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## ORIGINAL ARTICLE

# Assessment of Biochemical Characters and Development of Anticipated Performance Index for Air Pollution Stress Plants in Tiruchirappalli City

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**ABSTRACT**
*The urban forest is a collection of plant species growing in the urban area. Green plants are well known for their abilities in reducing air pollution. Plants used to develop the urban forest must be tolerant of air pollutants. In the present study, five plant species' air pollution tolerance index has been evaluated by two important biochemical parameters and one physiological parameter. The other biological and socioeconomic parameters of these plant species were also considered, along with air pollution tolerance index values for calculating the anticipated performance index under the effect of overall pollution stress. Based on these two indices, the most pollution-tolerant and economically valuable plant species have been identified for green belt development in and around an urban area, Tiruchirappalli, Tamil Nadu. It was revealed that* F. religiosa, and A. indica, *would be the outstanding performers among the five plants. These plants are recommended for green belt development.*
***Keywords:*** *Biochemical parameters, Air pollution Index, Air Pollution Tolerance Index*

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## INTRODUCTION

In recent years, air quality in urban cities in India degraded significantly due to the rise in Vehicular transportation, fossil fuel combustion in industries, coal mining activities, and deforestation [1,2]. Vehicular emissions and mining activities are considered essential sources of pollution, such as particulate matter, CO, NOx, SOx, and trace elements [3]. Recent studies showed various experts have also investigated the impacts of air pollution on plants [4]. As green belts are efficient means to mitigate air emissions by trapping particulate matter and capturing gaseous pollutants, environmental activists and policymakers emphasize the importance of a permanent green belt in and near urban areas and on highways to decrease the result of toxic fine particulates and to use as bioindicator of pollution [5,6].

Plants can eradicate pollution by three mechanisms: particulate deposition, leaf absorption, and particulate accumulation on the leaf surface on the protected side of the leaf due to the wide surface area of the leaves that acts as a sink (7,8). However, air pollutants, on the other hand, could harm plant growth by affecting the biochemical parameters, morphological characteristics, photosynthetic activity, and seed germination (9). Several plants will adapt to the ever-changing environments through adaptations in biochemical parameters, particularly in chlorophyll, ascorbic acid, leaf pH, and relative water content. The changes within the higher than biochemical parameters will be taken under consideration in estimating the Air Pollution Tolerance Index (APTI) of plant species, whereas classifying the plant species as sensitive, intermediate, or tolerant to air pollutants (10). The APTI is considered an effective method for identifying bio-indicator plants. The four biochemical parameters, including ascorbic acid (AA), leaf extract pH (pH), total chlorophyll content (TCH), and relative water content (RWC), are used to calculate the APTI values (10). Ascorbic acid is a molecule within the metabolism of carbohydrates, fats, and proteins, likewise because of the production of nucleic acid in polymer, photosynthetic activity and growth of plants (11).

TCH, together with the most important components of energy generation in green plants, clearly impacts plant health that is greatly influenced by several environmental factors (12). RWC could be a key determinant of plant protoplasmic permeability. As a result, plants with more significant water content levels could be additional tolerant to air pollutants (13). The pH of plants is powerfully associated with pollution, particularly sulfur dioxide. Plants appear extra sensitive to low pH and more tolerant as pH approaches 7 (14). Generally, Plants with higher APTI values are regarded as the most tolerant of polluted environments. They are ideal for establishing green belts, whereas plants with lower APTI values are the most sensitive and functional bioindicator species of air pollution (15).

Study area

Tiruchirappalli, better called Trichy. Tiruchirappalli city is the fourth largest city in Tamil Nadu state, India. It is the transportation centre of the state. It is located on the banks of the river Cauvery on which the first man-made dam, kallanai, was built. The world-famous landmark in Trichy city is the 85m tall rock fort right in the middle of the city, which was used as a military fort during the pre-British period. Being a central city in the state, all directions of road travelers are supposed to cross Tiruchirappalli town, so the vehicular pollution rate is higher. The recorded average annual rainfall of 945 mm mainly occurs during the monsoon season. The temperature in winter reaches a maximum of 41°C and a minimum of 36°C, and in summer temperature during this ranges from 19°C to 22°C. There are four highways, NH 38, NH 81, NH 83, and NH 336, by way of the city.

*Sample collection*

Five different plant species, most commonly in traffic areas such as *A. indica, P.pterocarpum, P.longifolia, P. pinnata*, and *F. religiosa* of the same age in triplicate were collected from ten different sites S1 Trichy Central bus stand, S2TrichyRailwaystation, S3Post office, S4Gandhi market, S5Main guard gate, S6Chatiram bus stand, S7Mambalasalai, S8Golden rock, S9Bishop Heber college, S10 Bharathidasan University . The leaves were placed in the marked sterile polythene bags, and these bags were put into the liquid nitrogen container. The leaf samples were maintained at $20^0$Cfor further analysis.

## MATERIAL AND METHODS

*leaf extract pH*

The pH determination was done following Singh and Rai (1983). One gram of fresh leaves was homogenized using 10 ml of deionized distilled water. The extract was filtered leaf samples and centrifuged and the supernatant was collected after measured by a digital pH meter.

*Total chlorophyll content*

Total chlorophyll content was estimated using the method by Arnon (1949). A sample of 0.5 g of fresh leaves was cursed and homogenized with 10 ml of 80% acetone and centrifuged at 2500 rpm for 5 min. The supernatant was collected in a brown container. This procedure was repeated until the white color precipitate. The collected supernatant was analyzed with a spectrophotometer absorbance was measured at 645 and 663 nm.

*Relative water content*

Relative water content was according to Henson et al (1981). Fresh leaves weight was obtained by weighing the fresh leaves, and turgid weight (TW) was determined after saturation of leaves in D.$H_2O$ for dark conditions overnight, the weight of turgid weighed. For dry weight estimation, turgid leaves were dried in a hot air oven at 70 °C for 48 h.

*Ascorbic acid*

Ascorbic acid was according to the method of Mukherjee and Chaudhuri (1983). The plant leaf 1 g was macerated with 10 ml of trichloroacetic acid (6% w/v) and centrifuged for 10 min at 10,000 rpm. Then, the supernatant was collected and made to a known volume with 6% (w/v) of trichloroacetic acid. In a separate test tube, 4 ml aliquot was taken from the sample solution, 2 ml of 2% dinitrophenylhydrazine and one drop of 10% thiourea in 70% ethanol were added subsequently. In a water bath, the mixture was boiled for 15 min, and then 5 ml of 80% $H_2SO_4$ was added.

### Air Pollution Tolerance Index (APTI)

The APTI score is determined from four biochemical characterizations of the plant species ascorbic acid (A), pH of the leaf extract (P), Relative water content(R), and Total chlorophyll content (T).

APTI was calculated by the following formula:

APTI = [A (T+P) + R] 10

## Anticipated performance index (API)

API is based on various factors influencing the performance of a certain species of plant. Most of the suitable plants for the development of urban forests can be determined by obtaining their API values. With a high value of the API, the growth performance of the plant species in the urban green forest will be higher. API is calculated by evaluating various socioeconomic, biochemical, and biological parameters of the plant species, such as APTI, plant habit canopy structure, and economic value. The API score is given to each plant species according to the criteria described in table 2.

**Table 1. Gradation of plants species based on anticipated performance indices (API) as well as biological parameters and socioeconomic importance**

| Grading character | Pattern of assessment | Grade allotted |
|---|---|---|
| **Tolerance** | | |
| APTI | 6.0 – 9.0 | + |
| | 9.0 – 12.0 | ++ |
| | 12.0 – 15.0 | +++ |
| | 15.0 – 18.0 | ++++ |
| | 18.0 – 21.0 | +++++ |
| **Biological and socio- economic** | | |
| Plant habit | Small | - |
| | Medium | + |
| | Large | ++ |
| Canopy structure | Sparse/irregular/globular | - |
| | Spreading crown/open/ semi-dense | + |
| | Spreading dense | ++ |
| Type of plant | Deciduous | - |
| | Evergreen | + |
| **Laminar structure** | | |
| Leaf size | Small | - |
| | Medium | + |
| | Large | ++ |
| Texture | Smooth | - |
| | Coriaceous | + |
| Hardiness | Delineate | - |
| | Hardy | + |
| Economic value | Less than three uses | - |
| | Three or four uses | + |
| | Five or more uses | ++ |

## RESULTS AND DISCUSSION

The present study clearly shows the changes in the plant biochemical characteristics pH Total chlorophyll content, Relative water content, and Ascorbic acid content in the five plant species of *A. indica, P.pterocarpum, P.longifolia, P. pinnata, F. religiosa* exposed traffic area.

### Leaf extract of pH

The pH of plant leaves was found to be more the all stations as compared to the reference site. The selected plant's leaf pH at ten different sites was shown in (Fig 2) comparison in pH values estimated at the experimental site and control site. The pH of the experimental site maximum and minimum values are 6.17 to 7.57*A. indica, 6.72 to 5.49 P.pterocarpum,* 6.98 to 5.77 *P.longifolia,* 6.98 to 6.18 *P. pinnata,* 7.49 to 5.36 *F. religiosa* and control site 6.11 *A. indica,* 5.6 *P.pterocarpum,* 5.92 *P.longifolia,* 5.98 *P. pinnata, and* 4.96 *F. religiosa* respectively. The pH of the plant leaf becomes acidic in the plants of the polluted environment. The pH is an indication of the development of detoxification mechanism in plant species necessary or tolerance (20). Its plays a significant character in the physiological processes of plants. It is reported by various such as researchers that the photosynthetic efficiency of plants is strongly dependent on pH. For example, when low pH, the photosynthetic actions are reduced (21). The presence of acidic pollutants has been reported as the leading cause of lowered pH of leaf extract, and sensitive species were set up to be more vulnerable to acidic Pollutants [22].

### Total chlorophyll content

Total chlorophyll content of the plants was shown in (Fig 1).Comparison of total chlorophyll content was the experimental and control site. The plant's total chlorophyll content (mg/g) was highest in *P.pinnata* 4.13(S8), 4.03(S7) and 3.96(S4) for these plants experimental site chlorophyll contents were 4.96, 4.92, 4.21, 3.39 and 3.39 respectively. In all the five plant species lowest total chlorophyll content was presented in the S6 site and their values of 1.52 *A. indica,* 1.31 *P. pterocarpum,* 1.07 *P. longifolia,* 1.56 *P. pinnata,* 1.31 *F. religiosa* in control site*.* The chlorophyll content was highly damaged by the air pollution. Chlorophyll is present in leaves, traps sunlight from the atmosphere, and converts it into chemical energy. A decrease in chlorophyll content is related to an accumulation of particulate matter on the leaf surface, which ultimately leads to blockage of stomata pores and a decrease in photosynthetic productivity (23).

**Table 2. Evaluation of plant species based on their API values and some biological and socio-economic characters**

| Name of the plants | Sampling sites and codes | APTI | Plant habit | Canopy structure | Type of plant | Leaf size | Texture | Hardiness | Economic value | Total plus (+) | % Scoring | API grade |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Azadirachta indica | S1 | ++++ | ++ | + | + | - | - | + | ++ | 11 | 68.75 | 4 |
| | S2 | ++++ | + | + | + | - | - | + | ++ | 10 | 62.5 | 4 |
| | S3 | +++ | ++ | + | + | - | - | + | ++ | 10 | 62.5 | 4 |
| | S4 | +++ | ++ | + | + | - | - | + | ++ | 10 | 62.5 | 4 |
| | S5 | +++ | ++ | + | + | - | - | + | ++ | 10 | 62.5 | 4 |
| | S6 | ++++ | ++ | + | + | - | - | + | ++ | 11 | 68.75 | 4 |
| | S7 | +++ | + | + | + | - | - | + | ++ | 9 | 56.25 | 3 |
| | S8 | ++ | + | + | + | - | - | + | ++ | 8 | 50 | 2 |
| | S9 | +++ | + | + | + | - | - | + | ++ | 9 | 56.25 | 3 |
| | S10 | ++ | + | + | + | - | - | + | ++ | 8 | 50 | 2 |
| Peltophorumpterocarpum | S1 | +++ | + | + | + | - | - | + | ++ | 9 | 5.25 | 3 |
| | S2 | +++ | + | + | + | - | - | + | ++ | 9 | 5.25 | 3 |
| | S3 | ++ | ++ | + | + | - | - | + | ++ | 8 | 50 | 2 |
| | S4 | ++ | ++ | + | + | - | - | + | ++ | 8 | 50 | 2 |
| | S5 | ++ | + | + | + | - | - | + | ++ | 8 | 50 | 2 |
| | S6 | ++++ | ++ | + | + | - | - | + | ++ | 11 | 68.75 | 4 |
| | S7 | +++ | ++ | + | + | - | - | + | ++ | 10 | 62.5 | 4 |
| | S8 | ++ | ++ | + | + | - | - | + | ++ | 9 | 5.25 | 3 |
| | S9 | ++ | ++ | + | + | - | - | + | ++ | 9 | 5.25 | 3 |
| | S10 | + | ++ | + | + | - | - | + | ++ | 8 | 50 | 2 |
| Polyalthialongifolia | S1 | ++ | + | + | + | + | - | + | + | 8 | 50 | 2 |
| | S2 | +++ | + | + | + | + | - | + | + | 9 | 56.25 | 3 |
| | S3 | ++ | + | + | + | + | - | + | + | 8 | 50 | 2 |
| | S4 | + | + | + | + | + | - | + | + | 7 | 43.75 | 2 |
| | S5 | +++ | + | + | + | + | - | + | + | 9 | 56.25 | 3 |
| | S6 | +++ | + | + | + | + | - | + | + | 9 | 56.25 | 3 |
| | S7 | + | + | + | + | + | - | + | + | 7 | 43.75 | 2 |
| | S8 | + | + | + | + | + | - | + | + | 7 | 43.75 | 2 |
| | S9 | + | + | + | + | + | - | + | + | 7 | 43.75 | 2 |
| | S10 | + | + | + | + | + | - | + | + | 7 | 43.75 | 2 |
| Pongamiapinnata | S1 | +++ | + | + | - | - | - | + | ++ | 8 | 50 | 2 |
| | S2 | +++ | + | + | - | - | - | + | ++ | 8 | 50 | 2 |
| | S3 | +++ | + | + | - | - | - | + | ++ | 8 | 50 | 2 |
| | S4 | ++ | + | + | - | - | - | + | ++ | 7 | 43.75 | 2 |
| | S5 | +++ | + | + | - | - | - | + | ++ | 8 | 50 | 2 |
| | S6 | ++++ | + | + | - | - | - | + | ++ | 9 | 56.25 | 3 |
| | S7 | ++ | + | + | - | - | - | + | ++ | 7 | 43.75 | 2 |
| | S8 | ++ | + | + | - | - | - | + | ++ | 7 | 43.75 | 2 |
| | S9 | ++ | + | + | - | - | - | + | ++ | 7 | 43.75 | 2 |
| | S10 | ++ | + | + | - | - | - | + | ++ | 7 | 43.75 | 2 |
| Ficusreligiosa | S1 | ++++ | ++ | + | + | ++ | + | + | + | 13 | 81.25 | 6 |
| | S2 | ++++ | ++ | + | + | ++ | + | + | + | 13 | 81.25 | 6 |
| | S3 | +++ | ++ | + | + | ++ | + | + | + | 12 | 75 | 5 |
| | S4 | +++ | ++ | + | + | ++ | + | + | + | 12 | 75 | 5 |
| | S5 | +++ | ++ | + | + | ++ | + | + | + | 12 | 75 | 5 |
| | S6 | +++++ | ++ | + | + | ++ | + | + | + | 14 | 87.5 | 6 |
| | S7 | +++ | ++ | + | + | ++ | + | + | + | 12 | 75 | 5 |
| | S8 | ++ | ++ | + | + | ++ | + | + | + | 11 | 68.75 | 4 |
| | S9 | +++ | ++ | + | + | ++ | + | + | + | 12 | 75 | 5 |
| | S10 | ++ | ++ | + | + | ++ | + | + | + | 11 | 68.75 | 4 |

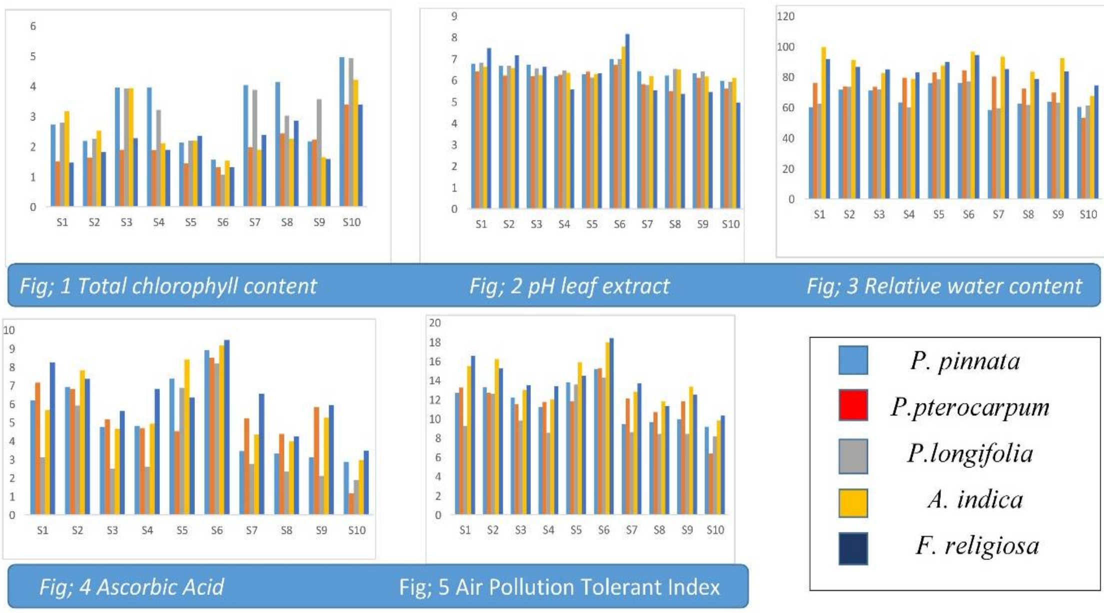
 

**Ascorbic acid content**

Ascorbic acid is also a significant metabolite in plants and activates the resistance mechanism in plants under stress. The present study increased level of ascorbic acid (mg/g) was observed in all plants and the increasing the level depends on pollution stress. Comparison of ascorbic acid content was the reference site and experimental sites shown in (Fig 4) 9.15 *A. indica*, 8.49 *P. pterocarpum*, 8.19 *P. longifolia*, 6.92 *P. pinnata*, 8.25 *F. religiosa*. As compare to the control site 2.96 A. indica, 1.17 *P. pterocarpum*, 1.89 *P. longifolia*, 2.87 *P. pinnata*, 3.48 *F. religiosa*. Ascorbic acid, a natural antioxidant, gives a stability to plants under pollution stress with free radicals [4].

**Relative water content**

Relative water content is associated with the tolerance of plants against pollutants. The water content in plants is of great importance, it regulates many physiological functions of plants under varied stress conditions such as when plants are exposed to a high load of pollutants [24]. The difference in relative water content among studied plants may be due to the changes in the tolerance of plants against different pollutants. A high level of water content under stress conditions is an indication of tolerance in plant species [25]. A comparison of relative water content was the reference site and experimental sites is shown in (Fig 3), the highest water content was observed in the reference site when compared to the experimental sites. 99.45 *A. indica*, 84.31 *P. pterocarpum*, 78.37 *P. longifolia*, 75.94 *P. pinnata*, 94.36 *F. religiosa.* As compare to the control site *67.55 A. indica, 53.16 P. pterocarpum, 62.32 P. longifolia,* 6.24 *P. pinnata*, and 74.42 *F. religiosa*. As water content is directly related to protoplasmic permeability, a higher proportion of water content in plants improves resistance and enables the plant more tolerant of stress caused by air pollution [26, 27].




*Fig; 1 Total chlorophyll content* *Fig; 2 pH leaf extract* *Fig; 3 Relative water content*

*Fig; 4 Ascorbic Acid* Fig; 5 Air Pollution Tolerant Index

**APTI and API**

Four biochemical parameters pH, total chlorophyll content, ascorbic acid and relative water content were used to calculate the APTI of an individual plant species APTI investigates the vulnerability of particular plant species to air pollution (28). Higher values of APTI of the plant species were found at the sites of experimental whereas lower APTI values were found at the reference site. Plants having a higher APTI value are regarded as tolerant to air pollution and may be utilized to reduce pollution levels. According to the values of APTI, in the present study, ten different sites were shown (Fig 5). As plants with high pollution tolerance can support pollutant accumulation, planting pollution-tolerant species to preserve contaminated areas is a long-term solution to satisfy industrial and commercial expansion (29). API plants were evaluated (Table 3) and plants into the grading pattern for their API for the development of the urban green belt in Trichy city. APTI and API are an important combination for measuring significance of green plants in air pollution mitigation (4).

## CONCLUSION

The air pollution tolerance index (APTI) becomes a powerful tool in the selection of suitable tree species when it was combined with the anticipated performance index (API) value. Plants having high APTI and API values are recommended for greenbelt development in an urban city. These indices are based on biochemical parameters and biological and socioeconomic characteristics and can be applied worldwide. This study indicates that *F. religiosa* and *A. indica* are the outstanding category of plant species and can be expected to perform well against air pollution. The remaining moderate, poor, and very poor categories of plants are sensitive to air pollution. Hence, APTI determination would be the target for future pollution mitigation and the purpose of greenbelt development.

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