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Assessment of Air Quality through Biomonitors of selected sites of Dindigul town by air pollution tolerance index approach

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ABSTRACT:

Rapid industrialization has led to different facts of pollution. Vegetation can absorb particulate and other gaseous pollutants into their system. But they also have some limitation and tend to show symptoms of damages after prolonged exposure. Based on the absorbing power and tolerance limit, vegetations can be classified as highly tolerant, moderately tolerant and sensitive. This has been incorporated by scientists into a quantitative value of Air pollution Tolerance index (APTI) depending on the score of the plant physiology indicators viz., leaf extract pH, Relative Water Content (RWC), Ascorbic acid and Chlorophyll content. The vegetation monitoring in terms of its APTI act as 'Bioindicator' of air pollution and can be incorporated into assessment studies. The present investigation were undertaken to assess the air quality of selected sites of Dindigul Town. A total of six plant species were collected at three different spots. The results were used to calculate the APTI (Air Pollution Tolerance Index) for each plant and their tolerance/sensitivity were assessed. In this study, in industrial area *Thyme rosemary* showed the highest APTI followed by *Moringa tinctoria, Calotropis gigantea, Delonix regia, Azadiracta indica* and *Cynodon dactylon.* In traffic area *Delonix regia,* showed the highest APTI followed by *Azadiracta indica, Moringa tinctoria, Calotropis gigantea, Thyme rosemary* and *Cynodon dactylon.* In Residential area, Cynadon *dactylon* showed the highest APTI followed by *Calotropis gigantea, Delonix regia, Moringa tinctoria, Thyme rosemary* and *Azadiracta indica,* Therefore, these plant species could act as the bio indicators for pollutants and could be utilized as tolerance species towards combating air pollution.

Keywords:

Biomonitoring, APTI, Bioindicator, Sensitive Tolerant, Ascorbic acid, Chlorophyll.

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INTRODUCTION

Dindigul is a fast developing industrial and commercial town and day by day increasing its geographical size. Air pollution is caused mainly due to industrial emission, motor vehicle emissions, domestic and construction activities. The initial step towards improving the air pollution situation is the monitoring of the air quality.

Today's growing population and increasing urbanization has resulted in deterioration of ambient air quality. Air pollution is causing vast changes in vegetation. Since plants are stationary and they are continuously exposed to chemical pollutants from the surrounding atmosphere, air pollution injury to plants is proportional to the intensity of the pollution .Reduction in plant height, canopy area, plant biomass chlorophyll, ascorbic acid and nitrogen content in plant growing at sites receiving higher pollution are some of the common responses as mentioned by Pandey and Agarwal (1992),Sarala et al.,(2012) and Chattopadhyay (1996) reported that leaves respond to pollution and undergo quantitative change in varying degree in a number of leaf surface micro morphological characters.

The leaves are generally used as experimental material as they take up large amount of pollution (Treshow, 1985). APTI is a species dependent plant attribute which expresses the inherent ability of the plant to encounter stress emanating from pollution. According to Mashita and Pise, (2001) there is a scale of APTI value which indicates that APTI value between 30 – 100 shows that the species is tolerant; APTI value between 17-29 are intermittently tolerant; and plants registering APTI value in the range of 1-16 are considered as sensitive; APTI value lower than 1 is branded as highly sensitive. According to Tiwari and Bansal (1993) APTI level of 25 species were found to be different at Bhopal and plants having higher APTI value are more tolerant to air pollution than those having lower APTI value. Species having lower APTI value may act as bioindicators of pollution. Impact of plant community has also been studied worldwide in terms of plant-environment interactions, since the plants are much more sensitive in comparison to other organisms.

The symptoms or effect including changes in the plant anatomy, physiology or biochemistry indicate a polluted environment. Thus, the regular monitoring of certain parameters of the plant physiology can indicate air pollution in terms of its severerity and degree.

Although sensitivity towards air pollution varies across the plant community and some being 'tolerant' showing no or minimal symptoms even if the air pollutants increase in small amounts the impact can be used for monitoring of air pollution in medium to large towns and cities in terms of air pollutant concentration to observe the air quality of the locality. The plant response to air pollution varies from species to species and also in terms of type of pollutant, its reacting mechanism, concentration and duration of exposure Sarala and Sabitha(2012). The pollutants enter into the plants and react in variety of ways before being removed or absorbed that may include accumulation, chemical transformation and incorporation into the metabolic system. In this process, some plants are injured while others show minimal effects (Choudhury et al, 2009). The trees such as *Azadiracta indica, Delonix regia are* found to be very common in the urban area of Dindigul. Near the tannery area the shrub and herbs such as *Moringa tinctoria, Calotropis gigantea, Thyme rosemary* and *Cynodon dactylon* are found in greater extent .These six plant species have been chosen for the Analysis of bio chemical parameters. In order to find out the variation in tolerance of pollution on Trees, Shrubs and Herbs have been taken for analytical study. Keeping in view of the importance of APTI value in formulating phyto-optimization of air quality, biomonitoring of air quality of selected sites of Dindigul Town were under taken. Tree species which are evergreen such as *Azadiracta indica* and, *Delonix regia,* Shrubs such as

Moringa tinctoria, Calotropis gigantea and Herbs like *Thyme rosemary* and *Cynodon dactylon* were selected to find the impact of air pollution on biochemical parameters. In order to compare the effect of air pollutant on ever green trees, shrubs and herbs these plant species have been chosen for the present research work. The important findings are reported in this communication.

MATERIALS AND METHODS

A total of six different plant species were selected for the study from three different spots from Dindigul Town. The study sites include Residential area (lakshmanapuram), Traffic cum commercial area (Bus stand) and industrial area (Tannery). The screening and selection of the plant species are partly based on literature survey of similar work and guidelines of Central Pollution Control Board (CPCB-1999). Composite leaf samples were sampled in polyethelene bags, tagged brought to the laboratory and analyzed for several biochemical parameters. At each sampling site composite leaf sample were collected in replications. Now on this pattern of work, a total of six plant species were selected for sampling from the above mentioned area. Again to trace the seasonal variation in the APTI value the sampling was done twice, once in winter season and the other in summer season. The 'Air pollution Tolerance Index' (APTI) was developed by analyzing the biochemical parameters of leaf materials, viz., pH, ascorbic acid, relative water content and total chlorophyll. (Pandey and Sharma, 2003). The pH values were estimated by using a digital calibrated pH meter. Ascorbic acid, total chlorophyll of leaf extract was estimated by spectrophotometric method. Relative water content was estimated by gravimetric method by determining the leaf weight under different condition like initial, turgid and dry weight. The formula used to determine the 'Air Pollution Tolerance Index' (APTI) using the four parameter is given by (Singh,1991)

$$\mathbf{APTI} = \frac{A\,(T+P) + \mathrm{R}}{10}$$

Where A = Ascorbic acid content (mg/g); T = Total chlorophyll content of leaf (mg/g/fw); P = pH of the leaf extract and R = Relative water content of leaf extract (%)

Based on the development and evaluation of APTI values among the samples they were categorized into three groups, namely <10 sensitive, >10 <16 is intermediate species and >17 is tolerant species.

RESULTS AND DISCUSSION

The analyzed value for all the six plant species in three different selected spots of Dindigul Town has been presented in **Table 1.** From the results it was found that the pH of the leaf extract was found to be acidic in nature in case of almost of all the plant species in all the sampling sites. But a variation exists in *Delonix regia* at all the three sites and in *Calotropis gigantea* at the residential and tannery area. The acidic nature demonstrates that the air pollutants are mostly gaseous types namely SO_2, NO_x, diffuse and form acid radicals in leaf matrix by reacting with cellular water. This further affects the chlorophyll molecules. (Singh,1991). Among the three sampling sites, the pH of the leaf extract of *Moringa tinctoria* and *Calotropis gigantea* at the tannery area are found to be 7.20 and 8.52 respectively.

Relative water content is a useful indicator of the state of water balance of a plant. The large quantity of water (in terms of RWC) in plant body helps in maintaining its physiological balance under stress conditions of air pollution (Gonzalez and Gonzalez-Vilar, 2001). The Relative Water Content (RWC) of leaves is an indicator of the plants water status with respect to its physiological consequences of cellular water. In residential area it ranged between 62.8% to 75.6% among the studied plant species. In traffic area it varied between 55.3% to 65.0% for all the plant species.

Table 1 Biochemical constituents in leaf samples collected from six different plant species at three different spots of Dindigul Town.

Name of the plant Species	Sampling Station (Residential)				Sampling Station (Traffic)				Sampling Station (Tannery)			
	pH	RWC	Total Chl	AA	pH	RWC	Total Chl	AA	pH	RWC	Total Chl	AA
Azadiracta indica	5.85	62.8	0.85	2.08	5.55	65	0.478	4.052	5.78	75	0.69	2.62
Delonix regia	7.53	65.3	0.531	2.65	9.65	55.3	0.384	3.58	6.92	79	0.76	3.15
Moringa tinctoria	6.75	72.05	0.948	1.65	5.5	62.5	0.636	3.55	7.2	82	0.48	3.68
Calotropis gigantea	7.6	70.5	0.674	2.56	4.56	58.5	0.47	3.65	8.52	86.5	0.43	1.89
Thyme rosemary	5.24	72.3	0.8	1.96	4.85	62.5	0.458	2.35	5.2	72.8	0.56	1.08
Cynodon dactylon	6.35	75.6	0.66	3.88	3.65	56.5	0.42	4.56	6.6	77.5	0.37	2.34

Units as expressed as mg/g fresh weight except pH and RWC content which is expressed in units and percentage respect.

But in tannery area it ranged between 72.8% to 86.5% for all the plant species. The highest value of RWC was recorded by *Calotropis gigantea* in tannery area whereas the lowest value of RWC was recorded by *Delonix regia* in traffic area of Dindigul Town. The Relative water content of *Azadiracta indica* is less at different sampling sites compared to herb *Cynodon dactylon*because the *Azadiracta indica* is a tall tree which reaches the height of 15-20m and the branches are wide spread and so the evaporation of water is more .But the herbs which is very short and growing to 2-15cm height and the evaporation of water is less .Hence it has more relative water content compared to *Azadiracta indica.*

The relative water content indicates change in leaf matrix hydration condition and will generate higher acidity condition when RWC is low. More water will dilute acidity. From the results it can also be concluded that the former species tends to be more tolerate to air pollution stress while the later is sensitive.

Total chlorophyll content comprises of Chlorophyll ‘a’, Chlorophyll ‘b’ and other accessory pigment. It provides greenness to the leaves and is the main organ of trapping sunlight and its conversion to chemical energy. The total chlorophyll content of *Azadiracta in*dica at the residential, traffic and industrial area are 0.85 mg/g, 0.475 mg/g and 0.69 mg/g respectively. It showed 43.76% reduction at the traffic area and 18.82% reduction at tannery area. The total chlorophyll content for all the sampling sites for *Delonix regia* are 0.531 mg/g, 0.384 mg/g and 0.76 mg/g respectively. The total chlorophyll content of *Azadiracta indica* at the three different sampling sites such as Residential, Traffic and Tannery sites are found to be more compared to the *Delonix regia.* The arrangement of leaves in Azadiracta indica is different from *Delonix regia.*It reason out the variation in photosynthetic pigment in the tree species.

Total chlorophyll content of *Moringa tinctoria* at the three sampling sites were 0.948 mg/g , 0.636 mg/g and 0.48 mg/g respectively. It showed 32.91% and 49.36% reduction at the traffic and tannery area respectively. *Calotropis gigantea* recorded the total chlorophyll content at the three sampling sites at 0.674 mg/g , 0.47 mg/g and 0.43 mg/g respectively. It showed 30.26% and 36.20% reduction at the traffic and tannery area. *Thyme rosemary* recorded the total Chlorophyll content as 0.80 mg/g, 0.458 mg/g and 0.56 mg/g respectively. It also showed 42.75% and 30% reduction traffic and tannery area. Similarly *Cynodon dactylon* showed the reduction of total chlorophyll at the traffic and tannery area as 36.36% and 43.93% respectively. The higher level of total chlorophyll content in the leaves of all the six selected species at residential area in comparison to traffic and tannery area indicate lower air pollution stress in residential area. The lowest value of total chlorophyll content in the leaves of six selected species at traffic and tannery area in comparison to residential area indicates higher air pollution stress.

Ascorbic acid, a stress reducing factor is a strong reducing agent and is associated with tolerant plants. It reduces the effect of SO_2 and acts as antioxidant. A high content of ascorbic acid in plant leaf is related to biochemical and physiological species of a particular environment. It provides specific physiological defense mechanism as for plants internally and its reducing power is directly proportional to its concentration (Khattab, 2007) and Sarala et al.,(2011). In the present study at the residential area it ranged between 1.65 mg/g to 3.88 mg/g with *Cynodon dactylon* having highest and *Moringa tinctoria* having lowest content. For all the six plant species at the traffic area the ascorbic acid content ranged between 2.35 mg/g to 4.56 mg/g with *Thyme rosemary* recording the lowest value and *Cynodon dactylon* showing the highest value. In tannery area the Ascorbic acid content ranged between 1.08 mg/g to 3.68 mg/g with Thyme rosemary showing lowest and *Moringa tinctoria* having highest content. Ascorbic acid of six test species in traffic and tannery road side plants (polluted plants) was increased. The increase in ascorbic acid might act as strong reductant for defense mechanisms against automobile pollutants. It is evident that ascorbic acid activates many physiological and defensive mechanisms. Its reducing power is directly proportional to its concentration.

The calculated APTI value associated with the sampled vegetation at the residential area ranges between 7.67 to 10.27, 7.49 to 9.08 at the traffic area and 9.3 to 13.5 at the tannery area are shown in **Table2.** All the six plant species at Dindigul Town, both at the control and the polluted area showing APTI value < 17 representing sensitive response to air pollution. APTI for *Azadiracta indica* at the Residential, Traffic and Tannery area are 7.673, 8.941 and 9.915 respectively. Due to the air pollution, the sensitive species moves towards tolerance. The APTI for *Delonix regia* at the different sampling sites are 8.66, 9.08and 10.31 respectively. At the tannery site, it changed in to intermediate tolerance. *Moringa tintoria* and *Calotropis gigantea* have the APTI values as 8.475, 8.428, 11.02, 9.168, 7.68 and 10.34 respectively. Due to the air pollutant from traffic and tannery sites, the tolerance indexes have been changed. *Thyme rosemary* has the APTI value as 8.1, 7.49 and 13.5 at the different sampling sites. Similar APTI values were recorded for *Cynodon dactylon.* APTI categorization of selected plant species of Dindigul Town at different sampling sites were tabulated in **Table 2a.**

This species having APTI less than 17 APTI value can be utilized as bio-indicator of the air quality in the study area.

The correlation matrix given in the **Table 3, 4, 5** signified the association of the four biochemical parameters among themselves and also with the

Table 2 Comparative APTI values for plant species at selected sites of Dindigul Town.

Plant species	APTI values for plant species at different sampling sites		
	Residential	**Traffic**	**Tannery**
Azadiracta indica	7.673	8.941	9.195
Delonix regia	8.66	9.08	10.31
Moringa tinctoria	8.475	8.428	11.02
Calotropis gigantea	9.168	7.68	10.34
Thyme rosemary	8.41	7.49	13.5
Cynodon dactylon	10.27	7.5	9.38

Table 2a APTI categorization of selected plant species of Dindigul Town

Plant species	Categories of Plant species		
	Residential	**Traffic**	**Tannery**
Azadiracta indica	Sensitive	Sensitive	Sensitive
Delonix regia	Sensitive	Sensitive	Intermediate
Moringa tintoria	Sensitive	Sensitive	Intermediate
Calotropis gigantea	Sensitive	Sensitive	Intermediate
Thyme Rosemary	Sensitive	Sensitive	Intermediate
Cynodon dactylon	Interme diate	Sensitive	Sensitive

dependent parameter APTI. It was found that there is a positive correlation between APTI and pH, RWC, total chlorophyll and ascorbic acid. In residential area APTI showed positive correlation with pH, RWC and Ascorbic acid but negative correlation with Total chlorophyll. APTI showed positive correlation with RWC and Ascorbic acid. In traffic area APTI showed positive correlation with all the four biochemical parameters.

Air Pollution Tolerate Index (APTI) is an inherent quality of plants to encounter air pollution stress, which is presently of my concern particularly of urban areas in the world.

CONCLUSION

The present study suggests that plants have the potential to serve as excellent Morphometric, Quantitative and Qualitative indices of pollution level. Biomonitoring of plants is an important tool to evaluate the impact of air pollution on plants. Based on the results it can be said that the Air Pollution Tolerance

Table 3 Correlation between the APTI values and biochemical parameters estimated from the leaf samples of the selected spots of Residential area

	pH	RWC	Total chlorophyll	Ascorbic acid	APTI
pH	1.00				
RWC	-0.124	1.00			
Total Chlorophyll	-0.530	0.077	1.00		
Ascorbic acid	0.208	0.373	-0.674	1.00	
APTI	0.291	0.743	-0.496	0.863	1.00

Table 4 Correlation between the APTI values and biochemical parameters estimated from the leaf samples of the selected spots of Traffic cum Commercial area

	pH	RWC	Total Chlorophyll	Ascorbic acid	APTI
pH	1.00				
RWC	-0.324	1.00			
Total Chlorophyll	-0.286	0.601	1.00		
Ascorbic acid	-0.142	-0.307	-0.115	1.00	
APTI	0.783	0.114	0.038	0.187	1.00

Table 5 Correlation between the APTI values and biochemical parameters estimated from the leaf samples of the selected spots of Tannery area

	pH	RWC	Total Chlorophyll	Ascorbic acid	APTI
pH	1.00				
RWC	0.989	1.00			
Total Chlorophyll	-0.378	-0.391	1.00		
Ascorbic acid	0.311	0.330	0.226	1.00	
APTI	-0.360	-0.290	-0.006	-0.504	1.00

Index (APTI) values estimated using the four biochemical parameters in plant leaves viz., Relative Water Content, total chlorophyll, pH and ascorbic acid can be used as predictor of air quality. These parameters are significant in studies in plant environment interactions and used for development of bioindicator groups. The APTI of particular geographical area can be used for biomonitoring of air quality. Species like *Azadiracta indica, Delonix regia, Moringa tinctoria, Calotropis gigantea, Thyme rosemary* and *Cynodon dactylon* can be potentially used for biomonitoring of air quality in polluted areas.

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