J. Sci. Trans. Environ. Technov. 2009, 3(2): 54-58

Evaluation of plants for their tolerance to air pollution in industrial area a case study in Karaikudi Region, Tamil Nadu, South India.

D. Sarala Thambavani*[1] S. Sendur Kumaran[2], and G.Rajeswari[3]

[1] Department of Chemistry, Sri Meenakshi Government College For Women, Madurai-625 002, Tamil Nadu, India.

[2] Krishi Vigyan Kendra, Kundrakudi 630 206, Tamil Nadu, India.

[3] Department of Physics, Sri Meenakshi Government College, For Women, Madurai-625 002, Tamil Nadu, India.

Abstract

Evaluation of Air Pollution Tolerance Index (APTI) values derived from the biochemical parameters such as leaf extract pH, total chlorophyll content, percent relative water content and ascorbic acid of the leaf samples of five plant species namely, *Mangifera indica*, *Psidium guajava*, *Tamarindus indica*, *Azadirachta indica* and *Delonix regia* showed that their APTI values were lower in the industrial area of the Karaikudi town when compared to the residential area of the same region. Further more, the results showed the plant species, *Azadirachta indica* and *Delonix regia* have lost their tolerance and become more sensitive to pollution due to their continuous exposure to air pollutants near the industrial area.

Keywords : Air Pollution Tolerance Index (APTI), ascorbic acid, bioindicators, chlorophyll, industrial pollutants, leaf extract pH, water content

INTRODUCTION

Air pollution levels at industrial sectors are increasing at an alarming rate and are causing a potential threat to crop production (Singh *et al.*, 2005). Vaisanen (1986) and Wen *et al.* (2004) emphasized that the emission of air pollutants from industries have already led to damage of the natural communities and environment round the world. A review by Kovacs (1992) showed that plant cells and tissues could be used as indicators of environmental pollution, as the effects of acid gases such as oxides of Nitrogen, oxides of Sulphur and Hydrogen Fluoride on cells and tissues were primarily on the mechanism of photosynthesis and stomatal conductance, leaf pigmentation, chlorophyll fluorescence, metabolite content, enzyme activity, morphological features, ultra structure, histopathology and genetical changes. This paper focuses on the use of biochemical parameters of plants as indicators of air pollution and their use for air quality monitoring in industrial areas.

MATERIALS AND METHODS

Karaikudi is the largest town in Sivaganga District of Tamil Nadu, South India. It is located at 10.07ºN 78.78°E between Trichy- Ramaswaram High road. The town of Karaikudi and its surrounding area are centres of rice bran oil industries, paddy processing units and co-operative red oxide primer industries. Burning of wood is a regular activity for generation of heat to extract oxides of primer from dehusked cashew shell. The fumes exerted from burning fuel wood is the ultimate pollutant carrier. Keeping this in view, leaf samples of five different fruit plant species, namely, *Mangifera indica, Psidium guajava, Tamarindus indica, Azadirachta indica* and *Delonix regia* were collected within a radial distance of 1 km from the industries focussed (polluted site). For comparison, leaf samples were also collected from the residential areas (unpolluted site) where the same kinds of plant species were maintained.

The leaf samples collected from the respective sampling stations were dried in an electric oven kept at temperature between 60ºC and 70°C. It was then ground in a Wiley mill and passed through a twenty mesh sieve. The powdered material was mixed thoroughly and put in for estimation of the biochemical parameters *viz.*, leaf extract pH (Chaudhary and Rao, 1977), percent relative moisture content of the leaf (A.O.A.C., 1962), total chlorophyll content (mg.g-1 of dry weight) (Arnon, 1949) and ascorbic acid content (mg.g-1 of fresh weight) (Foyer, 1993). To quantify the impact of air pollution, the above four biochemical indicators were combined together to formulate the Air Pollution Tolerance Index (APTI) (Raza *et al.*, 1985).

$$\text{APTI} = \frac{A[T+P]+R}{10}$$

Where, A is the ascorbic acid content (mg.g-1 fresh weight), P is the leaf extract pH, T is the total chlorophyll (mg.g-1 dry weight) and R is the percent relative water content of the leaf. The Air pollution Tolerance Index (APTI) can be used as a good indicator of the impact of pollution on plants by classifying them into three categories of sensitivity, namely, sensitive (APTI less than 10), intermediate (APTI between 10 and 16) and tolerant (APTI greater than 16). Sensitive plant species

*Corresponding Author
email: *sarala_dr@yahoo.com*

Fig.1a. *Mangifera indica* at Residential area

Fig. 1b. *Mangifera indica* at Industrial area

Fig. 2a. *Psidium guajava* at Residential area

Fig. 2b. *Psidium guajava* at Industrial area

Fig.3a. *Tamarindus indica* at Residential area

Fig. 3b. *Tamarindus indica* at Industrial area

Fig. 4a. *Azadirachta indica* at Residential area

Fig. 4b. *Azadirachta indica* at Industrial area

Fig.5a. *Delonix regia* at Residential area

Fig. 5b. *Delonix regia* at Industrial area

Figures 1-5 . Comparative views of selected plant species at residential and industrial areas

Table 1. Variations in the values of biochemical indicators in the five selected plant species at residential (RA) and Industrial (IA) areas of Karaikudi, Tamilnadu, South India

Name of the plant species	Family	Mean pH		Mean Percent relative water content		Mean Total chloro phyll mg.g^{-1}		Mean Ascorbic acid mg.g^{-1}	
		RA	IA	RA	IA	RA	IA	RA	IA
Mangifera indica	Anacardiaceae	6.525	6.025	75.585	70.985	1.282	1.063	6.492	5.635
Psidium guajava	Myrtaceae	6.550	5.975	72.480	67.167	1.205	0.915	6.900	5.727
Tamarindus indica	Fabaceae	6.450	6.100	69.387	66.060	1.252	0.799	6.917	6.225
Azadirachta indica	Meliaceae	6.650	6.050	71.077	66.175	1.267	1.071	5.742	4.760
Delonix regia	Fabaceae	6.650	5.825	67.665	63.567	1.209	0.725	5.520	4.715

are useful as bioindicators.

RESULTS AND DISCUSSION

Levels of the biochemical indicators of *Mangifera indica, Psidium guajava, Tamarindus indica, Azadirachta indica* and *Delonix regia* at different bioindicator stations are tabulated in Table 1. The values of leaf extract pH, leaf total chlorophyll, percent relative water content and ascorbic acid were lower for the selected plant species that were found near the industries when compared to the reference trees at the residential area.

The reduction in leaf extract pH at the industrial area, was highest for *D. regia* (12.4%) followed by *A. indica* (9.02%) *M. indica* (7.66 percent) and *T. indica* (5.42%) when compared to the residential area (Fig. 1). This lowering of leaf extract pH in industrial areas might be due to the presence of acidic pollutants.

The relative water content of *P. guajava* near the industrial area showed a maximum loss by 7.33 percent compared to residential area (Fig. 1). The loss in relative water content of *D. regia* (6.05 percent) is similar to *M. indica* (6.08 percent) but more than *T. indica* (4.79 percent) and less than *A. indica* (6.89 percent). The decrease in relative water content might be due to increase of cell permeability of leaves which causes loss of water.

The total chlorophyll contents of the leaf samples of *A. indica* in the residential area and near the industrial area were 1.267 mg.g-1 and 1.071 mg.g-1, respectively. The loss in *A. indica* is 15.47 percent which is less when compared to that of *M. indica* (17.08 percent), *P. guajava* (24.07 percent) and *T. indica* (36.10 percent) (Fig. 1). The reduction in total chlorophyll content was more pronounced in *D. regia* (40.03 percent). Generally, the reduction in chlorophyll in plants could unfavourably affect the photosynthesis, growth and productivity of plants.

The ascorbic acid content of *A. indica* is reduced to a maximum of 17.1 percent at the polluted industrial area when compared to the unpolluted residential area. This is almost similar for *P. guajava* (17 percent), while the reduction in ascorbic acid content was less for *M. indica* (13.2 percent), *D. regia* (14.58 percent) and *T. indica* (10 percent) (Fig. 1). Since the two different sites were subjected to the same meteorological variables, the observed variation in the biochemical parameters might will be due to the industrial air pollutants and sensitivity of the plants.

For all the five plant species, the APTI values at the industrial area were lower than the residential area (Table 2 & Fig. 2). The reduction in APTI was maximum for *P. guajava* (15.26%) followed by *D. regia* (15.03%), *A. indica* (14.07%), *M. indica* (12.19%) and *T. indica* (11.4%). The APTI values of the plant species of *Azadirachta indica* and *Delonix regia* got reduced to 10.01% and 9.44%, respectively, at the polluted site, which indicated that these species have lost their tolerance towards pollution and become sensitive as the industrial pollution load increases. The plant species such as *M. indica*, *P. guajava* and *T. indica* with higher APTI are comparatively more resistant and act as bioaccumulators of air pollutants.

In conclusion the present study suggests that plants have the potential to serve as suitable bioindicators to indicate the relative air quality of specific areas and biomonitoring of plant species might be considered

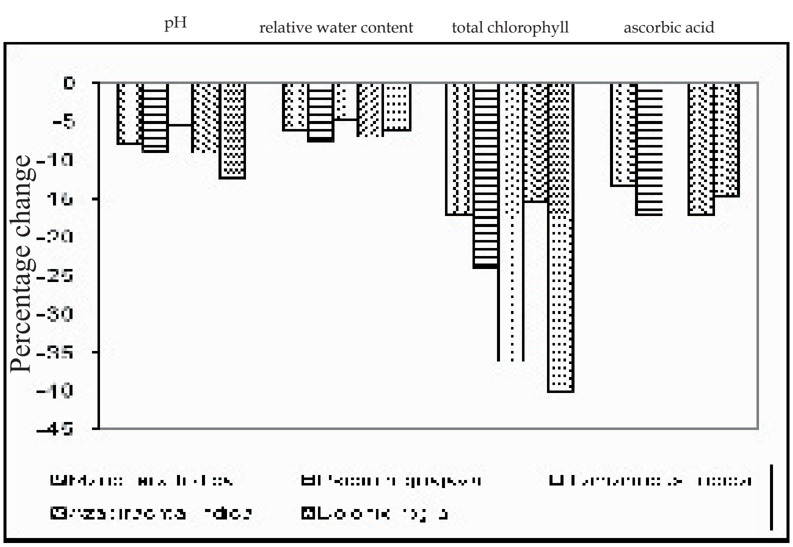

Figure 2. Per cent changes in the four biochemical parameters of the five plant species in the industrial area when compared to residential area

Table 2. Air Pollution Tolerance Index (APTI) of plant species at residential and industrial areas of Karaikudi, Tamilnadu, South India

Name of the plant species	APTI at Residential area	Sensitivity/Tolerance	APTI at Industrial area	Sensitivity/Tolerance
Mangifera indica	12.63	Intermediate	11.09	Intermediate
Psidium guajava	12.58	Intermediate	10.66	Intermediate
Tamarindus indica	12.27	Intermediate	10.90	Intermediate
Azadirachta indica	11.65	Intermediate	10.01	Sensitive
Delonix regia	11.11	Intermediate	9.44	Sensitive

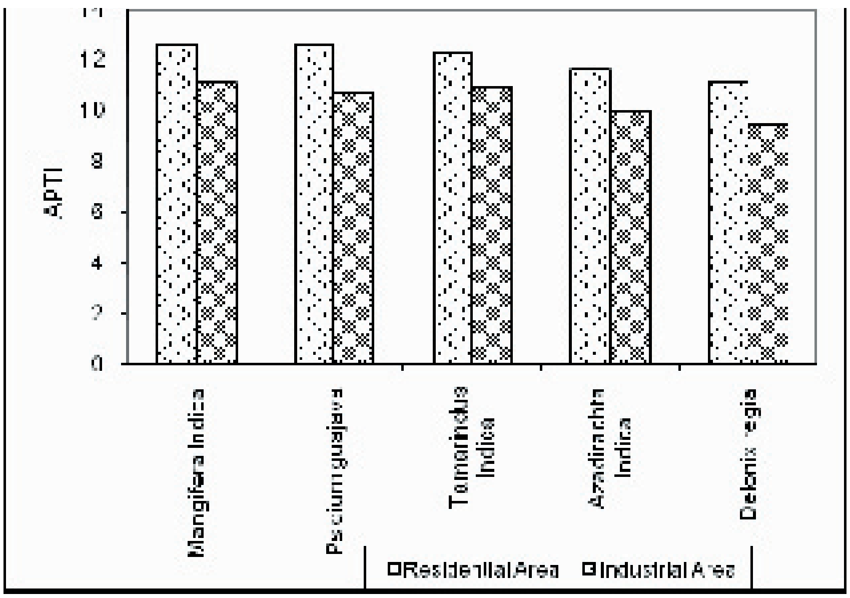

Figure 3. Air Pollution Tolerance Index (APTI) of the five selected plant species growing at residential and industrial areas of Karaikudi, Tamilnadu, South India

as an important and inexpensive tool to evaluate the impacts of air pollution.

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