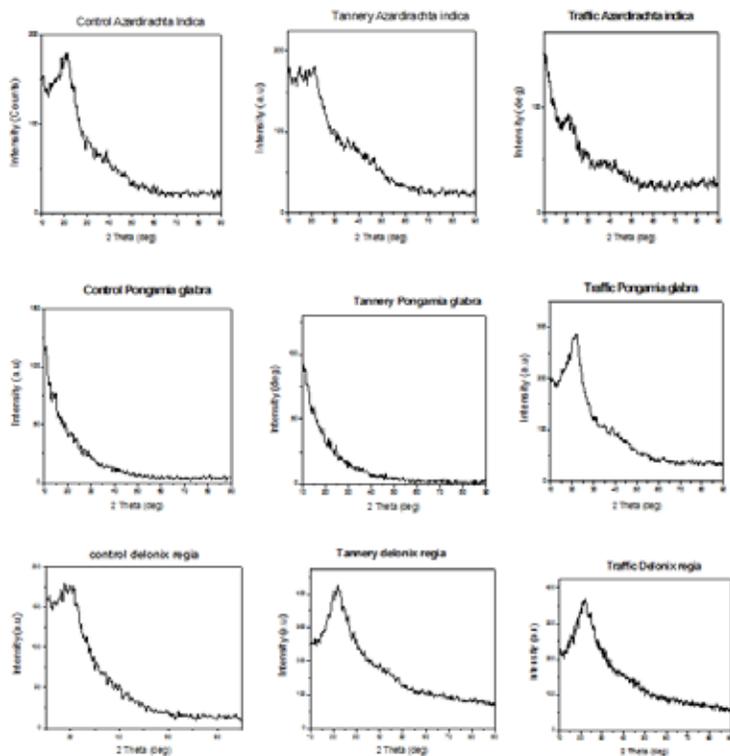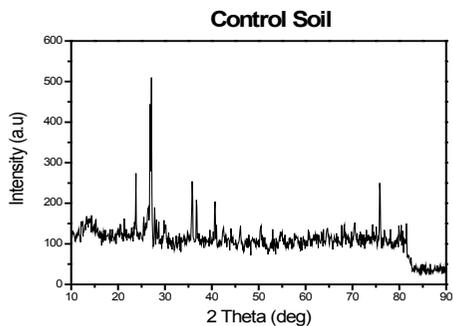

Fig – 10 XRD patterns of plants collected from control, traffic and tannery sites.

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