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Role of Plants for Evaluation of Air Pollution Tolerance Index on the Basis of Some Biochemical Parameters: A Concise Review

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ABSTRACT

Several common plants such as, *Mangifera indica*, *Pinus roxburghii*, *Thuja occidentalis*, *Tamarindus indica*, *Cassia fistula*, *Dalbergia sissoo*, *Quercus* sp., *Bauhinia recemosa* etc. are available to absorb various pollutant gases. Plant leaves are the ideal indicator to measure the degree of air pollution and most plant have exhibited various physiological changes before showing any visible symptom in the leaves. Air pollution tolerance index (APTI) is a simple and efficient method for identifying plant species that can tolerate air pollution. It only requires four different types of leaf biochemical parameters, including the pH of plant leaf extract, the relative water content of the leaf, ascorbic acid, and the total chlorophyll content of the leaf. The amount of plant susceptibility to air pollution was assessed using the APTI score. Higher APTI-valued plants are extremely beneficial as a bio-monitoring tool for improving the atmosphere. For plantation programmes in newly constructed urbanized areas and avenues to produce pollution-free green environments, plant species with higher APTI values can be prioritized.

Key words: *Air pollution, APTI, Biochemical parameters, Green environment, Leaf extract*

Introduction

21st century is the era of modern technology, which provides cozy lifestyle of human civilization. But environmental pollution is the major drawback behind the enormous success of scientific achievements and by product of industrialization and urbanization. Thus worldwide living organisms suffered severely as the effect of various types of pollution (Aasawari and Umesh, 2020).

Plants have an important role to reducing as well as monitoring air pollution through the recycling of gases specially CO_2 and O_2 by photosynthesis and also providing vast leaf canopy for accumulation, absorption and impingement of air pollutants to minimize the ambient environmental air pollution level (Suvarna *et al.*, 2008). They are the best dust collectors. Plant leaves are the ideal indicator to measure the degree of air pollution and most plant have exhibited various physiological changes before showing any visible symptom in the leaves. Acclimatization of plants to air pollutants might change their morphological structure such as thicker epidermal cells and longer trichomes (Steubing *et al.*, 1989; Dohmen *et al.*, 1990; Rangkuti, 2003). According to various reports many plant species such as *Mangifera indica* (Mango), *Pinus roxburghii* (Chir), *Thuja occidentalis*, *Tamarindus indica* (Imli), *Cassia fistula* (Amaltas), *Dalbergia sissoo* (Sishu), *Quercus* sp. (Oak), *Bauhinia recemosa* (Kanchan) etc. act as air pollution

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indicator plants. Several tree species such as *Shorea robusta* (Sal), *Tectona grandis* (Teak) *Terminalia arjuna* (Arjun), *Bauhinia purpurea* (Kanchan), *Butea monosperma* (Palas), *Azadirachta indica* (Neem) etc. also serve as importantdust collector plants (Enitan *et al*., 2022; Pandey *et al*., 1997). To select air pollutant tolerant plants within environment the air pollution tolerance index (APTI) is an important criterion.

Materials and Methods

Air Pollution Tolerance Index (APTI)

Roadside trees are affected maximally by the air pollution as they are the primary recipients to different air pollutants (CO_2, CO, SO_2, NO_X, O_3 etc.) and show various levels of tolerance and sensitivity. In determining air pollution tolerant plant species air pollution tolerance index (APTI) is the very easy and effective method proposed by Singh *et al.* (1991).

APTI is an empirical relation which evaluates the tolerance level of plant species towards air pollution from four types of leaf biochemical parameters; such as pH of plant leaf extract, relative water content of the leaf, ascorbic acid and total chlorophyll content of the leaf.

Biochemical parameters for evaluation of APTI

For the estimation of APTI value; four major biochemical characters are required, which are mentioned above. The details methods of extraction and calculation of those parameters are described below. Aqueous extract of fresh leaves was used for the entire study.

1. **pH of plant leaf extract:** 5 g of the fresh leaves was homogenized in 10 ml deionised water. This was then filtered and the pH of leaf extract was determined after calibrating pH meter with buffer solution of pH 4, pH 7 and pH 9 (Agbaire and Esiefarienrhe, 2009).
2. **Ascorbic Acid content of the leaf:** 1g of the leaf sample was measured into a test tube, 4 ml of oxalic acid-EDTA extracting solution was added. Then 1 ml of orthophosphoric acid followed by 1 ml 5% tetraoxosulphate acid, 2 ml of ammonium molybdate and then 3 ml of water was added. The solution was then allowed to stand for 15 minutes, after which the absorbance at 760nm was measured with UV-Vis spectrophotometer. The concentration of ascorbic acid in the leaf samples were then extrapolated from a standard ascorbic acid curve (Bajaj and Kaur, 1987; Agbaire and Esiefarienrhe, 2009).
3. **Relative Water Content of Leaf (RWC):** Fresh leaves were weighed (FW) and then immersed in water over night, blotted dry and then weighed to get the turgid weight (TW). Then, the leaves were dried overnight in an hot air oven at 70°C and reweighed to obtain the dry weight (DW).

   Calculations were made using the formula: $RWC = [(FW - DW)/(TW - DW)] \times 100$
4. **Total chlorophyll content of the leaf:** 1g of fresh leaves were blended and then extracted with 20 ml of 80% acetone and left for 15 minutes for thorough extraction. Then the liquid portion was poured into another text-tube and centrifuged at 5,000rpm for 5 minutes. The supernatant was then collected and finally the volume of the extract was adjusted to 100 ml, by adding 80% acetone. Then the absorbance was then taken at 645nm and 663 nm using UV-Vis spectrophotometer (Arnon, 1949).

   Calculations were made using the formula:

   Estimation of total chlorophyll / g tissue: $20.2 \times (A_{645}) + 8.02 \times (A_{663}) \times V / (1000 \times W)$

   Where, A= absorbance at specific wave length V= final volume of chlorophyll extraction in 80% acetone and W= fresh weight of extracted tissue

Evaluation of APTI value: The estimation of air pollution tolerance index is followed according to the calculation of Singh *et al*. (1991); which is given below:

$$APTI = \{A (T+P) + R\} /10$$

Where, A = Ascorbic Acid content (mg/g), T = Total Chlorophyll content (mg/g), P = pH of leaf extract, and R = Relative water content of leaf (%).

Tolerance level of plants based on APTI scale

According to Singh *et al*. (1991), the category of tolerance may vary from different groups of plants (Deciduous, Evergreen, Herbs and Crops) based on APTI value. There are four categories of tolerance level- tolerant, moderately tolerant, intermediate and sensitive according to the decreasing APTI value (Table 1).

Results and Discussion

Significance of APTI with examples: Plants have a very close relationship with nature and if any altered condition occurs in the atmosphere, it directly affects the physiology and biochemistry of plant. The recognition and classification of plants into tolerant and sensitive groups is essential because the sensitive plants can use as an indicator and the tolerant as a sink for the pollutants in city and developed habitats. Air pollution tolerance index indicate the potential of vegetation to encounter air pollution (Panda *et al*., 2018). Plants naturally pure the air by consuming particulate matter and smoke. Sensitive tree species are suggested as bio-indicators (Raina and Sharma, 2006).

Based on air pollution tolerance index several common plants are categorized into four types by renounced scientists to study numerous plants from different urban, industrial and polluted regions of India. According to their reports *Alstonia scholaris*, *Ageratum conyzoides*, *Acacia nilotica*, *Bauhinia variegata*, *Bougainvillea spectabilis*, *Casuarina equisitifolia*, *Cinnamomum burmanii*, *Lagerstroemia speciosa* etc. are regarded as sensitive plant species. *Gmelina arborea*, *Pterocarpus indicus*, *Mimusops elengi*, *Swietenia macrophylla*, Peepal, Jujube, Amla showed intermediate response to air pollution. *Ficus rumphii*, *Grewelia robusta*, *Pterocarpus indicus*, *Swietenia macrophylla*etc. are categorized in to moderately tolerance group. On the other hand various common plants, those are situated around us are designated as tolerant plants against air pollutants viz. *Azadirachta indica*, *Bambusa bambos*, *Cassia siamea*, *Delonix regia*, *Ficus glomerata*, *Ficus religiosa*, *Holoptelea integrifolia*, *Lagerstroemia speciosa*, *Psidium guajava*, *Pithecolobium dulcis*, *Saraca indica*, *Syzygium cumini*, *Ficus infectoria*, *Terminalia catappa* (Tiwari and Tiwari, 2006, Laxmi *et al*., 2008, Sulistijorini *et al.*, 2008; Tripathi *et al.,* 2009, Begum and Harikrishna, 2010, Gupta *et al.,* 2011, Panda *et al*., 2018; Aasawani and Umesh, 2020).

Importance of biochemical parameters to detect air pollution: The APTI value was used to evaluate the susceptibility level of plants to air pollutants (Singh *et al*., 1991). pH plays an important role in signifying the condition of plants with respect to the study area. pH of the fresh leaf extract signifies the tolerant capacity of species. Sensitive plants have lowered pH during the presence of acidic pollutant than tolerant plants. Higher level of pH in leaf extract indicates that the plants are tolerant against air pollution (Paulsamy and Senthilkumar, 2009). Ascorbic acid being a strong reducing agent protects chloroplasts against SO_2 induced H_2O_2, O_2 and OH accumulation and this protects the enzymes of the carbon dioxide fixation cycle and chlorophyll from inactivation (Chaudhary and Rao, 1977). Thus, higher concentration of ascorbic acid level under polluted condition is considered to be tolerant to air pollutants (Kumar and Nandini, 2013). The large quantity of water in plant helps in maintaining its water level balance under stressful conditions of pollution (Aasawani and Umesh, 2020). Relative turgidity is a direct measure of deficit in leaves. Relative water content indicates the capacity of the cell membrane to maintain its permeability under polluted conditions (Masuch *et al*., 1988). Thus tolerant plants exhibit higher relative water content value against pollution.

According to the reports of Paulsamy *et al.* (2000), chlorophyll level in tree species decreases many fold against air pollutants, however, the variation in chlorophyll content among the tree species in the study area may be owing to species tolerant nature (Kumar and Nandini, 2013).

Thus, this combination of four parameters (pH, Ascorbic Acid, RWC and Chlorophyll) is suggested as representing the best index to detect susceptible and tolerant plants under field conditions.

Conclusion

Plants with higher APTI value are very much useful as a bio–monitoring tool for the betterment of the atmosphere. The tree species with higher and low APTI value can serve as tolerant and sensitive respectively. Such tolerant tree species can effectively use as indicators and pollution scavengers. It is con-

Table 1. Different plants along with their tolerance level are categorized in accordance with APTI scale

Plantstype	Level of tolerance			
	Sensitive	Intermediate	Moderately tolerant	Tolerant
Deciduous	<14	15-19	20-24	>24
Evergreen	<12	13-16	17-20	>20
Herbs	<10	11-14	15-18	>18
Crop	<16	17-29	—-	>29

cluded that plant species having higher APTI value (*Azadirachta indica*, *Mangifera indica*, *Cassia siamea*, *Ficus benghalensis* etc.) can be given priority for plantation program in newly developed urbanized areas and avenue to create pollution free green environment.

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