Int. J. Life Sci. Scienti. Res., VOL 2, ISSUE 2, pp: 173-182 (ISSN: 2455-1716) Impact Factor 2.4 MARCH-2016

Research Article (Open access)

Air Pollution Tolerance Index of Some Trees Species from the Industrial area of Tarapur

Nitesh Joshi[1]*, Ambika Joshi[2], Bharati Bist[1]

[1]Department of Botany, Rizvi College of Arts, Science and Commerce, Bandra West, Maharashtra, India

[2]Department of Botany, Jai hind College, Churchgate, Maharashtra, India

ABSTRACT- To evaluate the susceptibility of plants growing in the industrial area of Tarapur, Maharashtra, Air pollution tolerance index (APTI) was determined for 30 plant species by calculating Ascorbic acid content, Leaf-extract pH, Total chlorophyll content and Relative water content and computing together in a formula. The result showed the order of tolerant species as *Putranjiva roxburghii >Mangifera indica >Ficus racemosa >Ficus hispida >Morinda citrifolia* and the order of sensitive species as *Nyctanthes arbor-tristis >Bauhinia purpurea> Peltophorum pterocarpum> Psidium guajava> Morinda pubescens.* APTI serves as a reliable technique in qualifying plants as tolerant and sensitive species in regard to air pollution. Tolerant species serve as the sink of air pollutants and thus can help in the abatement of air pollutants to some extent if planted in and around industrial vicinity and along traffic islands.

Key-Words- Air pollution tolerance index (APTI), Ascorbic acid content, Leaf-extract pH, Total Chlorophyll Content, Relative Water Content

---IJLSSR---

INTRODUCTION

Today the most important topic of global concern is pollution. With rising industrialization and development, an increase in degradation of the environment is faced all over the world. Air pollution is one of the most fatal of all as we can't cease the air we breathe. The three main sources of air pollution problem in India are vehicles, industries and domestic sources. As per the guidelines of Ambient air quality monitoring by Central pollution control board,[1] the reasons for high air pollution in India are: poor quality of fuel, poor vehicular design, uncontrolled expansion of vehicle population, old process technology in industries, wrong location of industries, no pollution preventive step in the early stage of industrialization, no pollution prevention or control system and poor compliance of standard in small/medium scale industries.

Air pollution affects the plants as much as it affects humans and animals. On exposure to air borne pollutants, plants experience physiological changes before showing visible damage to leaves [2]. Some plants can thrive in polluted environment and can thus help in cleaning the various sources of man-made pollution both organic (petrochemical) and inorganic (heavy metal toxins) [3]. As part of their regular functioning, trees remove significant amount of pollution from the environment, increasing the air quality and thus should be considered an integral part in aiming overall air quality [4]. The response of plants to pollutants at physiological and biochemical level can be understood by analyzing the factors that determine sensitivity and tolerance.[5] Singh and Rao [6] suggested a method where four biochemical parameters such as Ascorbic acid, Total chlorophyll content, Leaf-extract pH and Relative water content were used in determining the resistance and

***Address for Correspondence:**
Dr. Nitesh Joshi
Associate Professor
Department of Botany
Rizvi Collegeof Arts, Science and Commerce
Bandra West, Maharashtra, India
Received: 23 Jan 2016/Revised: 15 Feb 2016/Accepted: 29 Feb 2016

susceptibility of plants to air pollution. Plants with higher APTI value are more accomplished to combat against air pollution and can be used to mitigate pollution, while those with low index value show less tolerance and can be used to signify levels of air pollution. [7]

MATERIALS AND METHOD

Study Area: Tarapur industrial area was established in Palghar Taluka of Thane district, Maharashtra by Government of India in 1972. Also known as MIDC Tarapur, it is one of the largest chemical industrial estates of Maharashtra. Tarapur is located 100 km away from Mumbai on western railway track and Boisar is the nearest railway station. It houses many industries like 392 dye industries, 265 textile industries, 138 engineering, 26 iron and steel industries and 1 pesticide industry which are considered as the highly polluting industries by the Maharashtra Pollution Control Board (MPCB) [8]. CPCB [9] based on the Comprehensive Environmental Pollution Index (CEPI Index) declared 43 critically polluted areas in India. CEPI Index for Tarapur was 60.75 indicating high pollution levels and hence this area was considered for the experimental study. The location of the study site is given in Fig 1.

Sampling of plant species: Fully matured leaves samples were collected from 30 plant species found in this industrial area during two dry seasons i.e. summer and winter (2014). The leaves were brought to laboratory with care, were washed with distilled water to get rid of dust particles and fresh weight was taken immediately. Fresh leaf samples were then analyzed for Ascorbic acid, [10] Leaf-extract pH. [11] Total chlorophyll [12] and Relative water content. [13]

Analysis

Ascorbic acid determination: A homogenate was prepared using fresh leaves of the concerned tree species and oxalic acid which was later reacted with 2,4–Dinitrophenyl hydrazine reagent along with Sulphuric acid to give an orange red color solution. The absorbance was measured at 540 nm.

Leaf-extract pH: Total 1 gm fresh leaf of the concerned tree species was homogenized using distilled water and pH of the filtrate was detected using digital pH meter.

Total chlorophyll content: Chlorophyll content was analyzed by homogenizing 1 gm leaf sample in 20 ml pre-chilled acetone and centrifuging at 5000rpm. The supernatant was later collected and absorbance was measured at 645 and 663 nm.

Relative water content: Relative water was calculated by taking fresh weight, dry weight and turgid weight of leaf samples and substituting them in the following formula:

$$\mathbf{RWC = \frac{(FW - DW)}{(TW - DW)} \times 100}$$

Where,

FW- Fresh weight, DW- Dry weight and TW- Turgid weight

Air Pollution Tolerance Index (APTI): The values of all the above parameters where then incorporated in the equation as suggested by Singh and Rao [6] and the Air Pollution Tolerance Index for plants were calculated using the formula:

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

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

Statistical Analysis:

Data was analyzed using Correlation and Linear regression analysis between independent variables i.e. ascorbic acid, total chlorophyll, pH, relative water content and dependant variable like A.P.T.I.

Copyright © 2015-2016 | IJLSSR by Society for Scientific Research under a CC BY-NC 4.0 International License

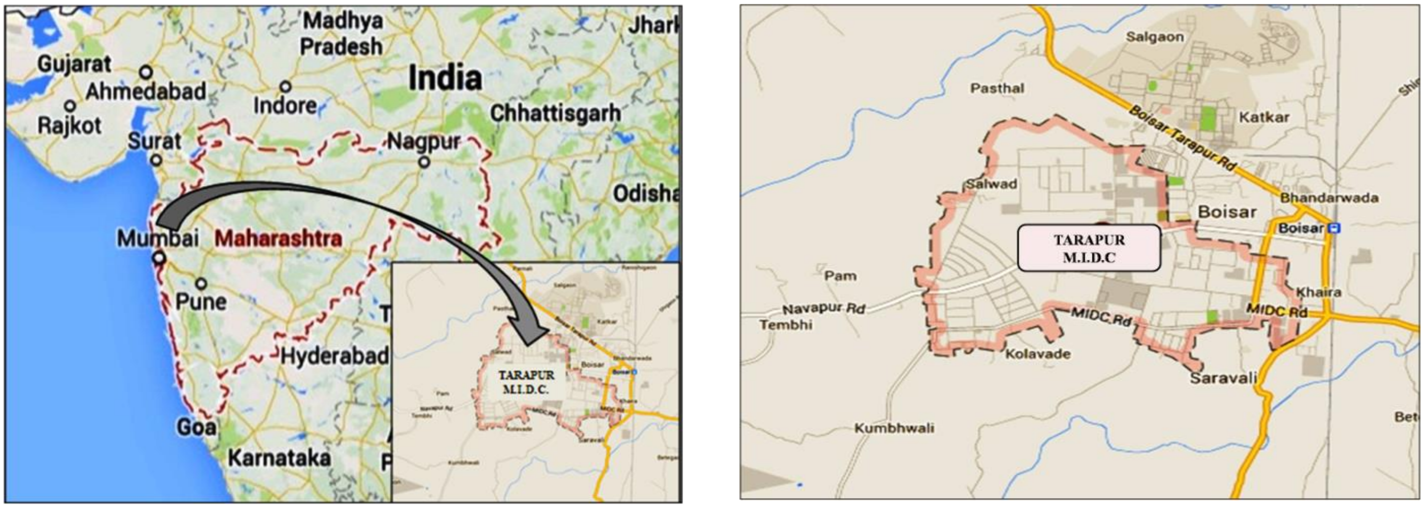

Fig 1: Location of study site – Tarapur M.I.D.C.

Table 1: General description of the plant species considered for APTI study

S.No	Plant species name	Family	Sub-family	Common name	Tree type
1	*Acacia auriculiformis* Benth	Leguminosae	Mimosaceae	Australian babul	Evergreen
2	*Albizia saman* (Jacq.) Merr.	Leguminosae	Mimosaceae	Rain tree	Deciduous
3	*Alstonia scholaris* (L.) R. Br.	Apocynaceae	–	Saptaparni	Evergreen
4	*Annona squamosa* L.	Annonaceae	–	Custard apple	Deciduous
5	*Artocarpus heterophyllus* Lam.	Moraceae	–	Jackfruit	Evergreen
6	*Azadirachta indica* A. Juss.	Meliaceae	–	Neem	Evergreen
7	*Bauhinia purpurea* L.	Leguminosae	Caesalpiniaceae	Apta	Deciduous
8	*Butea monosperma* (Lam.) Taub.	Leguminosae	Caesalpiniaceae	Palas, Flame of forest	Deciduous
9	*Cassia fistula* L.	Leguminosae	Caesalpiniaceae	Indian labur-num	Deciduous
10	*Delonix regia* (Boj. ex. Hook.) Raf	Leguminosae	Caesalpiniaceae	Gulmohar	Deciduous
11	*Ficus benghalensis* L.	Moraceae	–	Banyan	Evergreen
12	*Ficus hispida* L.	Moraceae	–	Benjamin tree	Evergreen
13	*Ficus racemosa* L.	Moraceae	–	Umbar	Evergreen
14	*Ficus religiosa* L.	Moraceae	–	Pipal	Evergreen

Copyright © 2015-2016 | IJLSSR by Society for Scientific Research under a CC BY-NC 4.0 International License

S.No	Plant species name	Family	Sub-family	Common name	Tree type
15	*Gardenia jasminoides* J. Ellis	Rubiaceae	–	Anant	Evergreen
16	*Gliricidia sepium* (Jacq.) Kunth ex Walp.	Leguminosae	Fabaceae	Giripushpa	Deciduous
17	*Lagerstroemia speciosa* (L.) Pers	Lythraceae	–	Taman	Deciduous
18	*Mangifera indica* L.	Anacardiaceae	–	Mango	Evergreen
19	*Morinda citrifolia* L.	Rubiaceae	–	Noni	Evergreen
20	*Morinda pubescens*J. E. Sm.	Rubiaceae	–	Bartondi	Evergreen
21	*Nyctanthes arbor-tristis* L.	Oleaceae	–	Parijatak	Evergreen
22	*Peltophorum pterocarpum* (DC.) K.Heyne	Leguminosae	Caesalpiniaceae	Copper pod tree	Evergreen
23	*Plumeria obtusa* L.	Apocynaceae	–	Chafa	Evergreen
24	*Polyalthia longifolia* Sonn.	Annonaceae	–	False Asoka	Evergreen
25	*Pongamia pinnata* (L.) Pierre	Leguminosae	Fabaceae	Karanj	Deciduous
26	*Psidium guajava* L.	Myrtaceae	–	Guava	Evergreen
27	*Putranjiva roxburghii* Wall.	Putranjivaceae	–	Putranjiva	Evergreen
28	*Senna siamea* (Lam.) H.S. Irwin & Barneby	Leguminosae	Caesalpiniaceae	Kashid	Evergreen
29	*Syzygium cumini* (L.) Skeels	Myrtaceae	–	Jamun	Evergreen
30	*Tamarindus indica* L.	Leguminosae	Caesalpiniaceae	Imli	Evergreen

Copyright © 2015-2016 | IJLSSR by Society for Scientific Research under a CC BY-NC 4.0 International License

Table 2: Air pollution tolerance index of trees from industrial area of Tarapur (Average of biochemical parameters from summer and winter season± SD)

No	Plant species name	Ascorbic acid content	Total chloro-phyll content	pH	Relative water content	APTI
1	*Acacia auriculiformis*	0.64±0.04	0.39±0.03	6.44±0.54	85.01±1.91	8.93±0.13
2	*Albizia saman*	0.48±0.09	0.74±0.25	6.43±0.13	67.06±2.34	7.05±1.16
3	*Alstonia scholaris*	0.88±0.25	0.78±0.02	5.94±0.01	82.11±2.66	8.80±0.44
4	*Annona squamosa*	0.31±0.02	0.40±0.09	5.53±0.72	73.44±1.00	7.53±0.07
5	*Artocarpus heterophyllus*	0.54±0.09	0.45±0.11	6.58±0.07	71.72±1.30	7.55±0.64
6	*Azadirachta indica*	1.39±0.02	0.41±0.05	6.21±0.13	73.56±2.56	8.27±0.26
7	*Bauhinia purpurea*	0.47±0.17	0.39±0.02	4.82±2.57	66.75±2.00	6.92±0.82
8	*Butea monosperma*	0.64±0.05	0.42±0.13	6.42±0.27	78.94±1.85	8.33±0.23
9	*Cassia fistula*	1.55±0.05	0.67±0.02	6.79±0.45	78.50±3.17	9.00±0.72
10	*Delonix regia*	0.21±0.04	0.40±0.24	6.83±0.13	74.06±2.22	7.56±1.31
11	*Ficus benghalensis*	0.58±0.05	0.36±0.01	6.18±0.91	87.96±3.21	9.17±0.21
12	*Ficus hispida*	0.49±0.04	0.55±0.15	5.75±0.91	90.08±3.37	9.31±0.67
13	*Ficus racemosa*	0.97±0.03	0.37±0.01	5.55±0.45	92.87±3.01	9.86±0.20
14	*Ficus religiosa*	0.51±0.04	0.69±0.01	5.88±0.91	80.21±0.65	8.36±0.67
15	*Gardenia jasminoides*	0.61±0.06	0.43±0.47	6.27±0.13	76.17±2.44	8.02±0.47
16	*Gliricidia sepium*	0.91±0.03	0.33±0.08	6.23±0.15	64.75±1.71	7.07±1.94
17	*Lagerstroemia speciosa*	0.97±0.15	0.31±0.04	5.59±0.13	71.38±1.60	7.71±0.85
18	*Mangifera indica*	1.49±0.41	0.51±0.01	6.47±0.31	89.88±1.17	10.03±1.44
19	*Morinda citrifolia*	1.30±0.01	0.70±0.16	6.31±0.06	83.53±3.13	9.26±0.30
20	*Morinda pubescens*	1.47±0.56	0.64±0.06	5.97±0.62	60.32±3.06	7.00±2.00
21	*Nyctanthes arbor-tristis*	0.64±0.06	0.50±0.04	6.38±0.04	64.25±0.25	6.87±0.02
22	*Peltophorum pterocarpum*	0.33±0.04	0.70±0.01	6.29±0.28	67.40±3.08	6.97±0.60
23	*Plumeria obtusa*	0.60±0.03	0.58±0.18	5.89±0.14	83.62±3.13	8.75±0.53

Copyright © 2015-2016 | IJLSSR by Society for Scientific Research under a CC BY-NC 4.0 International License

No	Plant species name	Ascorbic acid content	Total chloro-phyll content	pH	Relative water content	APTI
24	*Polyalthia longifolia*	0.20±0.01	0.42±0.03	6.68±0.11	89.69±1.83	9.11±0.26
25	*Pongamia pinnata*	1.59±0.37	0.58±0.35	6.92±0.08	80.01±2.99	9.19±0.27
26	*Psidium guajava*	1.56±0.01	0.30±0.01	6.45±0.21	59.48±2.43	7.00±0.23
27	*Putranjiva roxburghii*	8.35±0.19	0.53±0.06	6.25±0.13	91.97±2.70	14.85±0.45
28	*Senna siamea*	0.64±0.31	0.65±0.06	5.65±0.28	78.55±3.29	8.26±0.53
29	*Syzygium cumini*	0.45±0.09	0.34±0.15	6.23±0.14	77.95±1.81	8.09±1.74
30	*Tamarindus indica*	0.44±0.01	0.38±0.01	3.63±0.04	81.64±2.62	8.34±0.47

Table 3: Correlation between different biochemical parameters and APTI values

	Ascorbic acid content	Total chlorophyll content	pH	Relative water content	APTI
Ascorbic acid content	1				
Total chlorophyll content	0.075	1			
pH	0.122	0.174	1		
Relative water content	0.246	0.058	-0.030	1	
APTI	0.800	0.094	0.080	0.777	1

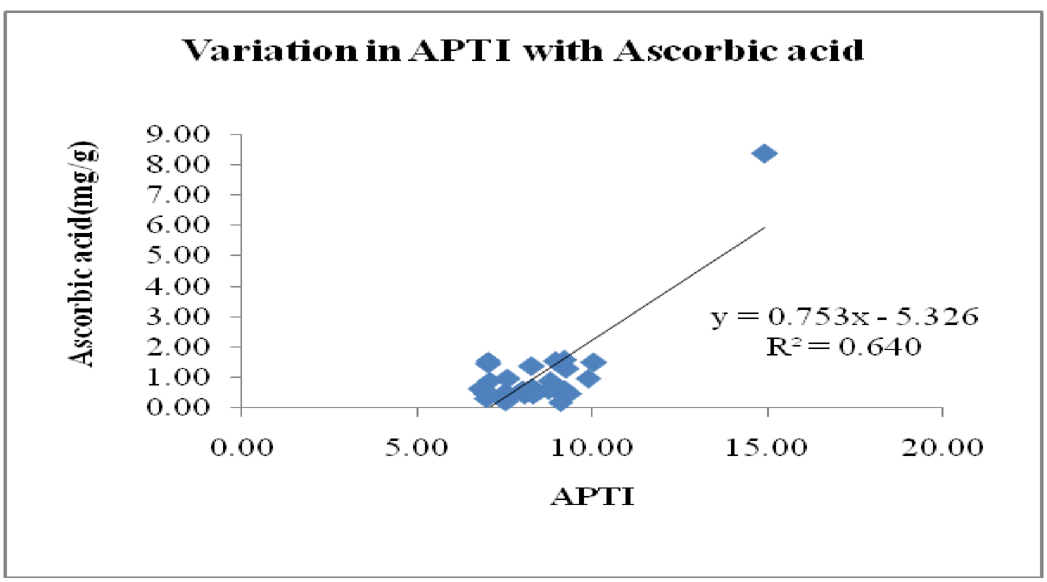

Fig. 2: Linear regression analysis between APTI and Ascorbic acid content

Copyright © 2015-2016 | IJLSSR by Society for Scientific Research under a CC BY-NC 4.0 International License

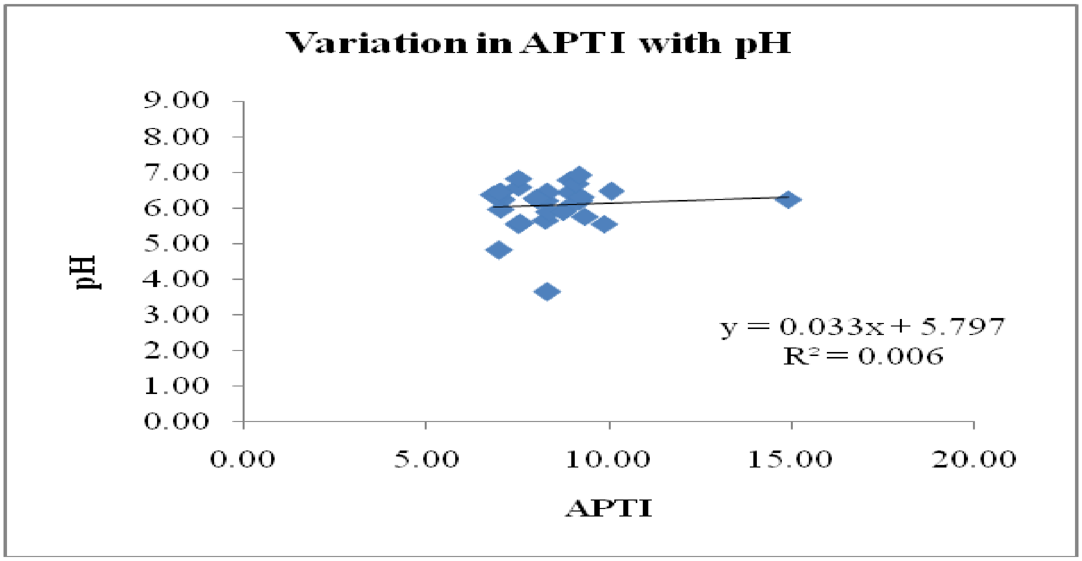

Fig. 3: Linear regression analysis between APTI and pH

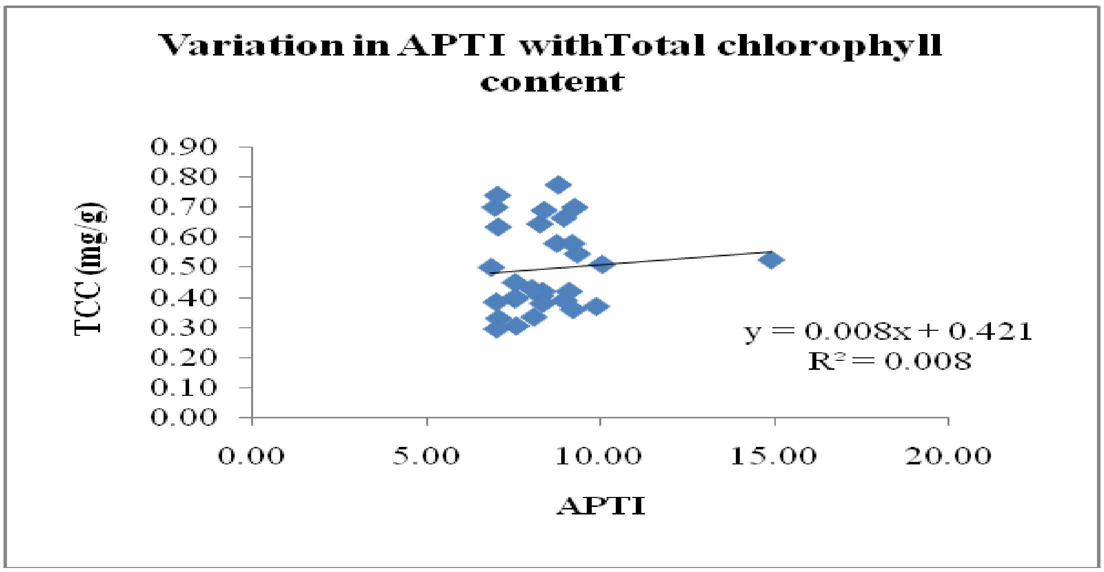

Fig. 4: Linear regression analysis between APTI and Total chlorophyll content

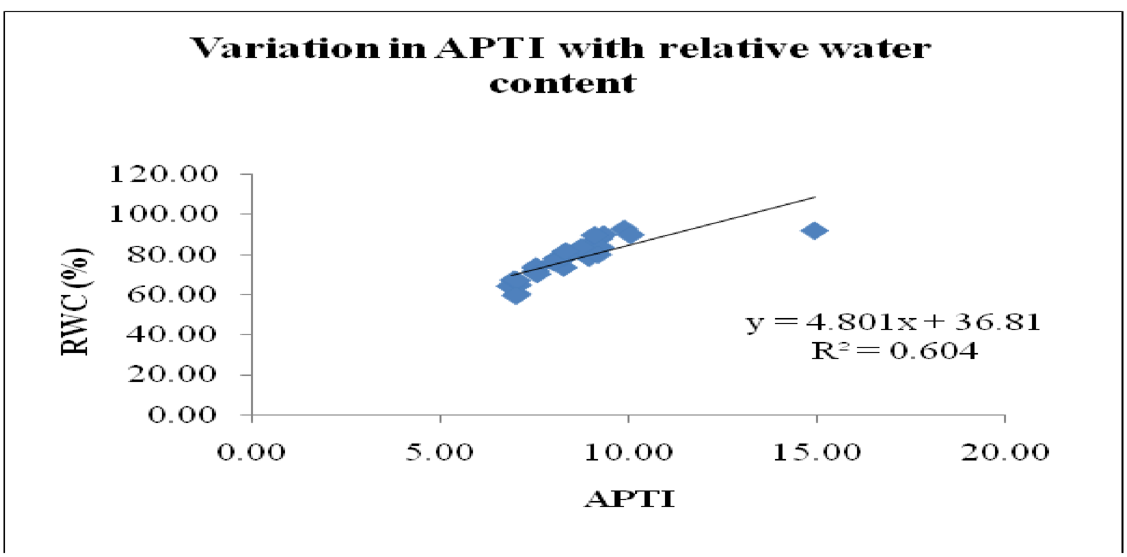

Fig. 5: Linear regression analysis between APTI and relative water content

Copyright © 2015-2016 | IJLSSR by Society for Scientific Research under a CC BY-NC 4.0 International License

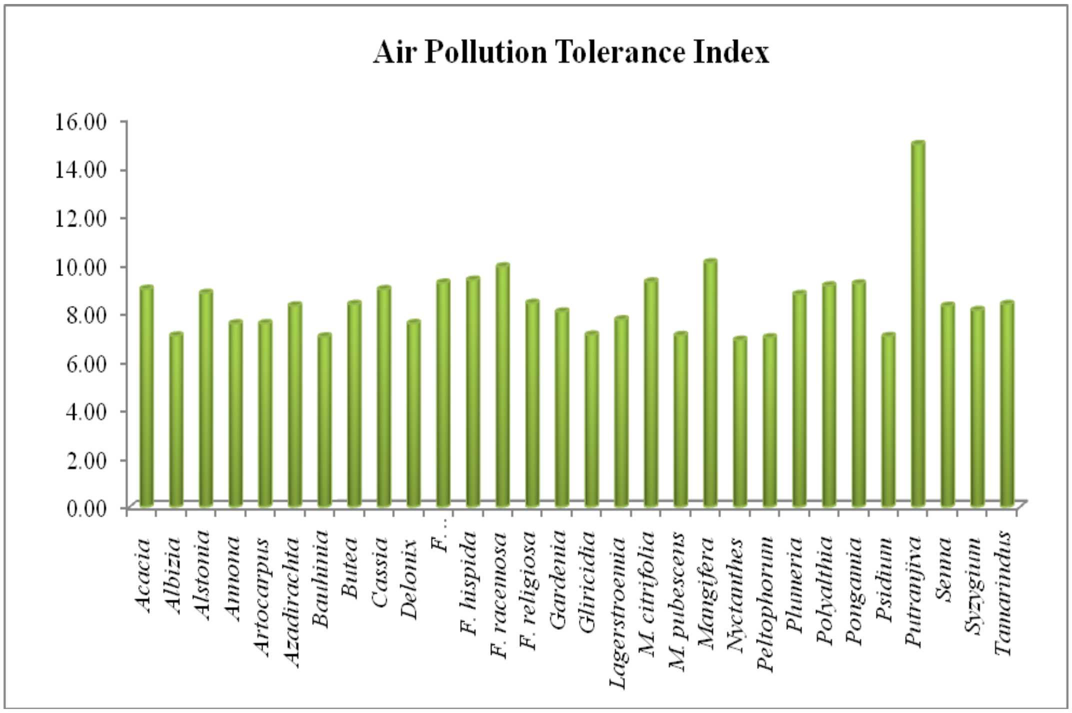

Fig. 6: APTI of plant species from industrial area of Tarapur

RESULTS AND DISCUSSION

Most of the plant species selected for the study showed higher APTI in winter as compared to summer season. The average value of summer and winter season was evaluated for all the biochemical parameters and then substituted in APTI formula to give an average APTI for all the plant species considered for the study (Table 2, Fig. 6). This helped in identifying the tolerant and sensitive nature of plant species towards pollution.

Ascorbic acid content: Ascorbic acid showed a weak positive correlation with Total chlorophyll content (r=0.075), pH (r=0.122) and relative water content (r= 0.246) but had a strong positive correlation with APTI (r=0.80) of plant species (Table 3). *Putranjiva roxburghii* (8.35mg/g) showed high ascorbic acid content while lowest ascorbic acid was seen in *Polyalthia longifolia* (0.2mg/g) (Table 2). Being a natural antioxidant, Ascorbic acid plays an important role in pollution tolerance by activating many physiological and defense mechanism in plants. [13] According to Garg and Kapoor [14] boost in the level of ascorbic acid content may be due to the resistance mechanism of plant to cope with stress condition since it slows down the leaf senescence. Thus *Putranjiva* shows tolerance nature to air pollutants while *Polyalthia* shows sensitive nature.

Leaf-extract pH: A negative correlation (r= -0.030) was seen between pH and relative water content and weak correlation existed between pH and APTI value (r=0.080) (Table: 3). Highest value for pH was seen in *Pongamia pinnata* (6.92) while lowest pH value was seen in *Tamarindus indica* (3.63) (Table 2). Agarwal [15] stated that low pH decreases the efficiency of hexose sugar conversion to ascorbic acid and the reducing activity of Ascorbic acid is more at higher pH than at lower pH. Thus high pH can provide tolerance to plants against pollutants. Hence we can say that *Pongamia* is tolerant species while *Tamarindus* is sensitive species.

Total chlorophyll content: Total chlorophyll depicted a weak positive correlation with pH (r=0.174), relative water content (r=0.058) and APTI (r=0.094) (Table 3). *Alstonia scholaris* (0.78mg/g) showed high total chlorophyll content, thus showing sensitivity to pollution while lowest chlorophyll content was seen in *Psidium guajava* (0.3mg/g) thus showing tolerance behavior. Joshi and Swami [16] concluded in their research that the most important photoreceptor in photosynthesis is Chlorophyll and its measurement is a significant tool to calculate the effects of air pollutants on plants as it plays a crucial role in plant metabolism; any reduction in chlorophyll content directly affects the plant growth. Total chlorophyll content of all the plant samples was less than 1 mg/g. Das and Prasad [17] suggested that high dust accumulation during the winter may be due to wet leave surface with foggy condition and gentle breeze which prevents particle dispersion; and low dust accumulation in summer may be due to high wind speed. Low chlorophyll content during winter season may be due to high dust accumulation on foliar surface of plants inhibiting photosynthesis due to presence of various metals and particles.

Relative water content: A strong positive correlation (r=0.777) exists between relative water content and APTI of plant species (Table: 3). *Ficus glomerata* (92.87%) showed high relative water content while lowest was seen in *Psidium guajava* (59.48%). Relative water content is the water content of leaf which helps in maintaining the physiological balance in plant body under stress conditions induced by air pollution. Dedio [18] High Relative water content would mean tolerance to pollutants.

Air pollution tolerance index of plants: By evaluating all the four biochemical parameters in the equation of APTI given by Singh and Rao [8]. Air pollution tolerance index of plants was calculated for 30 plants species and is depicted in Table 2. The tolerant plant species were *Putranjiva roxburghii, Mangifera indica, Ficus glomerata, Ficus benjamina* and *Morinda citrifolia* while the sensitive species were *Nyctanthes arbor-tristis, Peltophorum pterocarpum, Bauhinia purpurea, Psidium guajava* and *Pithecolobium saman* (Fig. 6). Regression analysis as shown in Fig. 2, 3, 4 and 5 revealed that Ascorbic acid content and Relative water content were positively correlated with APTI value while Leaf extract pH and total chlorophyll content showed a lesser correlation with APTI of the plant species. This means that both Ascorbic acid content and Relative water content are reliable parameters for checking the susceptibility of plant species.

CONCLUSIONS

Air pollution tolerance index study proves significant in determining the tolerant and sensitive nature of plant species in environment. Higher the A.P.T.I. value more is the tolerance of the plant species and lesser the APTI value, more is the sensitivity of the plant species. Among 30 plant species considered for the experimental study, the order of plants tolerant to air pollution can be stated as *Putranjiva roxburghii>Mangifera indica>Ficus racemosa>Ficus hispida>Morinda citrifolia> Pongamia pinnata>Ficus benghalensis> Polyalthia longifolia>Cassia fistula> Acacia auriculiformis*. Tolerant plant species can be used in green belt development as they tend to serve as barriers and act as sink for air pollutants. These can thus be planted in and around industrial vicinity and traffic islands to control the level of air pollution. The order of sensitive plant species can be given as *Nyctanthes arbor-tristis>Bauhinia purpurea> Peltophorum pterocarpum>Psidium guajava> Morinda pubescens> Albizia saman> Gliricidia sepium> Annona squamosa>Artocarpus heterophyllus> Delonix regia*. Sensitive plant species on the other hand act as Bio-indicators of air pollution and thus can be planted in order to check the environmental health from time to time. High pollution levels can lead to deforestation in long run and thus this kind of study helps in understanding the plants susceptibility and resistance to pollution loads.

REFERENCES

[1] Central pollution control board (CPCB). Guidelines for ambient air quality monitoring. A report by Central pollution control board, Ministry of Environment and Forest, Delhi, 2003.

[2] Dohmen GP, Koppers A. Langebartels C.Biochemical response of Norway spruce (*Picea abies* (L.) Karst.) towards 14-month exposure to ozone and acid mist: effects on amino acid, glutathione and polyamine titers. Environ. Pollu., 1990; 64: 375-83.

[3] Thambavani SD, Sabitha MA. Variation in air pollution tolerance index and anticipated performance index of plants near a sugar factory: implications for landscape-plant species selection for industrial areas. J. Res. Biol., 2011; 7: 494-502.

[4] Abida B, Ramaiah H M.Evaluation of some tree species to absorb air pollutants in three industrial locations of South Bengaluru, India. J. Chem., 2010; 7(S1): S151-56.

[5] Suvarna lakshmi P, Lalitha Sravanti K, Srinivas N. Air pollution tolerance index of various plant species growing in industrial areas. Ecoscan, 2008; 2 (2): 203-06.

[6] Singh SK, Rao DN. Evaluation of plants for their tolerance to air pollution." In: Proceedings Symposium on Air Pollution Control, (Indian Association for Air Pollution Control, New Delhi, India) 1983; 1: 218-24.

[7] Joshi N and Bora M.Impact of air quality on physiological attributes of certain plants: Report Opin., 2011; 3(2): 42-47.

[8] Maharashtra Pollution Control Board (MPCB). Action plan for Tarapur industrial area, 2010. http://mpcb.gov.in/CEPI/pdf/Action%20Plan%20CEPI-Tarapur.pdf.

[9] Central Pollution Control Board (CPCB).Current air quality issues in India, a paper presented by Central Pollution Control Board, Ministry of Environment and Forests, Delhi, 2011.

[10] Sadasivam S, Manickam A. Biochemical methods. 2nd ed. New Delhi; New Age International Pvt. Ltd. Publishers, 2009: pp. 284.

[11] Arnon DI. Copper enzyme in isolated chloroplasts. Polyphenol oxidase in Beta vulgaris. Plant Physiol., 1949; 24:1-15.

[12] Weatherly PE. Examination of the relative turgidity technique for estimating water deficit in leaves. J. Biol. Sci., 1965; 15: 413-28.

[13] Chen YM, Lucas PW, Wellburn AR. Relative relationship between foliar injury and change in antioxidants levels in red and Norway spruce exposed to acidic mists. Environmental Pollution, 1990; 69(10): 1-15.

[14] Garg OP, Kapoor V. Retardation on leaf senescence by ascorbic acid. J. Exp. Bot., 1972; 23: 699-703.

[15] Agarwal AL. Air pollution control studies and impact assessment of stack and fugitive emission from CCI Akaltara cement factory, project sponsored by M/S CCI Akaltara cement factory, NEERI, Nagpur, 1988.

[16] Joshi PC, Swami A. Air pollution induced changes in the photosynthetic pigments of selected plant species. J. Environmental Biol., 2009; 30(2): 295-98.

[17] Das S, Prasad P. Seasonal variation in air pollution tolerance indices and selection of plant species for industrial area of Rourkela. Ind. J. Env. Protection, 2010; 30(12): 978-88.

[18] Dedio W. Water relation in wheat leaves as screening test for drought resistance. Canadian J. Plant Sci., 1975; 55: 369-78.

Copyright © 2015-2016 | IJLSSR by Society for Scientific Research under a CC BY-NC 4.0 International License