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# BIO-MONITORING OF HEAVY METALS ACCUMULATION IN PLANTS GROWING AT KANCHIPURAM TOWN, TAMILNADU

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**ABSTRACT**

**Environmental monitoring is a great concern that leads to explore the plants as bio identity tool for pollutants. They act as the excellent indicators of showing the environmental air conditions. Therefore, three common tree species such as *Szygium Cumini* (species 1), *Ficus Religiosa* (species 2) and *Pongamia glabra* (species 3), were selected for the accumulation of heavy metal pollutants from the ambiance air for this study. This work aimed to investigate the concentration of heavy metals deposited on the leaves of selected tree species at various places in Kanchipuram town. The selected sites showing the different level of pollutants depends on the areas subjected to the disturbance like highly, moderately and slightly polluted areas. Leaves from each species were collected and analyzed for heavy metals such as Fe, Pb, Cu, Zn, Al, Cd, As, Cr and Mn in the laboratory by using Inductive coupled Plasma mass spectrometry. The results gathered from the experiment were statistically analyzed by using SPSS software and correlation study also carried out for the pollutant parameters. The pollutant level with species and with sites varied as predicted. The concentration of Fe and Al were high and almost deposited on all species and found in all sites. Zn and Mn were in lower concentration and other metals were found below their detectable limit. The heavy metal concentration was arranged in the order of Fe>Al Zn Mn and other metals such as Pb, Cu, Cd, As and Cr were not identified. The species selected acted as active bio monitors for the environment.**

**KEY WORDS:** Monitoring, Indicator, Ambiance, Correlation, Species, Pollutant

## INTRODUCTION

Pollutants are discharged into the ambient air from various processes and from variety of sources such as combustion of waste products and fossil fuel, farming works, vehicular movements and mining and industrial activities (Daniela Malizia *et al*., 2012; Santosh Kumar Prajapati, 2012 and Dogan *et al.,* 2015). Quality of air in the environment is investigated by a precise strategy for analyzing the atmospheric conditions and it is the essential elements for clean air control management. The amount of pollutant parameters such as gases, particulate matter and other heavy metals associated with pollution make clear the clean air in the atmosphere (Mangala Yatawara *et al*., 2019). Pollutants present in the air causes serious health hazards such as respiratory problems and chronic pulmonary and cardio vascular diseases (Jamal Mohamed Ben Sasi, 2013 and Hamza Badamasi, 2017). These toxic metals are in finest size with enriched concentrations in the air and easily entered into the ambient air may be taken by the human beings through inhalation and by plant life through deposition or accumulation on the various parts specially on leaves (Miguel Izquierdo-Diaz *et al*., 2019). These factors stimulus to promote the well defined systems to monitor the quality of air in easy and inexpensive aspects (Maghakyan *et al.,* 2017). Observing and analyzing of various pollutants in the air are carried out by means of various elemental methods by using instrumental techniques. These methods furnished the reliable results with accuracy but it is very costly and finds difficulty to locate in large wider areas (Alpy Sharma *et al*., 2016). Difficulties posed by the use of instruments are overcome by bio monitoring techniques.

Bio monitoring is the effective technique used for the measurement of pollutants in the environment by using plants which are either lower or higher in variety (Giuseppa Grazia Aprile *et al.*, 2016 and Rita Sabry Mansour, 2014). This method is cheaper and convenient for the continuous measurement in larger areas without any maintenance and skilled supervision in case of equipments (Khageshwar Singh Patel *et al*., 2015). Most of the studies presented the efficacy of lower varieties like lichens and mosses used as the bio indicators of ambiance air (Chang Liu *et al*., 2016 and Srivastava Kuldeep *et al.,* 2015). They grow very rapidly and abundant in number by absorbing all the pollutant nutrients from the air and are susceptible to changes in environment (Clarisse Mariet *et al*., 2011). The high level of contamination and the deterioration of natural territory make these lower species has rarely detected in towns and cities and hence higher plants are widely used as heavy metal bio monitors (Hulya Arslan *et al*., 2010). The rate of deposition of heavy metals from air varies from species to species depends upon the surface area of the leaf, structure, opening of stomata and coarseness (Manzoor iqbal Khattak *et al.,* 2012).

The prime objective of this study is to analyze the heavy metals such as Iron, Lead, Copper, Zinc, Aluminum, Arsenic, Cadmium, Manganese and Chromium accumulated on the leaves of the species *Szygium cumini*, *Ficus religiosa* and *Pongamia glabra* grown at various places in the Kanchipuram town. The results observed from the experimental results shown that their absorbing capacity varied with respect to species and locations.

## MATERIALS AND METHODS

### Species Description

*Syzygium cumini* (species 1) is a perennial tree grown up with diameter 4 m and 15 m height. Their evergreen leaves are 5 to 25 cm long and 2.5 to 10 cm wide, dark green smooth, glossy, leathery and oblong shape. These trees live more than 100 years and are a native of India.

*Ficus religiosa* (species 2) is a gigantic partly evergreen and losing their leaves in the winter season and growing with a height of 30 m and 3 m diameter at its trunk. Their leaves are in glossy, dark green in colour, heart shape with 10 to 17 cm long, 8 to 12 cm wide and 6 to 10 cm at stem where the leaves attached. These trees have a long life span of more than 2000 years and originated in Indian region.

*Pongamia glabra* (species 3) is speedy growing enduring trees with a height of 15 to 25 m and 0.5 to 0.8 m in diameter. They have glossy green colour leaves which are deciduous for a short period and replaced by new leaves. They have a longer life span and spread in India.

### Study area

Kanchipuram is the most ancient famous religious centre in South India named as temple city and it is also famous for silk weaving and dyeing hence it is also called as silk city. It was located 72000 m from the capital of Tamilnadu, Chennai. The latitude of Kanchipuram is 12.834$^o$N and longitude is 79.703$^o$E (http://www.kanchi.in.nic.in/history/html; https://en.wikipedia.org/wiki/kanchipuram). The city covered an overall area of 11.61sq.Km and with a population of 1.64 lakhs as per the census taken before one decade. The population at now was tremendously increased due to tourism and industrial development. The pollution level was rapidly increased because of this urbanization and industrialization. Hence it is very important to monitor and control the pollutant concentrations in the air. The sampling sites were taken within Kanchipuram area in a distributed way such as residential, commercial, institutional, industrial and sensitive areas are given in Table 1.

**Table 1.** Name of the sampling sites

| Site | Sampling locations | Nature of the zone |
|---|---|---|
| Site 1 | Vella Gate | Industrial area (Rice mills) |
| Site 3 | CSI Hospital | Sensitive areas |
| Site 2 | Near Cancer Institute | Institutional areas |
| Site 4 | MoongilMandapam | Heavy traffic area |
| Site 5 | Collectrate | Commercial area |
| Site 6 | PallavarMedu | Residential area |

### Sampling

The leaves from three tree species such as species 1, 2 and 3 were collected at the height not more than 1.2 m. Generally the leaves at the height greater than 1.8 m were collected but in this study it was collected at lower points to analyze the accumulation rate. The samples collected were stored in zip lock polythene bags not exposed to outer environment and carried to the testing laboratory for identifying the concentrations of heavy metals absorbed on the leaves. The samples were digested in microwave closed system mineralization techniques and analyzed the heavy metals by ICMPS -Inductively coupled plasma mass spectrometry.

**Statistical Analysis**

The test results obtained from the experimental analysis were related with heavy metal parameters by using Pearson's correlation co - efficient method and statistical analysis was carried out with software package as SPSS. The results were given in Table 2, 3 and 4.

## RESULTS AND DISCUSSION

The concentration of heavy metals dispersed in the air was examined by their deposition on the leaves of higher plants in the present work. The metal levels obtained from the analysis clearly shows that it depends upon the type of species and also where the sampling was carried out. The level of pollutant in the selected sites varied with the type of anthropogenic activities carried out in that area (Azim Ozturk *et al.*, 2019). Out of nine metals, only four metals such as Fe, Al, Zn and Mn were absorbed by all the species and their concentrations also differed from species to species. Cu and As were found only in few sites with very lower levels. Some toxic metals were not identified in any selected sites.

The results obtained from the analysis clearly indicated that the pollutant level was almost similar in all the selected sites but they are highly influenced by the species. From the experimental results obtained for nine metals, Fe was found with higher concentrations in all the selected sites except in site 3, cancer institute located on national highway. Deterioration of any old machines, obsolete and old equipments and vehicles were the sources for Fe in the atmosphere. The accumulation of Fe on the leaves of *Szygium cumini* was higher than other two species in site 2 and site 4 and lesser than *Pongamia glabra* in site1, site 6. The maximum concentration of Fe was 82.8 near site 2 and with below detection limit near site 3 was given in Table 2.

The percentage of absorption was highest in *Szygium cumini* (55%), *Pongamia glabra* (53%) and lowest in *Ficus religiosa* (45%) was shown in Fig. 1, Fig. 2 and Fig. 3. From the correlation analysis it was observed that Fe was highly correlated with Al in all three species and significantly related with Mn, Cu in *Szygium cumini* and only with Mn in *Pongamia glabra* and *Ficus religiosa.* Lower correlation was observed in all the three species with Zn and negative correlation was noticed for Cu in *Pongamia glabra* was shown in Table 3. The regression equations for the heavy metals of Fe Vs Zn, Cu, Al and Mn in three species as shown in Fig. 4, Fig. 5 and Fig. 6.

Copper is one of the heavy metal released from burning of coal, high usage of brake pads in diesel

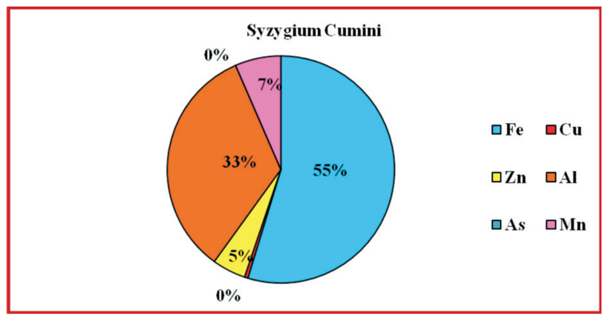


**Fig. 1.** Heavy metals deposited on *SyzygiumCumini* from six sites

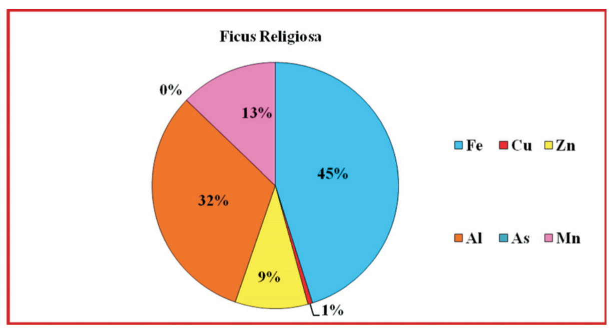


**Fig. 2.** Heavy metals deposited on *FicusReligiosa* from six sites

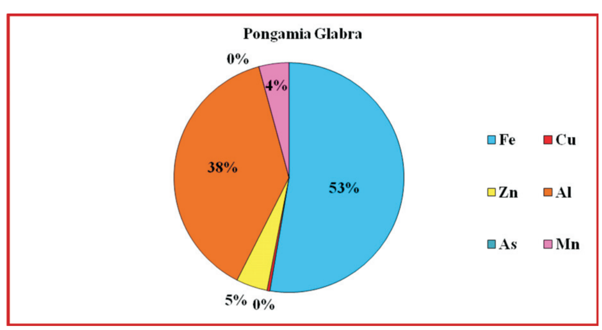


**Fig. 3.** Heavy metals deposited on *PongamiaGlabra* from six sites

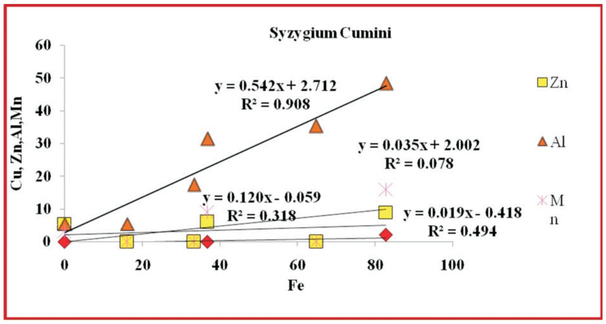


**Fig. 4.** Regression equation for Fe Vs Zn, Cu, Al and Mn in *Syzygium cumini*

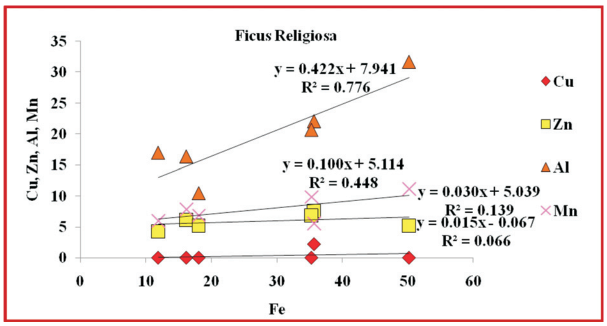


**Fig. 5.** Regression equation for Fe Vs Zn, Cu, Al and Mn in *Ficus religiosa*

engines and vehicles in to the environment (Rita Sabry Mansour, 2014; Sweta Tiwari *et al.*, 2016). The test results indicated that Cu was settled on the leaves of *Pongamia glabra* and *Szygium cumini*, in site 2 and in site 5 by *Ficus religiosa*. The value ranged from 2.1 to below detectable limit. The percentage of absorption was 0% in *Szygium cumini*, *Pongamia glabra* and 1% in *Ficus religiosa* was shown in Fig.1, Fig.2 and Fig.3. The correlation study given that Cu was highly correlated with Zn, Al and Mn in *Szygium cumini*, positive correlation with Zn, weakly related with Al and negatively correlated with Mnin *Ficus religiosa.* In *Pongamia glabra* Cu was weakly related with Zn, Mn and negatively with Al shown in Table 3.

Zinc was identified in all three species from site1, 2 and 3 and accumulated only on the leaves of *Ficus religiosa* in sites 4, 5 and 6. Zn could be released into the air from the combustion of petroleum products and wood, high usage of pesticides, insecticides and brake pads in vehicles (Ugulu *et al.*, 2012). The concentration of Zn ranged between 9.0 and below detectable in *Szygium cumini*, in *Ficus religiosa* the amount varied from 7.6 to 4.3 and 10.6 to BDL in *Pongamia glabra*. Percentage of accumulation was nil in both *Szygium cumini* and *Pongamia glabra* and 1 in *Ficus religiosa*. From the correlation study Zn was highly related with Mn and positive relation with Al in *Szygium cumini* and *Pongamia glabra*. In *Ficus religiosa* it showed a weak relation with Al and negative correlation with Mn.

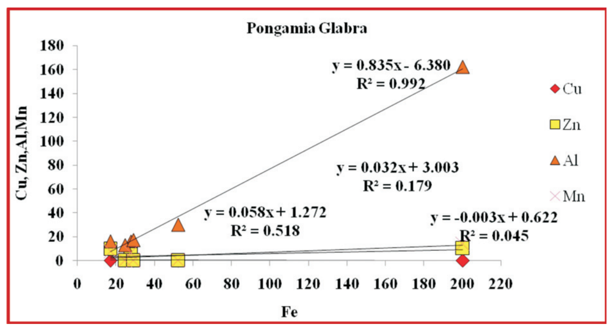


**Fig. 6.** Regression equation for Fe Vs Zn, Cu, Al and Mn in *Pongamia glabra*

**Table 2.** Heavy metals accumulated from six sites on three species

| Species | Parameters | Max | Min | Mean | Median | SD |
|---|---|---|---|---|---|---|
| *Szygium cumini* | Fe | 82.8 | | 38.97 | 35.05 | 30.55 |
| | Cu | 2.1 | 0 | 0.35 | 0 | 0.86 |
| | Zn | 9.0 | 5.5 | 3.4 | 3 | 3.92 |
| | Al | 48.4 | 5.4 | 23.87 | 24.35 | 17.4 |
| | Mn | 16.0 | 0 | 4.65 | 1.51 | 6.55 |
| *Ficus religiosa* | Fe | 50.2 | 11.9 | 27.9 | 26.7 | 14.8 |
| | Cu | 2.2 | .0 | 0.4 | .0 | .9 |
| | Zn | 7.6 | 4.3 | 5.9 | 5.7 | 1.2 |
| | Al | 31.7 | 10.5 | 19.7 | 18.9 | 7.1 |
| | Mn | 11.2 | 5.6 | 7.9 | 7.4 | 2.2 |
| *Pongamia glabra* | Fe | 200.0 | 17.0 | 58.52 | 28.45 | 70.32 |
| | Cu | 2.6 | 0 | 0.43 | 0 | 1.06 |
| | Zn | 10.5 | 0 | 4.90 | 4.65 | 5.38 |
| | Al | 162.3 | 13.0 | 42.52 | 16.85 | 58.98 |
| | Mn | 13.9 | 0 | 4.70 | 3.34 | 5.71 |

Aluminum was another heavy metal found in higher concentration next to Fe. It finds their entry into ambient air through various activities in industrial plants and from huge damaged drums and containers. Accumulation of Al was almost same in all the selected sites and in all the three species except in site 1 by *Pongamia glabra*. The level of Al ranged from 48.4 to 5.4 in *Szygium cumini*, 31.7 to 10.5 in *Ficus religiosa* and 162.3 to 13 in *Pongamia glabra*. The deposition of Al was found with 38% in *Pongamia glabra* and 33, 32% in *Szygium cumini and Ficus religiosa* respectively. The correlation study revealed that Al was only but highly correlated with Mn in all selected three species.

Manganese was deposited on the leaves of all the three species from sites 1, 2 and 3 but absorbed only by *Ficus religiosa* from other three sites. This metal was emitted into the environment from the higher applications of pesticides and insecticides (Subodh Kumar Maiti *et al.,* 2017). The concentration of Mn was identified between 16 and below detectable limit in *Szygium cumini*, 11.2 to 5.6 in *Ficus religiosa* and 13.9 to below detectable limit in *Pongamia glabra*. The highest percentage of accumulation of 13 was found in *Ficus religiosa*, 7% in *Szygium cumini* and 4% in *Pongamia glabra*. The correlation study indicated that Mn was not correlated with any other parameters. The results clearly predicted that the level of Mn was not influenced by the variation in any other parameters.

The other heavy metals such as Pb, Cd, As and Cr was not identified in all the three species and in all selected sampling sites. The results shown that the tremendous changes and advancement in the field of medical, agriculture and automobile, stringent standards given by the pollution control board, rigorous rules and regulations framed and implemented by the (Environmental protection agency Environmental Protection Agency EPA. 2010) considerably reduced the emission of such pollutants into the surrounding environment. In the present work, Fe and Al was identified with higher values, Mn, Zn and Cu was in lesser amount and Pb, Cd, As and Cr was not traced in any selected locations.

## CONCLUSION

Species selected for the experiment such as *Szygium cumini*, *Ficus religiosa* and *Pongamia glabra* formed a

**Table 3.** Correlation co efficient for the heavy metals accumulated from six sites on three species

| Species | Parameters | Fe | Cu | Zn | Al | Mn |
|---|---|---|---|---|---|---|
| *Syzygium cumini* | Fe | 1 | | | | |
| | Cu | .703 | 1 | | | |
| | Zn | .280 | .700 | 1 | | |
| | Al | .953 | .691 | .480 | 1 | |
| | Mn | .564 | .849 | .922 | .709 | 1 |
| *Ficus religiosa* | Fe | 1 | | | | |
| | Cu | .257 | 1 | | | |
| | Zn | .374 | .679 | 1 | | |
| | Al | .881 | .163 | .148 | 1 | |
| | Mn | .670 | -.510 | -.035 | .636 | 1 |
| *Pongamia glabra* | Fe | 1 | | | | |
| | Cu | -.214 | 1 | | | |
| | Zn | .423 | .400 | 1 | | |
| | Al | .996 | -.216 | .480 | 1 | |
| | Mn | .720 | .169 | .930 | .766 | 1 |

**Table 4.** Regression equations for the heavy metals on three species

| Parameters | *Syzygium cumini* | | *Ficus religiosa* | | *Pongamia glabra* | |
|---|---|---|---|---|---|---|
| | Regression Equation | $R^2$ | Regression Equation | $R^2$ | Regression Equation | $R^2$ |
| Fe Vs Cu | y=0.019x-0.418 | 0.494 | y=-0.015x-0.067 | 0.066 | y=-0.003x+0.622 | 0.045 |
| Fe Vs Zn | y=0.035x+2.002 | 0.078 | y=0.030x+5.039 | 0.139 | y=0.032x+3.003 | 0.179 |
| Fe Vs Al | y=0.542x+2.712 | 0.908 | y=0.422x+7.941 | 0.776 | y=0.835x-6.380 | 0.992 |
| Fe Vs Mn | y=0.120x-0.059 | 0.318 | y=0.100x+5.114 | 0.448 | y=0.058x+1.272 | 0.518 |

greater role in the absorption of heavy metals $Fe^{2+}$, $Al^{2+}$, $Zn^{2+}$, $Mn^{2+}$ and $Cu^{2+}$ in the ambient air. The heavy metals, other than Pb, Cd, Cr and As were successfully deposited on the leaves of trees. The uptake of Fe was almost high in all the species in the order of *Szygium cumini*, *Pongamia glabra* and *Ficus religiosa*. The present work proved that all the selected species were used as indicator of the heavy metal pollution in the surrounding air and their absorption capacity varied with land use pattern and also with species.

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