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Research Article

EVALUATION OF AIR POLLUTION TOLERANCE INDEX OF THE FLORAS IN THE MANUFACTURING ZONE NEAR COIMBATORE IN INDIA AND CERTIFICATION OF FORBEARING TYPES

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ABSTRACT

A research work on Air pollution tolerance index of existing nineteen types of flora were carried out to assess their response to air pollutants around the manufacturing zone, Arasur Coimbatore, Tamil Nadu, India. Four biochemical parameters, viz., leaf relative water content, ascorbic acid, total leaf chlorophyll and leaf extract pH were examined and Air pollution tolerance index of the flora were assessed. All the parameters of the flora were analyzed systematically, grouped as four types namely Tolerant, Moderate, Intermediate and Sensitive. The forbearing types having higher Air pollution tolerance index value can be considered for plantation program around the manufacturing zone, so as to reduce the effects of air pollution and make the surrounding location clean, healthy and safe for working and living conditions.

Key words: Air pollution tolerance index, Ascorbic acid, Biochemical parameters, Plantation, Total leaf chlorophyll.

INTRODUCTION

Quick development and expansion with upsurge in vehicular movement has a great danger to air quality world-wide. Air pollutants are frightening the way of life of the living creatures [1]. Due to use of huge mass in manufacturing sectors, local unruly situation becomes a provincial one. The wild use of fossil fuel in manufacturing sectors and automobiles has led to the increase in concentrations of smoky pollutants such as SO_2, NO_x, Suspended Particulate matter etc., in the air. Particulate matter is of serious concern and cause opposing impact on social health and flora [2].

No conventional methods are known to improve air pollution. A suitable alternative is to encourage a natural method by growing green plants in and around manufacturing zone and towns [3, 4]. Flora provides one of the best accepted ways of cleaning the air by providing an enormous leaf area for impingement, captivation and gathering of air pollutants in the surrounding with a numerous range [5]. Bio-monitoring of flora is an important tool to evaluate the influence of air pollution. The response of flora towards air was determined by air pollution tolerance index. The worth of evaluating APTI for the assessment of tolerance as well as sensitiveness of forbearing were followed by several authors[6].Sensitive plants species are recommended as bio-indicators[7]. Different flora showed diverse behavior for pollutants and any floral part could be indifferently used as bio-monitors[8]. To screen flora for their sensitivity/tolerance level to air pollution, a proper choice of individual flora is of vital importance[9]. A total of four plant parameters have been used including ascorbic acid, relative water content, total chlorophyll content and leaf extract pH. The computation of air pollution tolerance index using flora may assist as a best tool to evaluate the sensitive, intermediate, moderately tolerant and tolerant flora types. This helps in providing green belt in the neighboring areas[10].

The present study was carried out to examine the APTI values for nineteen plant species along the industrial area, Arasur, Coimbatore, Tamil Nadu, India and recommend the most tolerant plant species for the plantation programme in the area selected for study. This study would also provide a technical support to the air quality management in the manufacturing zone.

MATERIALS AND METHODS

Location of study

The proposed research work was done in the highly populated manufacturing zone near Coimbatore, which is prime industrial city in India. The location of study is Arasur - 10°56’31”N 77°10’25”E as shown in Figure 1.

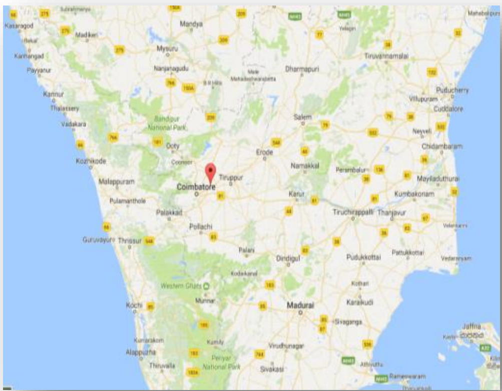

Figure 1: Location of selected manufacturing zone (Arasur near Coimbatore)

Relative water content

Water is highly vital in the life of flora. Relative water content is a chief aspect which decides the physical status of the flora. It is highly interrelated with protoplasmic permeability in the cells of flora. The reduced relative water content specifies disturbed physiological status in the flora due to pollution[11].High water content in a leaf sustains its physiological balance and act as a sign of drought confrontation in flora. When the transpiration amounts are usually high loss of water and dissolved nutrients result in early senescence of leaves under stress surroundings of air pollution [12]. The leaf samples of selected individual flora were collected often during the early morning hours. Fully grown leaves of similar size from each flora types were taken to the laboratory for analysis. The fresh leaves of each flora were weighed using single pan balance (Shimadzu with ± 0.0001g). The analysis was conducted in triplicates during the summer season. Fresh weight was determined by weighing the fresh leaf samples. The samples were later immersed in water over night, blotted dry and weighed to determine the dry weight of leaf samples. The leaves were then subjected to drying, in an oven, at 80^0C and reweighed to determine the dry weight. Leaf Relative Water Content was determined[13] using the relation (1)

$$\mathbf{RWC} = \frac{(w_f - w_d)}{(w_t - w_d)} * \mathbf{100} \quad \mathbf{(1)}$$

Where, w_f,w_t,w_d are the fresh weight, turgid weight and dry weight.

pH of Leaf extract

pH indicates Hydrogen ion concentration and expresses the acidity or alkalinity of the leaf extract. pH of the plant leaf extract in water is an important aspect to adsorb or absorb the visible suspended particulate matter and invisible NO_x, SO_2 in the atmosphere. 0.5gm of well cleaned fresh leaves were employed for this analysis. The leaves were crushed using mortar and pestle without any other materials. A constant mass (5ml) of extracts were dissolved in 50 ml of deionized water and filtered[14]. The pH of the sample was measured using digital pH meter.

Total Chlorophyll pigment

In the food producing factory of leaves, chlorophyll plays a vital role. The intake of food is centered on the chlorophyll content in leaves of flora. Chlorophyll content of individual flora differs with species, age, pollution level as well as with other biotic and abiotic circumstance[15]. The attack of air pollutants is always at the chloroplast [16]. Air pollutants move into the tissues through stomata and cause partial denaturation of the chloroplast and lessen the pigment content in the cells of polluted leaves of flora. Chlorophyll is responsible for growth, biomass storage and health status of flora. High amount of gaseous SO_2 causes destruction and degradation of chlorophyll molecules[17].

The total chlorophyll in the leaves were estimated by collection of the fresh leaf samples. Three replicates were used for each flora. Fresh leaf material selected were weighed and extracted thrice in 80% acetone, then a known volume of acetone extract was made and optical density (OD) was read at 645 nm and 663 nm wavelength on a spectrophotometer[18].The concentration of chlorophyll pigments was then calculated and results were expressed in mg/g of fresh weight.

$$\mathbf{Cholrophyll\ a} = [(\mathbf{12.7} \times \mathbf{OD_{663}}) - (\mathbf{2.69} \times \mathbf{OD_{645}})] \times \mathbf{dilutionfactor} \quad \mathbf{(2)}$$

$$\mathbf{Cholrophyll\ b} = [(\mathbf{22.9} \times \mathbf{OD_{645}}) - (\mathbf{4.68} \times \mathbf{OD_{663}})] \times \mathbf{dilutionfactor} \quad \mathbf{(3)}$$

$$\mathbf{Total\ Cholrophyll} = [(\mathbf{20.2} \times \mathbf{OD_{645}}) + (\mathbf{8.02} \times \mathbf{OD_{663}})] \times \mathbf{dilutionfactor} \quad \mathbf{(4)}$$

Where the $\mathbf{dilution\ factor} = \left[\frac{\mathbf{v}}{\mathbf{1000}}\right] * \mathbf{w} \quad \mathbf{mg/g}$

Ascorbic acid

The reduction of sulphur di-oxide in flora is found to be brought about by ascorbic acid, considered as a strong reducing agent. It is essential in activation of biological and security mechanism, also it is responsible for the stability of cell membranes in flora in conditions of pollution stress. Its reducing power is related to its concentration[19].Reducing action of the ascorbic acid is dependent on pH and is found to be more at high values of pH because high pH plays an essential role in the conversion of hexose sugar to ascorbic acid, by increasing its efficiency and is associated to the tolerance to pollution[20]. Ascorbic acid was carefully examined using the fresh leaf sample of flora.

1g weight of leaf sample of the individual flora were,ground and homogenised using 4% Trichloroacetic acid and made upto 10ml.Centrifuged for 10min at 2000rpm.Activated charcoal was added to the supernatant and thoroughly shaken for 10 minutes. Later the charcoal residue was centrifuged and removed. The supernatants were taken for the determination. 0.5 and 1ml of the supernatant were taken for the test. The test volume was made up to 2ml with 4% trichloroacetic acid. 0.2 to 1.0ml of the working standard solution containing 20 – 100µg concentration of ascorbic acid respectively were pipetted out into different dry tubes for analysis and made up to 2.0 ml with 4% trichloroacetic acid. 0.5 ml of dinitrophynyl hydrazine reagents were added to all the test tubes, with the addition of 2 drop of 10% thiourea solution. It is then carefully incubated at 370°C for a period of 3 hours. The osazones obtained was dissolved in 2.5ml of 85% sulphuric acid, in cold, drop by drop, without any temperature increase. To the blank solution alone dinitrophynyl hydrazine reagent and thiourea were added after the addition of sulphuric acid. The tubes were then further incubated for a period of 30minutes at room temperature, and the absorbance was taken read carefully in spectrophotometer at 540nm. The ascorbic acid content in the sample was calculated using the standard graph[21].

Air Pollution Tolerance Index

Air Pollution Tolerance Index was determined and computed using the standard formula [22]

$$\boldsymbol{A}\mathbf{PTI} = \frac{[\,\mathbf{A(T+P)+R}]}{\mathbf{10}} \quad \mathbf{(5)}$$

Where R, A, T and P are the relative water content (%), the amount of ascorbic acid, the total chlorophyll content and pH of the sample. On this basis, the flora were sorted and classified into (i) Sensitive species, ii) Intermediate species iii) Moderate and iv) Tolerant species [20].

i) Tolerant: APTI>mean APTI+ SD
ii) Moderately tolerant: meanAPTI<APTI<mean APTI+SD
iii) Intermediate: mean APTI-SD<APTI<mean APTI
iv) Sensitive: APTI<mean APTI-SD
where SD is the standard deviation.

RESULTS AND DISCUSSION

pH of the extract

The pH ranges from 5.20 to 7.50 in the leaf samples considered for analysis. Most of the leaf samples of flora exhibited an acidic values of pH. The pH of the leaf extract was found to be maximum of 7.54 in Phyllanthus emblica, 7.50 in Bougainvillea spectabilis, 7.41 in Pongamia pinnata, 7.40in Tabernaemontana divaricate and minimum of 5.18in Albezia lebbeck, 5.65 in Annona squamosal, 5.80 in Hibiscus rosa-sinensis, 5.90 in Allamanda cathartica. The analysis showed that flora with lower pH are more at risk while those with pH around 7 were tolerant. A reduction in photosynthesis in the flora signifies low leaf pH. The plants showed significant changes due to industrial pollutants. Earlier reports suggest that in the presence of acidic pollutant, leaf pH of flora is found to be lowered[23]. The decline in pH is greater in sensitive than in forbearing types in the observed work. The existence of SO_2 and NO_x in the ambient air causes a change in pH of leaf sap towards acidic value. Due to diffusion of SO_2 through stomata, gaseous SO_2 tends to dissolve in water forming sulphites, bisulphate and their ionic species with the generation of protons inducing the cellular pH. Thus higher pH in plant leaf samples under polluted condition may increase their tolerance to air pollution[24].

Ascorbic acid

The ascorbic acid content was found to be a maximum of 2.7195 in Jasminumsambac,2.7150 in Bougainvillea spectabilis, 2.6760 in Azadirachta indica,2.5545 in Muntingia calabura and minimum of 0.4650 in Pongamia pinnata,0.7875 inTerminalia catappa, 0.7995 in Syzygium cumini and 1.2045in Allamanda cathartica. The long term, low concentration exposures of air pollutants produces harmful effects on leaves of flora without damage. Earlier report show that a definite relationship exist between ascorbic acid content and resistance to pollution in flora[20]. The ascorbic acid level is found to reduce on exposure to pollutants. Tolerant flora have higher amount of ascorbic acid while sensitive flora possess a lower amount of ascorbic acid. Thus plants maintaining high ascorbic acid level even under polluted conditions are considered to be tolerant to air pollution[25].

Total chlorophyll

Total chlorophyll was found to be maximum of 0.9582 in Bauhinia variegeta, 0.5733 in Muntingia calabura, 0.4236 in Annona squamosa, 0.3791 in Tabernaemontana divaricate and minimum of 0.0748 in Allamanda cathartica, 0.1005 in Syzygium Cumini, 0.1341 in Bougainvillea spectabilis, 0.1612 in Mangifera indica. Chlorophyll is a key to yield of plants. Degradation of photosynthetic pigment is considered as an indicator of air pollution[26]. Some of the pollutants are liable for the increase in chlorophyll content, while the others decrease it[27]. Dust deposition prevents diffusion of air and reduces photosynthetic activities thus creating stress on flora metabolism. The chlorophyll level in plants decreases under pollution stress. However higher the value of total chlorophyll content indicates tolerance to air pollution[28].

Relative Water Content

Relative water content was found to be maximum of 90.7928 in Mangifera indica ,89.7402 in Terminalia catappa, 85.6053 in Nerium oleander,85.0032in Thespesia populnea and a minimum of 33.4161 in Annona squamosa ,46.4900 in Albizia labbak,50.0555in Muntingia calabura and 50.3569 in Bauhinia variegeta. Among the 19 flora types selected for analysis, most of the species showed comparatively higher relative water content. Presence of air pollutants show reduction in transpiration rate and damage to the leaf that pulls water up from the roots. Consequently it neither brings minerals nor cools the leaf. Thus it is likely that plant with high relative water content under polluted conditions may be tolerant to air pollutants[28].

Table 1: Bio-chemical parameters of flora types in manufacturing zones

Plant sample number	Plant Species	Family	RWC (%)	Leaf extract pH	Ascorbic acid (mg/g)	Total Chlorophyll(mg/g)	APTI
1	*Nerium oleander*	Apocynaceae	85.6053	7.29	2.2110	0.1689	10.2097
2	*Tecoma stans*	Bignoniaceae	75.0208	6.92	2.4855	0.1636	9.2627
3	*Pongamia pinnata*	Fabaceae	80.8578	7.41	0.4650	0.3045	8.4445
4	*Mangifera indica*	Anacardiaceae	90.7928	6.25	1.5885	0.1612	10.0977
5	*Azadirachta indica*	Meliaceae	77.2487	6.59	2.6760	0.2377	9.5520
6	*Albezia lebbeck*	Mimosaceae	46.4900	5.18	2.0610	0.3529	5.7893
7	*Thespesia populnea*	Malvaceae	85.0032	6.50	2.1510	0.2009	9.9417
8	*Muntingia calabura*	Muntingiaceae	50.0555	6.07	2.5545	0.5733	6.7026
9	*Annona squamosa*	Annonaceae	33.4161	5.65	2.0610	0.4236	4.5934
10	*Phyllanthus emblica*	Phyllanthaeceae	56.2726	7.54	1.3245	0.3086	6.6668
11	*Psidium guajava*	Myrtaceae	73.7394	6.79	2.4375	0.1980	9.0773
12	*Terminalia catappa*	Combretaceae	89.7402	6.68	0.7875	0.2782	9.5220
13	*Jasminum sambac*	Oleaceae	58.2912	6.81	2.7195	0.2009	7.7357
14	*Syzygium cumini*	Myrtaceae	82.1773	7.02	0.7995	0.1005	8.7870
15	*Allamanda cathartica*	Apocynaceae	81.8570	5.90	1.2045	0.0748	8.9054
16	*Bougainvillea spectabilis*	Nycteaginaceae	77.6474	7.50	2.7150	0.1341	9.8374
17	*Tabernaemontana divaricata*	Apocynaceae	65.3677	7.40	2.5530	0.3791	8.5228
18	*Hibiscus rosa-sinensis*	Malvaceae	83.9674	5.80	1.8285	0.2498	9.5029
19	*Bauhinia variegeta*	Caesalpiniaceae	50.3569	6.20	1.7865	0.9582	6.3145

Table 2: Air pollution tolerance index and grade results

Plant Species	APTI	APTI Grade
Nerium oleander	10.2097	TOLERANT
Tecoma stans	9.2627	MODERATE
Pongamia pinnata	8.4445	MODERATE
Mangifera indica	10.0977	TOLERANT
Azadirachta indica	9.5520	MODERATE
Albezia lebbeck	5.7893	SENSITIVE
Thespesia populnea	9.9417	MODERATE
Muntingia calabura	6.7026	SENSITIVE
Annona squamosal	4.5934	SENSITIVE
Phyllanthu semblica	6.6668	SENSITIVE
Psidium guajava	9.0773	MODERATE
Terminalia catappa	9.5220	MODERATE
Jasminum sambac	7.7357	INTERMEDIATE
Syzygium cumini	8.7870	MODERATE
Allamanda cathartica	8.9054	MODERATE
Bougainvillea spectabilis	9.8374	MODERATE
Tabernaemontana divaricata	8.5228	MODERATE
Hibiscus rosa-sinensis	9.5029	MODERATE
Bauhinia variegeta	6.3145	SENSITIVE

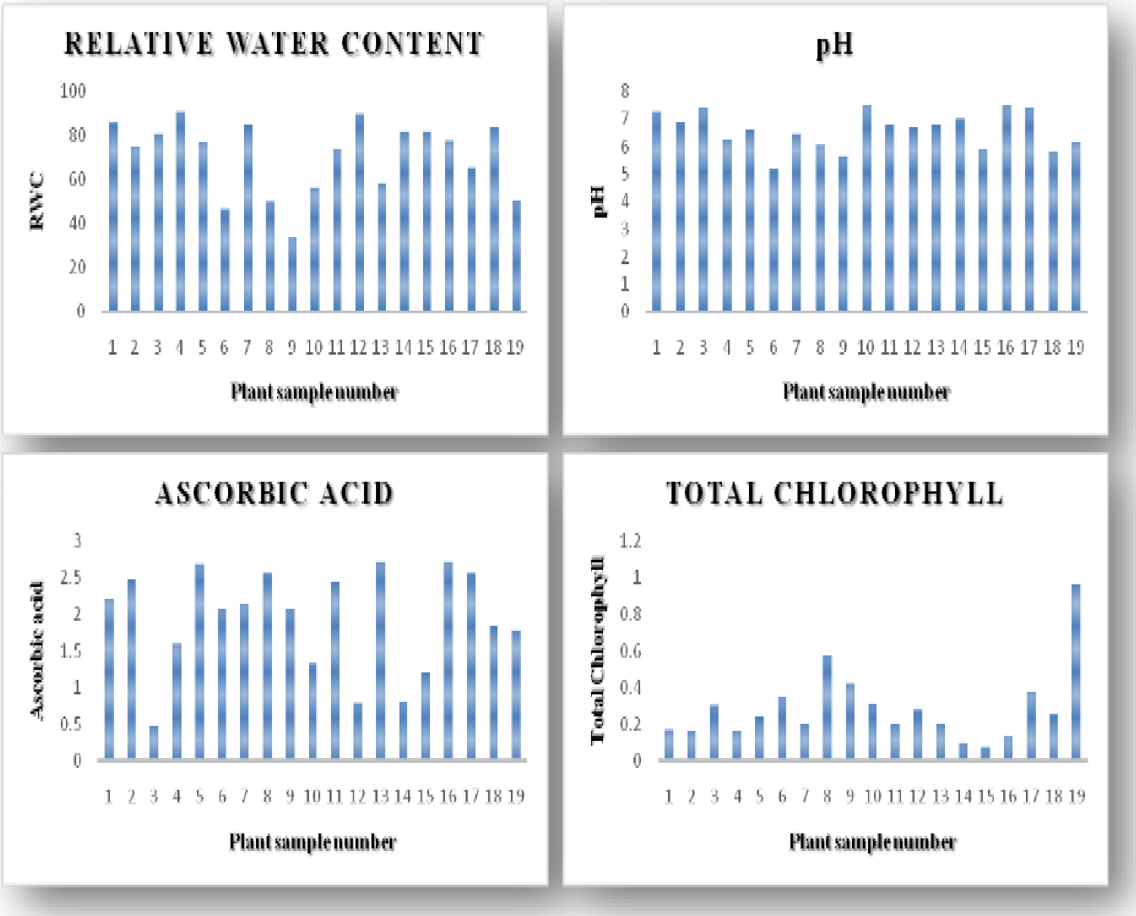

Figure 2: Determined values of the four biochemical parameters of the flora

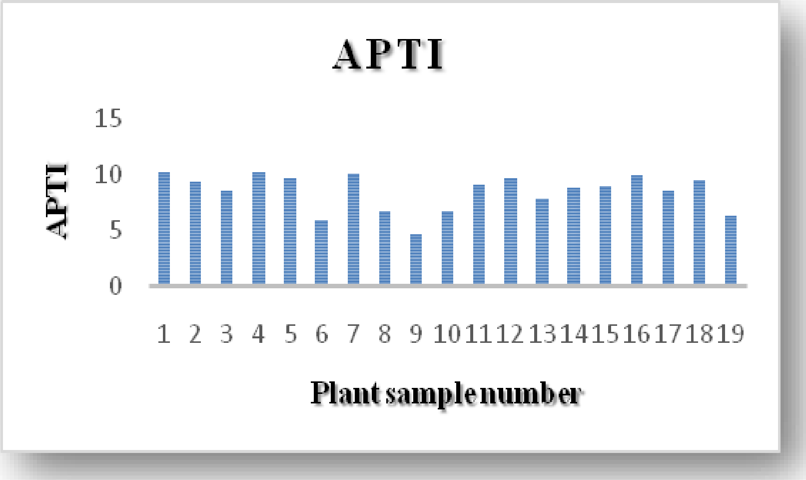

Figure 3: APTI of the Flora

Air Pollution Tolerance Index

Air Pollution Tolerance Index is a unique index which is due to the incorporation of biochemical and physiological parameters. It is not dependent on individual parameters like relative water content, pH, ascorbic acid and total chlorophyll but they are interdependent with each other in nature[29].Thus Air Pollution Tolerance Index helps to rank the selected flora types in the order of their computed tolerance level to air pollution. Flora with high index value are found to be more tolerant to pollution and can be considered as sink to mitigate pollution, while flora with low tolerance index value show less tolerance and were used to indicate level of pollution.

CONCLUSION

Air pollution tolerance indices viz., pH, Ascorbic acid, total chlorophyll, and relative water content of nineteen types of flora (Industrial area, Arasur, Coimbatore in India) were assessed by bio-monitoring method during summer season. The four strategic parameters were independent to each other. The further calculated Air Pollution Tolerance Index of the nineteen flora types was used to categorize them as tolerant, moderate, intermediate and sensitive types. The species with high Air Pollution Tolerance Index index were considered to be tolerant to pollution in the manufacturing zone. From the obtained results it has been identified that Nerium oleander and Mangifera indica were the more tolerant species because of high Air Pollution Tolerance Index value in the investigation zone. The research work suggest that Nerium oleander and Mangifera indica are the forbearing types that could be considered for plantation program to provide green belt in the manufacturing zone so as to reduce the effects of industrial air pollution. Further investigation on air pollution tolerance index could be carried out by considering multiple parameters for future examination of tolerant types in manufacturing zones for betterment of the surrounding environment.

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