Bio-monitoring of Atmospheric Heavy Metals Deposited on Selected Tree Leaves in Kanchipuram, Tamilnadu

Sumathi Ramesh[1], Sriram Gopalsamy[2]

[1]Assistant Professor, Department of Civil & Structural Engineering, [2]Professor, Department of Mechanical Engineering, Sri Chandrasekharendra Saraswathi Viswa Mahavidyalaya, Enathur, Kanchipuram, Tamilnadu, India

Abstract

Kanchipuram, one of the holiest cities is highly polluted with heavy metals due to industrialization and urbanization. It is most important to know the role of plants in the cleansing process of heavy metals in this temple city. In this study, the heavy metals (Fe^{2+}, Pb^{2+}, Cu^{2+}, Zn^{2+}, Al^{2+}, Cd^{2+}, As^{2+}, Cr^{3+}, Mn^{2+}) from the dust deposited on the leaves of the trees were analyzed. The tree species were collected from different zones of the Kanchipuram town such as residential area, traffic area, Institutional area, hospital area and industrial area. Heavy metals concentrations were analyzed by inductively coupled plasma mass spectrometry. Most of the heavy metals were found below their detectable limits (Pb^{2+}, Cd^{2+}, Cu^{2+}, Cr^{3+}, and As^{2+}). Some of the heavy metals were in highly increased values (Fe^{2+}, Al^{2+}) almost in selected species. In few locations the content of As^{2+} and Mn^{2+} in lower levels were deposited on some species. The results obtained from the analysis were compared statistically and correlated by using Pearson's co-efficient. The results obtained from the analysis shown that the heavy metals were emitted from various combustion processes and other anthropogenic activities. The tree species selected can be used in bio monitoring as bio indicators of increased Fe^{2+}, Al^{2+} in the ambient air.

Keywords: *Heavy metals, Bio Monitoring, Bio Indicators, Species, Deposition, Correlation.*

Introduction

Pollution due to air is one of the major issues in heavily populated towns and cities, which mainly begins from fast and unsystematic development of industrialization and urbanization[1,2]. As human undergone industrialization the quantity of waste thrown away in the ambience starts to increase enormously. This increased population and industries force the environment as highly polluted[3,4]. Out of various pollutants heavy metals are one of the major pollutants in the cities due to various anthropogenic activities such as emission from combustion processes, automobile exhaust and disposal from industries[5,6]. Heavy metals distributed in the local and regional areas are not clearly defined but they worsen the quality of air[7]. The study and analysis of heavy metal pollution in the environment is very important and interest due to their severe and harmful health disorders. The characteristics of air, water and soil, microbial activities and growth of vegetation are greatly disturbed by heavy metals[8,9]. Heavy metals are also named as silent killer when they are exceeding their values of $5gm/m^3$ but they are generally specified as toxic metals. Hence the testing of heavy metals is an important mechanism to improve and regulate the environmental impact assessment in developed and developing cities and towns[10].

Bio monitoring is one of the simplest and cheapest method for detecting heavy metal concentration in the ambient air[11,12]. Plant bio monitoring is the better choice for determining the air quality compared to other conventional method because of its cheapness and easy to carry out the work. Monitoring by equipment poses the problem in setting the proper stations and also suitable for confined areas but plant species are readily available and existing at all places and easy to monitor[13]. The plant called as a good bio monitor, when it should be widespread in the topography and to find and collect at the time of sampling [14]. Bio indicators give the feasible way of estimating the pollutant level in the environment and it has been used for several years to examine the

accumulation and deposition of heavy metals on the leaves. Plants absorbed the various air borne pollutants thereby reducing the pollutant level. The degree of absorption and adsorption capacity differs from plant to plant without showing any toxic effects and they are acting as a sink for gases, particulate matters and toxic heavy metals[15]. Lower plants like mosses and lichens are acting as ideal bio indicators but it is difficult to plant in the urban areas and in industrial areas, higher plants can serve this purpose. Different types of higher species are used as bio indicators to monitor and detect the heavy metal pollution [16,17,18] . The dust deposited on the tree leaves predict the level of heavy metal contamination in the environment [19]. Most of the countries are successfully using the different types of species as bio indicators for analyzing the various levels of pollutant in the atmospheric air [20].

The purpose of this study is to determine the present levels of atmospheric trace element pollution in the Kanchipurm town. Therefore, two different plant species such as Saraca Asoca and Terminalla Cattappa were selected as potential biomonitors of trace elements including iron, lead, copper, zinc, Aluminum, chromium, cadmium, arsenic and manganese (mg/ Kg, dry weight). The samples were collected from two different heights of each tree species as high point and low point. Inductively coupled Mass spectrometry was used to determine the concentrations of trace elements.

Method

i. Species: Saraca asoca is an important tree grown mostly in various parts of India. It is an evergreen tree grown up to a height of 9.14m. This tree is effectively used for controlling noise pollution hence it is commonly planted in all places Fig.1. *Terminalia Cattappa* is a large tree grown in tropical areas. It grows up to a height of 35m with horizontal branches and grown equally and properly at its top. The leaves are 0.1-0.14m broad, large and 0.15-0.25m long.

ii. Study Area: Kanchipuram is one of the districts in the northeast of the state of Tamil Nadu in India and 72 km (45 mi) from Chennai. It lies between 77° 28' to 78° 50' longitudes and 11° 00' to 12° 00' latitudes. Total geographical area of the district has 4,432 km^2 (1,711 sq mi) and coastline of 57 km (35 mi). It is very famous for temples and silk sarees hence it is named as temple city and silk city. Kanchipuram is one of the important industrial cities, which is very nearer to Chennai, capital of Tamil Nadu. The population of the town is suddenly increased which leads to heavy traffic and urbanization.

iii Sample sites: In this study the sites were selected from industrial areas Vella Gate near rice mills(site1), institutional areas near National highway(site2), sensitive areas as hospital located on the highways(site3), heavy traffic zone(site4), residential area Pallavar Medu (site5) and commercial area such as collector office(site6).

iv. Sampling: Samples from *Saraca Asoca* and *Terminalla Cattappa* were collected the

height of above 1.8m. The leaves were collected in air tight zip lock polythene bags and taken to the laboratory for analysis. The heavy metals were analyzed by using closed-system mineralization by microwave digestion and measurement with inductively coupled plasma mass spectrometry.

Statistical Analysis: The results obtained from the study were correlated using Pearson's correlation co efficient and statistical analysis was carried out for the results. Statistical analysis was done with SPSS software package. The results were given in Table 1.

Table 1. Heavy metals deposited on species from six sites

Parameters	Saraca Asoca					Terminalla Catappa				
	Mean	Median	Max	Mini	SD	Mean	Median	Max	Mini	SD
Fe	75.5	73.15	96	57	15.18	36.25	21.9	131	0	47.35
Cu	0.5	0	3	0	1.22	0.53	0	3.2	0	1.31
Zn	52.6	6.3	21.3	0	9.49	4.41	3.5	10.5	0	4.96
Al	44.3	42.4	60.4	31.1	10.09	20.48	8.85	82	2.8	30.49
Mn	4.25	3.65	10.8	0	4.82	4.02	2.25	10.3	0	4.82

Table 2. Correlation co- efficient for the heavy metals deposited on species at selected sites

Parameters	Correlations - Saraca Asoca					Correlations - Terminalla Catappa				
	Fe	Cu	Zn	Al	Mn	Fe	Cu	Zn	Al	Mn
Fe	1					1				
Cu	.661	1				-.099	1			
Zn	.145	.388	1			.557	.452	1		
Al	.730	.305	.394	1		.984	-.072	.651	1	
Mn	.145	.320	.995	.437	1	.635	.537	.978	.707	1

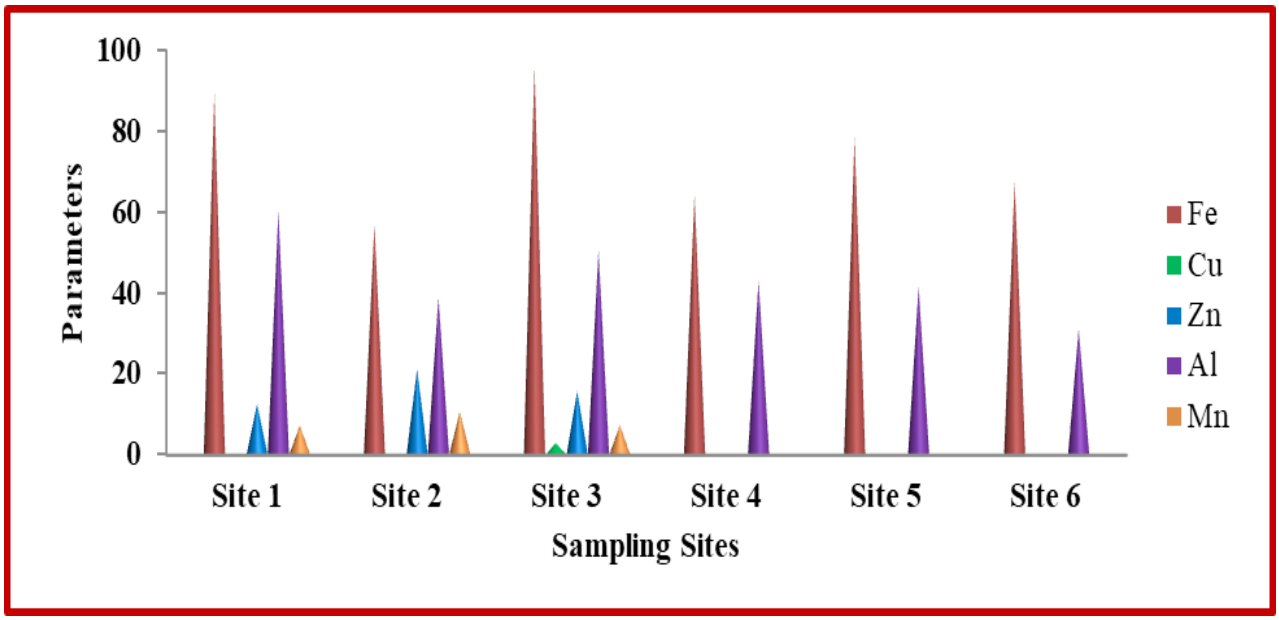

Fig.1: Heavy metals concentrations at selected sites in Saraca Asoca

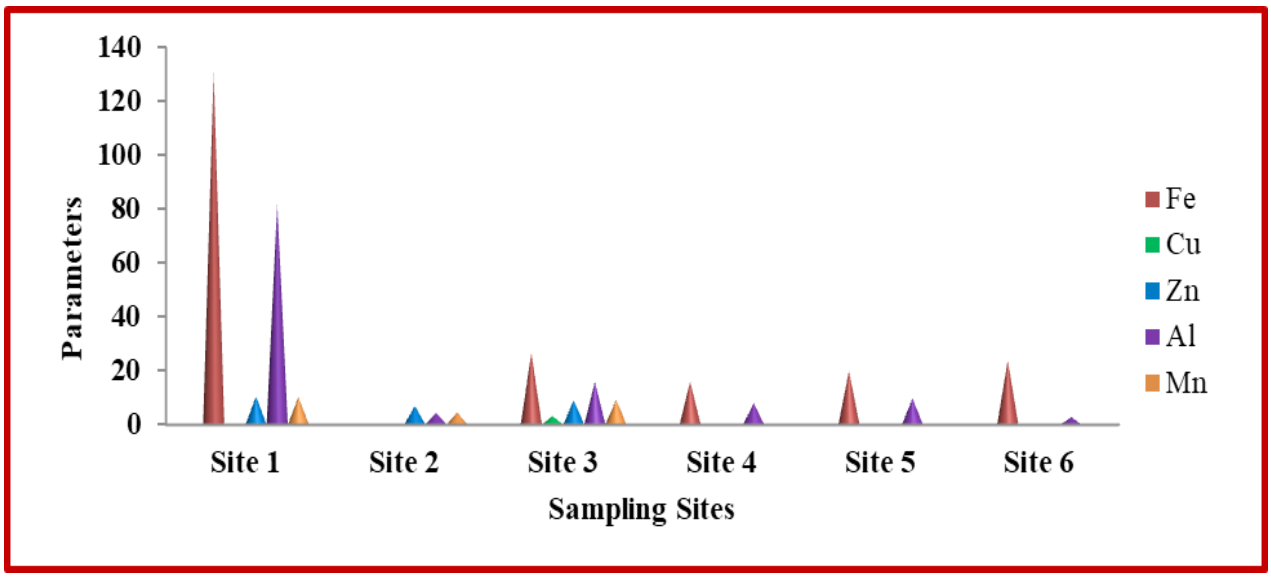

Fig.2 : Heavy metals concentrations at selected sites in Terminalla Cattappa

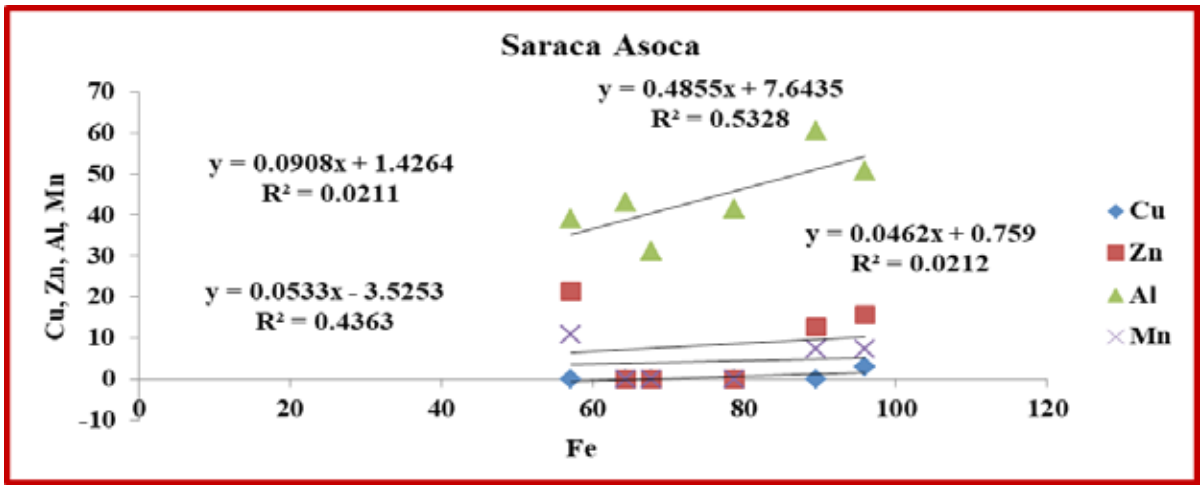

Fig. 3: Regression equation for Fe Vs Cu,Zn,Al and Mn in Saraca Asoca

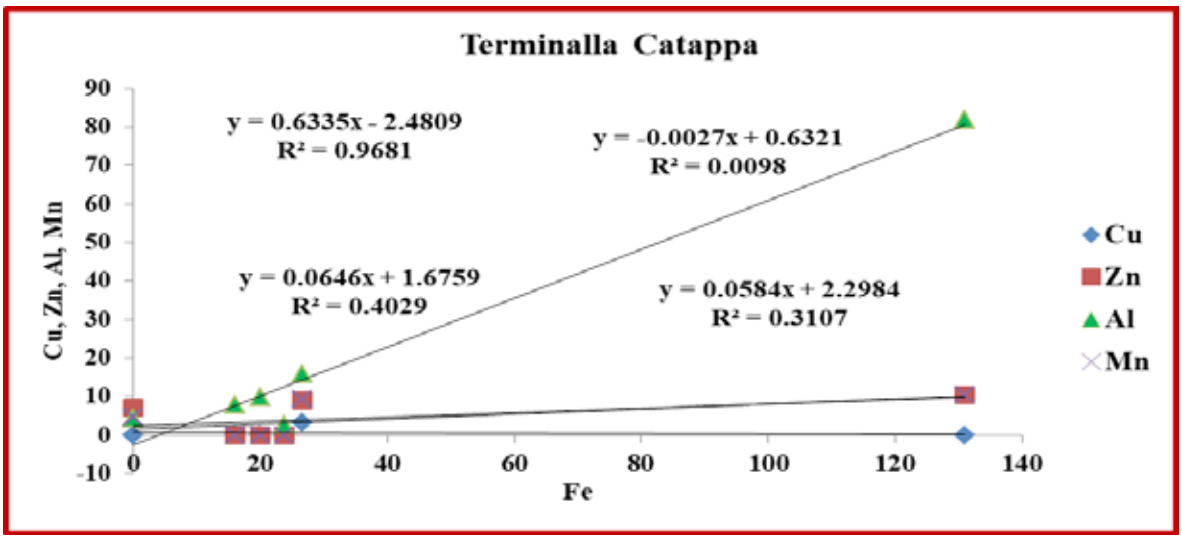

Fig. 4: Regression equation for Fe Vs Cu, Zn, Al and Mn in Terminalla Cattappa

Results and Discussion

Heavy metals widespread in the ambient air were clearly proved in the present study. Metals deposited on the leaves varied from species to species and with sampling sites. The samples collected from the selected sites showed the different levels of pollution in the air. Few heavy metals were found with high concentration in the sensitive areas such as hospital and also near rice mill located along the highway. Most of the heavy metals were with lowest concentration and below their detectable limit. The results obtained from the study was not shown a significant difference in the concentration of heavy metals taken from various places but clearly indicated that it depends upon the type of species selected[21].

Among the nine metals analyzed, Fe was found in all the selected six sites with highest concentration. This higher level of Fe was due to abrasion, wear and tear of any machines or obsolete equipments and vehicles. The test results clearly indicated that the absorbing capacity of heavy metals by *Saraca Asoca* was higher than *Terminalla Cattappa* in all the selected sites except near rice mill along the highway as shown in Fig.1. Concentration of Fe ranged between 57 and 96 and the highest value was identified near CSI hospital and lower value near the cancer institute. This results clearly indicated that the proper disposal method and widespread of trees near the institute were reduced the Fe level in the environment. From the correlation study Fe was positive correlation with Cu and Al and weak

relation with Zn and Mn in *Saraca Asoca.* In *Terminalla Cattappa* significant correlation with Al and positive relation with Zn and Mn. Fe was negatively correlated with Cu as shown in Table 2.

Alike Fe, Al was found in the selected species. Al enters the environment from a large industrial plant and through containers such as drum or bottle. The absorption capacity of Al by *Saraca Asoca* was comparatively higher than *Terminalla Cattappa* as shown in Fig.2. In *Saraca Asoca* the value ranged from 31.1 to 60.4 and in *Terminalla Cattappa* the concentration varied from 2.8 to 82.0.

The concentration of Al was found in higher figure near the rice mills located on the road side compared than other five sites. The results obtained from the analysis showed that the more usage of Al leads to increase their content in the atmosphere. From the correlation study Al was positively correlated with Mn in *Saraca Asoca* and in *Terminalla Cattappa.*

Zinc is also an important metal released from the use of pesticides, insecticides and due to the combustion of fossil fuel and the use of brake shoes used in all types of vehicles. Zn concentration was absorbed by both *Saraca Asoca* and *Terminalla Cattappa* was below their detectable limit in three sites. Lower results were found in sensitive areas and near rice mill both in *Saraca Asoca* and *Terminalla Cattappa.*Zn values ranged between below detectable limit and 21.3 in *Saraca Asoca* and 10.5 in *Terminalla Cattappa.* The correlation study showed that Zn was highly related with Mn and weakly correlated with Al in *Saraca Asoca.* In Terminalla *Cattappa* Zn had significantly correlated with Mn and positive relation with Al as shown in Fig. 3 and Fig.4.

Mn was identified only near the hospital sites and rice mill site with lower concentration due to the usage of more pesticides, insecticides. The response to the absorption of Mn by *Saraca Asoca* and *Terminalla Cattappa* were nearly same. The concentration of Mn was below their detectable limit in other three sites where the usage of pesticides was negligible.

Pb was not found in any samples collected from all the sites. This is due to the continuous improvement in automotive technologies, usage of unleaded fuel and stringent rules and regulations made on the emission of Pb. The level of Pb in the air was decreased 89 percentage by the regulatory efforts taken by Environmental Protection Agency [22].

Cr, Cd and As also not detected in any collected samples. The concentration of Cu was below their detectable limits in all the selected sites except near CSI hospital. Cu absorbed by both the species were in lower concentrations.

In the present study concentration of Fe and Al were on the higher side and the values were exceeded their threshold limits. Zn, Mn were with lowest concentrations and the other metals such as Cu, Cd, Pb, As and Cr were below their detectable limits.

Vehicular emission is not only the source for pollution, usage of pesticides and combustion process also plays a vital role the distribution of heavy metals in the atmosphere. The present study was used to prove the species selected such as *Saraca Asoca* and *Terminalla Cattappa* are the best indicator of heavy metal pollution. The results obtained from the study clearly indicated that the concentration of Fe and Al were higher level in air compared to other metals as Pb, Cu, Zn, Cd, As, Cr and Mn. The species responded to the absorption of heavy metals were varied with different locations. From this study, *Saraca Asoca* can be effectively used than *Terminalla Cattappa* f*or* the bio monitoring of heavy metal pollution.

Ethical Clearance: I got ethical clearance for my paper from my University ethical Clearance committee and from the Guide.

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