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AN ASSESSMENT OF ANTICIPATED POLLUTION INDEX OF SOME COMMON PLANTS AND TREES OF ROHTAK CITY OF HARYANA (INDIA)

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ABSTRACT
Urban air quality around commercial and residential areas in cities has been progressively deteriorating due to gaseous pollutants released by an increasing load of vehicular on the roads resulting in adverse effects on human health. Plants due to their gas exchange have capability combat gaseous pollutants. The Phytoremediation capability and capacity of plants has been studied through the use of Anticipated Pollution Index (API) and Air pollution tolerance Index (APTI). Apart from other factors, the ecological significance of each plant has been considered for evaluating the API. The present study was undertaken for 40 plants, *Syzygium cumini, Menispermum cordifoliu, Albizia lebbeck, Saborium chinense Raf. Eclipta prostrate, Tectona grandis, Thevetia peruviana, Nerium oleander Linn, Pithecellobium dulc, Alianthus excelsa Roxb., etc.. Phoenix humili (*3.65) and *Calotropis gigantean (*15.13) with highest APTI were found to be more tolerant to gaseous pollutants, whereas *Syzygium cumini* is anticipated to be better performer along road sides on the API score. Others plants found to be excellent performers *were Thevetia peruviana, Tectona grandis* , *Grevillea robusta*, *Alstonia scholaris*, *Olea paniculata*, *Delonix regia*, *Casuarine equisetifolia*, *Pinus roxbughi Sarg* .
Keywords- APTI, API, Ascorbic acid, Total Chlorophyll, Air pollution.

INTRODUCTION

Air pollution is a major problem for world cities with ever increasing population and vehicular load. The released pollutants cause human and animal health problems and damage to the ecosystems.[1] Physical processes like winds and atmospheric lapse rates impact the pollutants through the horizontal and vertical movement of air. Wind causes the pollutants to disperse hence causing their dilution. Conditions like temperature inversion and stagnant air cause pollutants to concentrate near the surface.[2] High levels of air pollutants are observed in commercial areas and at a red light on road crossings, due to high density and slow movement of vehicles.

Other than physical processes the plants mean to play an important part in the mitigation of pollution in the local environment. Plants through their functioning remove a significant amount of pollutants from the atmosphere. Plants have enormous, surface areas, which help harness various air pollutants, directly through absorption or adsorption processes or by deposition on the biologically active leaf surface area. The surfaces of leaves are colonized by microorganisms[3], and have been reported to cause degradation of various organic pollutants.[4]

On exposure to air pollution, physiological changes are exhibited by the plans followed by visible damage.[5,6] Plants are complex and their physiological response depends on different parameters and factors affected by pollutants. Tolerant species are affected least while sensitive ones get injured more by air pollution.

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Air Pollution Tolerance Index (APTI) has been used to analyze the plant's suitability for use under air pollution environment.[5] APTI is based on four biochemical parameters viz. Quantities of ascorbic acid, chlorophyll, relative water content and pH of the leaf extract. Ascorbic acid is an important reducing agent and it helps plants against oxidative gases like SOx, NOx, etc. which generate cytotoxic free radicals.[6] Ascorbic acid also plays a crucial function in the synthesis of the cell wall, cell division and defense [7], so related to growth and maintenance of the plant. The chlorophyll content is related to the photosynthetic activity resulting in growth and accumulation of biomass. For air pollution, the degradation of the photosynthetic pigment can be used as indicator.[8] High pH may be responsible for efficiently converting hexose sugar to ascorbic acid[7.] The presence of acidic pollutants in the ambient air the leaf ph is lowered. Reduced photosynthesis has been observed in plants at low pH.[9] High water content in plants indicates their drought resistance and helps maintain the physiological functioning in stress conditions on exposure to air pollutants.[10] So to determine the tolerance level of plants to air pollutants these four parameters have been used. Comparable results have been reported for the level of susceptibility of plants to air pollution indicated by their APTI values with the plant responses observed under controlled and field experiments[5] Higher the index value more tolerant the plant will be to the pollutants. For screening plants, according to their sensitivity level or tolerance, this index gives a reliable method. Landscape planners use APTI in selecting tolerant plants [11] which can act as natural sinks for gas pollutants.[12,13]

Study Area

This study has been undertaken in Rohtak city of Haryana state (India). It is the fourth largest city in Haryana and spreads over an area of 139.4 km^2 with a total population over 0.48 million (Fig.-1). It is the education hub of the state. Being part of the national capital, it is rapidly growing in terms of population and number of vehicles on the road (Fig.-2.) Traffic load is even higher due to vehicles passing from other cities and tractors from the surrounding rural areas.

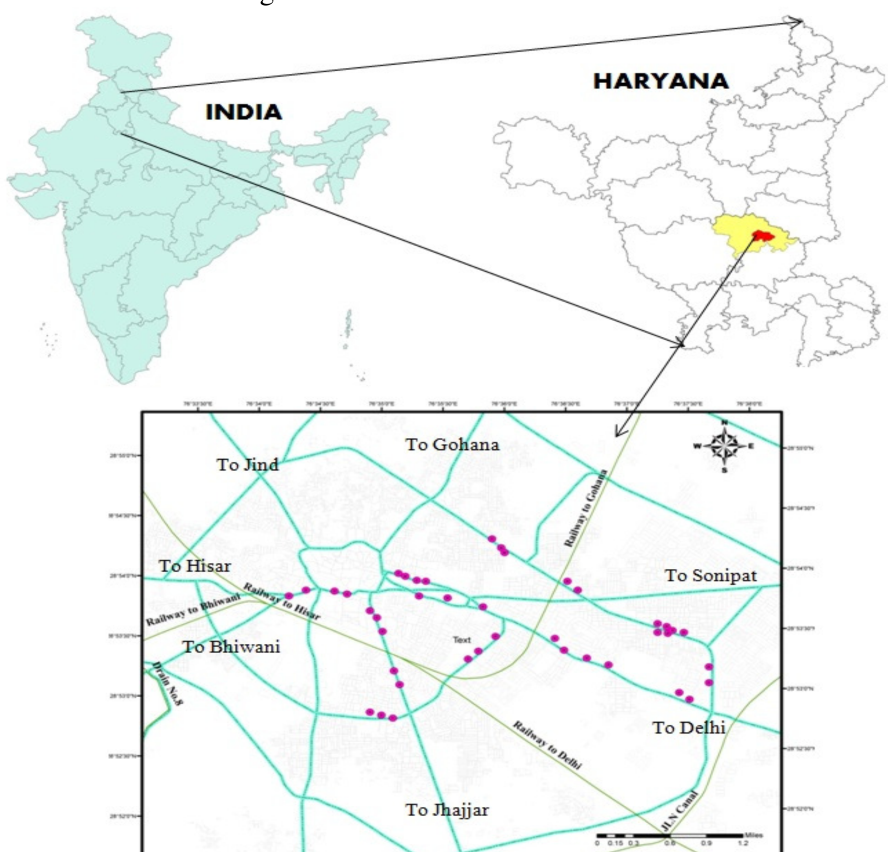


Fig.-1: Location Map of Sampling Sites in the Study Area.

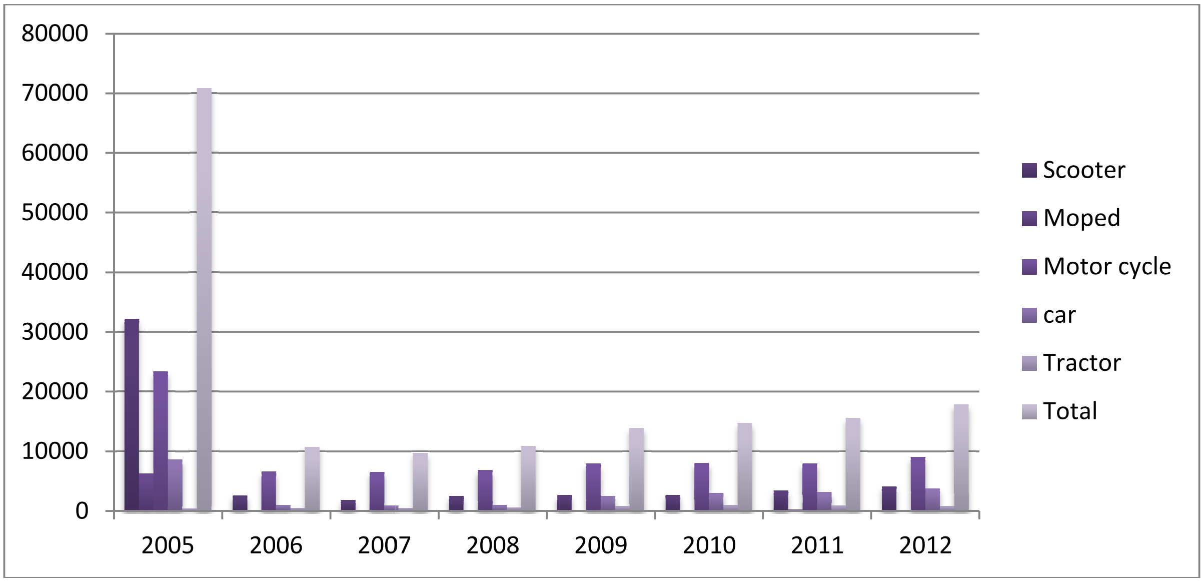


Fig.-2: Number of Registered Vehicles in Rohtak City from 2005 to 2012.

EXPERIMENTAL

Sampling

Forty plant species were selected randomly from heavy traffic road and these were designated as pollution site (P). Another site with similar light, water and ecological conditions was chosen as a control site (C). Mature leaf samples of the selected plants were collected in zip-lock poly bags in the morning and taken immediately to the laboratory for analysis. All the samples were collected in triplicate. The leaf fresh weight was taken immediately in the laboratory. Samples were kept preserved in the refrigerator for further analysis.

Relative Water Content (RWC)

It was determined according to the modified method described by Henson et al [14] and was calculated using the following formula:

$$\text{RWC} = \frac{\text{FW}-\text{DW}}{\text{TW}-\text{DW}} \text{ x } 100$$

Where FW= Fresh weight, DW= Dry weight, TW = Turgid weight of leaf sample.

Fresh weight was obtained by weighing the fresh leaves. To get turgid weight the leaves were then kept immersed in water over night, blot dried and then weighed. The leaves were then dried at 60°C in the oven for 24 hrs and weighed again to obtain the dry weight.

Total Chlorophyll Content (Tch)

Total chlorophyll was determined according to the method of Arnon [15]. 0.5 g of leaf sample was blended 80% acetone, the absorbance was taken at 645nm (OD_{645}) and 663 nm (OD_{663}) using UV visible spectrophotometer. The following formula was used:

$$\text{Total chlorophyll (mg/g)} = [(20.2 \text{ x } OD_{645}) - (8.02 \text{ x } OD_{663})] \text{ x dilution factor}$$

Where total chlorophyll= chlorophyll a+b (mg), OD= absorbance of the extract at specified wavelengths, dilution factor =V/W, V=total volume of extract (ml) and W=weight of leaf tissue taken for analysis (mg)

Ascorbic Acid Content

The ascorbic acid was estimated following the method of Keller and Schwager [16]. 1g of fresh leaf sample was homogenized in extracting solution (5 g oxalic acid +0.75 g EDTA in 1000 ml of solution with distilled water). Extract was centrifuged and 1 ml of this supernatant was then added to 2,6-

dichlorophenol indophenols (DCPIP) (20µg/ml). The optical density (OD) of the pinkish. the mixture was taken at 520nm (Es). The pink color is then bleached using one drop of ascorbic acid and OD again taken at 520nm (Et). The OD of DCPIP solution at 520 nm (Eo) was also taken. The standard curve was prepared by using a different concentration of ascorbic acid. The amount of ascorbic acid in the sample was calculated using a standard curve and the following formula:

$$\text{Ascorbic acid (mg/g)} = \left[\frac{Eo-(Es-Et)fxV}{WxV1\ x\ 1000}\right]$$

V=total volume of extract, W=weight of leaf tissue and f is the standard curve factor.

The pH of Leaf Extract

pH was determined by the method of [17] . 0.5 g of leaf sample was crushed and homogenized in 10 ml distilled water, the mixture was centrifuged and the supernatant was collected for taking pH readings.

Air Pollution Tolerance Index (APTI)

From the above parameters, APTI value was calculated according to the formula used by [5].

$$\text{APTI}=\frac{[A(T+P)]+R}{10}$$

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

Anticipated Pollution Index (API)

The APTI values along with morphological, ecological and socioeconomic values of the plants were considered in calculating the anticipated pollution index (API). Method of [18] was modified to assign grades for each characteristic. The API value of a particular species was based on the percentage score obtained by the species. The percentage score can be calculated as:

$$\%\ \text{score} = \frac{\text{GPS}}{\text{MPS}}\ \text{x}\ 100$$

GPS = Grade obtained by plant species
MPS= Maximum grades possible for any plant species (16 in this case)
The API value is based on the percentage score assigned to a particular plant species. The API value quantifies the phytoremediation performance of plant species. (Table1).

Statistical Analysis

Statistical analysis was performed using Microsoft Excel 2007. All the results are presented as mean ± standard error of triplicate values. Linear regression (R^2) to check the impact of change in independent variables, viz., pH, relative water content, total chlorophyll, and ascorbic acid contents, on the independent variables air pollution tolerance index (APTI). Pearson's correlation coefficient (r) to determine the strength or degree of correlation/association between variables. The box and whisker plots were developed to compare the distribution of the analyzed APTI parameters based on maximum, minimum and quartile values.

Air Pollution Data Collection

The daily mean of real-time air quality data of $PM_{2.5}$, SO_2, NO_2, O_3, and CO from November 2017 to April 2018 were obtained from the local monitoring station installed by Central Pollution Control Board (CPCB). Data of the period prior to sampling gives the range of the above pollutants to which the plants of the study area were exposed to prior to the sampling.

RESULTS AND DISCUSSION

Air Pollution Data

The daily concentration range (mean) of $PM_{2.5}$, SO_2, NO_2, O_3, and CO values was 43.68-353.57 µg/m^3(120.22), 3.36- 53.13µg/m^3 (15.14), 3.55-149 µg/m^3(19.36), 23.83-27.29 µg/m^3(26.06), and 0.41-1.20 mg/m^3 (1.01) respectively.

pH

The trend of pH of plant species on polluted and control site showed in Figure-3. The pH of leaf samples collected from polluted sites ranged from 4.33 (*Acacia pennata*) to 7.9 (*Pithecellobium dulce*)with minimum and maximum value respectively with mean value 5.96. At the control site, the minimum value is 4.66 (*Jacaranda mimosifolia*) and maximum value 8.59 (*Pithecellobium dulce*). 50% of plant species exhibited lower ph value in comparison with the mean value. the pH of leaves of the plant at the control site as compared to the control site has greater value. Low pH of plant leaves can be due to dissolution of gaseous air pollutants like SO_2 and NO_2 in the cell sap and their conversion into acid radicals [19,20]. Low pH reduces the conversion of sugar (hexose) to ascorbic acid and leads to an increase in the air pollution tolerance level of plants.[21,22] Highly sensitive plants have faster stomatal closing when exposed to gaseous air pollutants like $NO_2$and SO_2.[23-25] Consequently, sensitive plants had higher leaf-extract pH than tolerant plants. In previous work it was noticed the reduction of photosynthetic process in the plant at lower pH of leaf extract and it shows good correlation with sensitivity to air pollution [21,26].The result of pH in the conformity with the results reported earlier.[27-29]

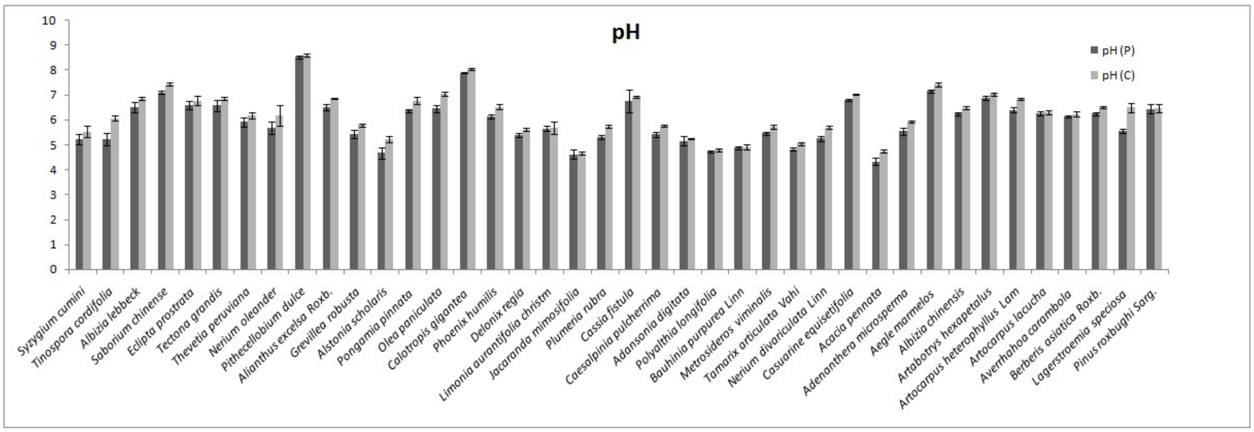


Fig.-3: Extract pH in Leaves of Plant Species. (Notes: the error bars = standard error)

Relative Water Content

The value are presented in Fig.-4. The relative water content was in range of 36.40% (*Phoenix humilis)* to 93.45 % (*Calotropis gigantea*)in plants of polluted site (P) compared to 37.57 % (*Phoenix humilis*) to 96.43 % (*Calotropis gigantean)* for control site (C) with mean value of 70.46% and 71.77% respectively. Pollutants causes loss of water by inducing cell permeability.[30] More water content in plants can dilute acidity inside the leaf cell sap [30]. Leaf water status is intimately related to several leaf physiological variables, such as leaf turgour, growth, stomatal conductance, transpiration, photosynthesis and respiration.[28,29,31] The relative water content and APTI are found to be positively correlated with correlation coefficient of 0.773.The study conformed with the results reported earlier.[21,32,33]

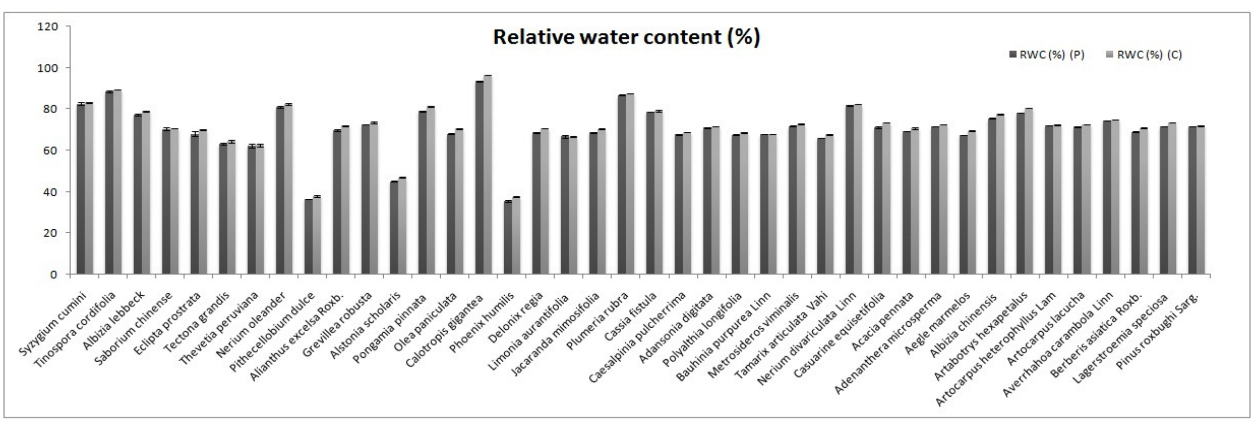


Fig.-4: The Relative Water Content of Plant Leaves of Control Site and Polluted Site. (Note: the error bars = standard error).

Total Chlorophyll Content

The minimum and maximum value of total chlorophyll level observed in leaves of *Artocarpus lacucha* (0.29 mg/g) and *Syzygium cumini (*8.97 mg/g), respectively. And the average value is 2.133 mg/g. At the control site, the observed range was 0.33 mg/g to 9.03 mg/g in same plant species respectively. 35 % of plants species have more value of total chlorophyll than the mean value (Figure-5). Total chlorophyll content signifies its photosynthetic activity as well as the growth and development of biomass in tree or plant species.[19] Chlorophyll molecule can be degraded to pheophytin by replacement of Mg^{++} ions with two hydrogen atoms.[23,34,35,36] under the high level of air pollutants, and hence the productivity is affected through reduced efficiency of chloroplasts, leading to reduced photosynthetic rate, stomatal conductance and premature leaf fall.[37,38,39,40]. Chlorophyll content of plant leaves can also be affected by high temperature, drought environment [41] , light intensity [42] salt stress environment [43] and it can also vary from species to species, age of leaf, and pollution level (O_3).[44,45,46] Chlorophyll content in plants of control site was found to be higher than that in the polluted site. Our result indicates that higher pollution load tends to decrease total chlorophyll content in plants on polluted site as compared to the control site, which is an agreement with previous study.[29,47] Certain study has been reported to high chlorophyll content at polluted site. [39,48,49]

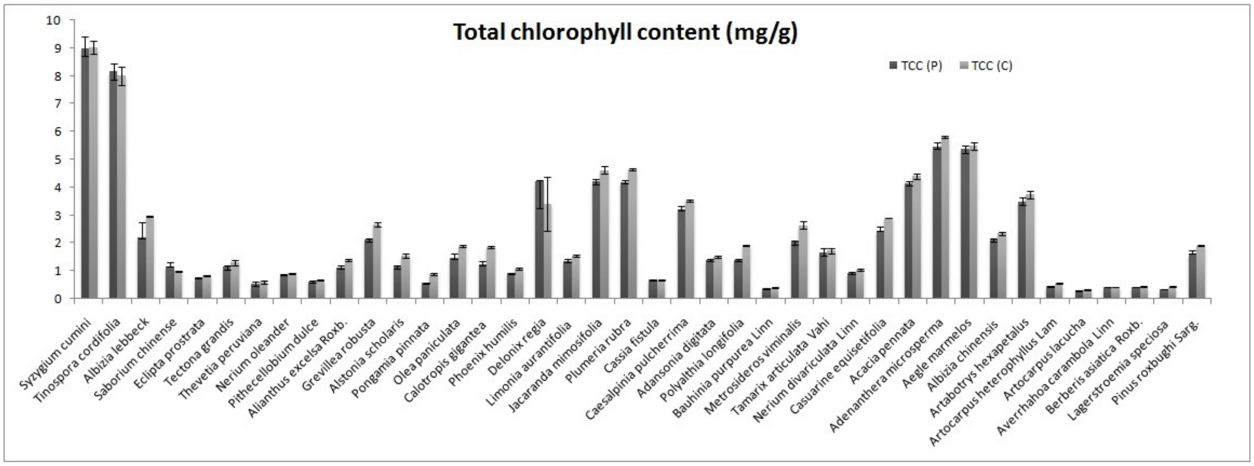


Fig.-5: Total Chlorophyll Content of Plant Leaves of Control Site and Polluted site. Note: the error bars = standard error.

Ascorbic Acid Content

Ascorbic acid content of leaf extracts showed a range of 0.03mg/g (*Polyalthia longifolia*) and 6.28 mg/g (*Calotropis gigantea*) was found to be minimum and maximum value respectively, where as the mean value is 2.28 mg/g at polluted site, where as at control site the minimum, maximum and mean value is 0.03 mg/g (*Berberis asiatica Roxb.*), 6.06 mg/g (*Calotropis gigantea*), and 1.981 mg/g respectively.63 % of plant species have greater value of ascorbic acid as compared to mean value. As compared the value at control site except for *Albizia lebbeck* all other species have greater ascorbic acid value at the polluted site (Figure-6). Ascorbic acid was considered as an important factor for judging a plant's tolerance to various environmental stresses including heat stress[50], salt stress[51], and drought stress.[52] The antioxidant property of ascorbic acid maintains cell wall and membrane formation, and cell division due to photo-oxidation of SO_2 to SO_3[15,30,53] plants during stress conditions by scavenging cytotoxic free radicals and reactive oxygen;[54]. Ascorbic acid can prevent plant tissues from air pollutants and contribute to higher air pollution tolerance .[5,56,57] The role of ascorbic acid content is well supported.[29,58,59]

Air Pollution Tolerance Index

The observed range of minimum and maximum value for APTI at polluted site is 3.65 (*Phoenix humilis*) and 15.13 (*Calotropis gigantea*) with mean value of 8.96, whereas at control site the minimum, maximum and mean values are 4.4 (*Grevillea robusta*), 15.65 (*Calotropis gigantean),* and 7.34, respectively.17% of plant species have more APTI value at Polluted site (Figure-7). *Pogamia pinnata* and *Artabotrys* *heterophyllus* have the same value at both sites 9.1 and 8.33 respectively. The higher APTI values were observed for respective plant samples from the control site than from polluted site[31]. Among these 40 species top five best species are *Calotropis gigantean >Syzygium cumini >Plumeria rubra >Albizia lebbeck >Delonix regia.* The high tolerance level of these plants is well documented in many studies.[60-64]

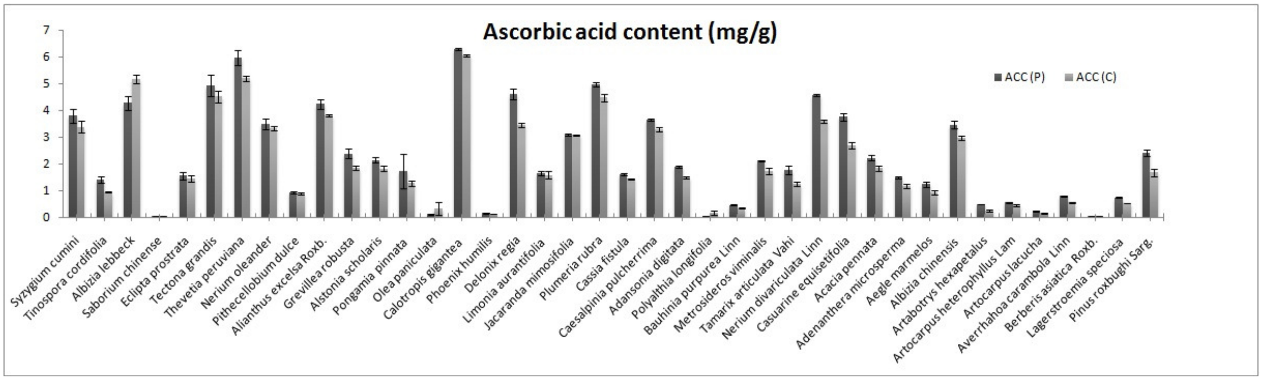


Fig.-6: The Ascorbic Acid Content of Plant Leaves of Control Site and Polluted Site. Note: the error bars refer to standard error.

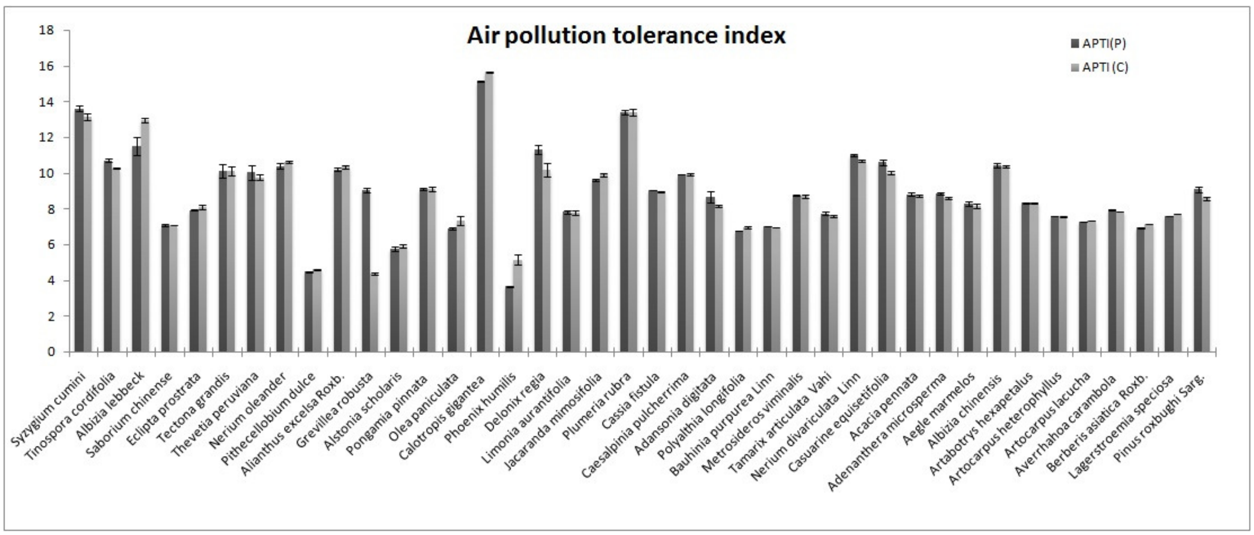


Fig.-7: Ascorbic Acid Content of Plant Leaves of Control Site and Polluted Site. Note: the error bars refer to standard error.

Anticipated Performance Index

The Anticipated performance index (API) values of all forty plants collected from Rohtak city were determined on the basis of their APTI and other plant characteristics parameters. Different grades (+ or -) were allotted to plants based on APTI and different plant characteristics (Table-1). Total "+" grades, percentage score and API Values are given in Table-2.

Table-1: Gradation of Plant Species based on Air Pollution Tolerance Index (APTI) as well as Biological Parameters and Socioeconomic Importance.

Grading Character	Pattern of Assessment	Grade* allotted
	(a)Tolerance	
APTI	<1	+
	1-5	++
	6-10	+++
	>11	++++
	(b) Plant characteristics	
Plant Habit	Small	-

	Medium	+
	Large	++
Canopy structure	Sparse/Irregular/globular	-
	Spreading crown/open/semi –dense	+
	Spreading Dense	++
Type of Plant	Deciduous	-
	Evergreen	+
Laminar structure		
Size	Small	-
	Medium	+
	Large	++
Texture	Smooth	-
	Curvaceous	+
Hardiness	Delineate	-
	Hardy	+
Ecological value	Food(Fruit)	-
	Nesting/perching	+
Aesthetic value	Non	-
	Flower	+
	Leaves	++

*Maximum grades that can be scored by a plant = 16

Table-2: Anticipated Performance Index (API) of Plant Species.

Grade	Score (%)	Assessment Category
0	Up to 30.0	Not recommended (NR)
1	31.0 – 40.0	Very poor (VP)
2	41.0 – 50.0	Poor (P)
3	51.0 – 60.0	Moderate (M)
4	61.0 – 70.0	Good (G)
5	71.0 – 80.0	Very Good (G)
6	81.0 – 90.0	Excellent (E)
7	91.0 – 100.0	Best (B)

In the study, *Syzygium cumini* (Java plum) is anticipated to be best performer along road sides. Whereas *Thevetia peruviana* (Yellow oleander) and *Tectona grandis* (Teak), *Grevillea robusta* (Australian silver oak), *Alstonia scholaris*(Devil tree), *Olea paniculata*(Native olive), *Delonix regia*(Flame tree), *Casuarine equisetifolia*(Australian pine tree), *Pinus roxbughi Sarg* (Chir pine) are revealed to be Excellent performers (Table-3). From enviornmental point of view plantation of mentioned plants around the city will be highly beneficial for mitigation and minimization of air pollution load. And moreover *Albizia lebbeck(Siris), Saborium chinense(Chinese tallow tree), Nerium oleander Linn(Nerium), Plumeria rubra(Frangipani), Cassia fistula(Golden rain tree), Albizia chinensis (osbeck) merr (Siris), Artocarpus heterophyllus Lann (Kattal), Artocarpus lacucha(Monkey fruit)* these revealed to be very good performers for road side plantation.[65,66] reported *Syzygium cumini* as the best tolerant species with high APTI and API for plantation along roadside (greenbelt).

Table-3: Evaluation of API Values of Plant Species based on their APTI Values and Some Other Biological and Ecological Characters.

Plant Species	APTI	PH	CN	TY	Laminar structure			EV	AV	Grade allotted			Category
					S	T	H			Total	%	API	
Syzygium cumini (Java plum)	++++	++	++	+	++	+	+	-	++	15	93.75	7	B
Menispermum cordifolium	++++	-	+	-	+	-	-	-	++	8	50	2	P

(Moonseed)													
Albizia lebbeck (Siris)	++++	++	-	-	++	+	-	+	++	12	75	5	VG
Saborium chinense (Chinese tallow tree)	+++	++	-	-	++	+	+	+	++	12	75	5	VG
Eclipta prostrata (Bhringraj)	+++	-	-	-	-	-	-	-	-	3	18.75	0	NR
Tectona grandis (Teak)	++++	++	+	-	++	+	+	+	++	14	87.50	6	E
Thevetia peruviana (Yellow oleander)	++++	+	+	+	++	+	+	+	++	14	87.50	6	E
Nerium oleander Linn *(Nerium)*	++++	+	+	+	++	-	-	+	++	12	75	5	VG
Pithecellobium dulce *(Singri)*	++	++	-	-	+	+	+	-	-	7	43.75	2	P
Alianthus excelsa Roxb. (Mahaneem)	++++	++	+	-	+	-	-	+	++	11	68.75	4	G
Grevillea robusta (Australian silver oak)	+++	++	+	+	++	+	+	+	++	14	87.50	6	E
Alstonia scholaris (Devil tree)	+++	++	++	+	++	-	+	+	++	14	87.50	6	E
Pongamia pinnata (Linn.) Pierre (Kidamar)	+++	++	-	+	+	-	+	+	-	9	56.25	3	M
Olea paniculata (Native olive)	+++	++	++	+	+	-	+	+	++	13	81.25	6	E
Calotropis gigantea *(Crown flower)*	++++	-	+	+	+	-	-	-	++	9	56.25	3	M
Phoenix humilis (Dwarf Fan Palm)	++	+	+	+	+	-	+	+	++	10	62.50	4	G
Delonix regia (Flame tree)	++++	++	+	+	++	-	+	+	+	13	81.25	6	E
Limonia aurantifolia christm (Indian Lime)	+++	-	-	+	++	-	+	-	-	7	43.76	2	P
Jacaranda mimosifolia (Jacaranda)	+++	++	+	-	++	-	+	+	+	11	68.75	4	G
Plumeria rubra (Frangipani)	++++	+	+	-	++	+	-	+	++	12	75	5	VG
Cassia fistula (Golden rain tree)	+++	++	+	+	++	-	+	+	+	12	75	5	VG
Caesalpinia pulcherrima (Peacock Flower)	+++	+	+	+	++	-	-	+	+	10	62.50	4	G
Adansonia digitata (dead-rat tree)	+++	++	-	-	++	-	-	+	-	8	50	2	P
Polyalthia	+++	++	-	+	++	-	-	-	++	10	62.50	4	G

longifolia (Ashoka)													
GBauhinia purpurea (orchid tree)	+++	++	+	-	-	+	-	+	+	9	56.25	3	M
Metrosideros viminalis (Weeping bottlebrush)	+++	+	-	+	+	+	-	+	++	10	62.50	4	G
Tamarix articulata Vahi (Farash)	+++	++	-	+	-	+	+	+	++	11	68.75	4	G
Nerium divaricualata	++++	+	+	+	++	-	-	+	++	12	75.00	5	VG
Casuarine equisetifolia (Australian pine tree)	++++	++	-	+	+	+	+	+	++	13	81.25	6	E
Acacia pennata (Agla Bel)	+++	-	-	+	-	-	-	+	++	7	43.76	2	P
Adenanthera microsperma (Red Lucky Seed)	+++	-	+	-	-	+	-	+	++	8	50	2	P
Aegle marmelos (Bael)	++++	+	+	-	+	+	-	-	++	10	62.50	4	G
Albizia chinensis (osbeck) merr (Siris)	+++	++	+	+	++	-	-	+	++	12	75	5	VG
Artabotrys hexapetalus (Manorangini)	+++	+	-	+	+	-	-	-	++	8	50	2	P
Artocarpus heterophyllus Lam (Kattal)	+++	++	+	+	++	+	-	-	++	12	75	5	VG
Artocarpus lacucha (Monkey fruit)	+++	++	+	+	++	+	-	-	++	12	75	5	VG
Averrhahoa carambola Linn (Karmal)	+++	+	+	+	+	-	-	+	++	10	62.50	4	G
Berberis asiatica Roxb. (Daruharidra)	+++	+	+	+	+	-	-	-	-	7	43.75	2	P
Lagerstroemia speciosa (Linn.) (Queens Crape-Myrtle)	+++	+	+	+	-	-	+	+	++	10	62.50	4	G
Pinus roxbughi Sarg. (Chir pine)	+++	++	-	+	++	+	+	+	++	13	81.25	6	E

PS= Plant species, PH= Plant habit, CN= Canopy structure, TY= Type of plant, LM= Laminar structure, S= Size, T= Texture, H= Hardiness, EV= Ecological value, AV= Aesthetic value.

Linear Regression Analysis

Linear regression analysis depicts no significant effect of pH (R^2 = 0.001), RWC (R^2= 0.598), Total chlorophyll content (R^2= 0.199), on APTI, whereas, ascorbic acid (R^2= 0.663) showed significantly positive impact (Fig.-8).

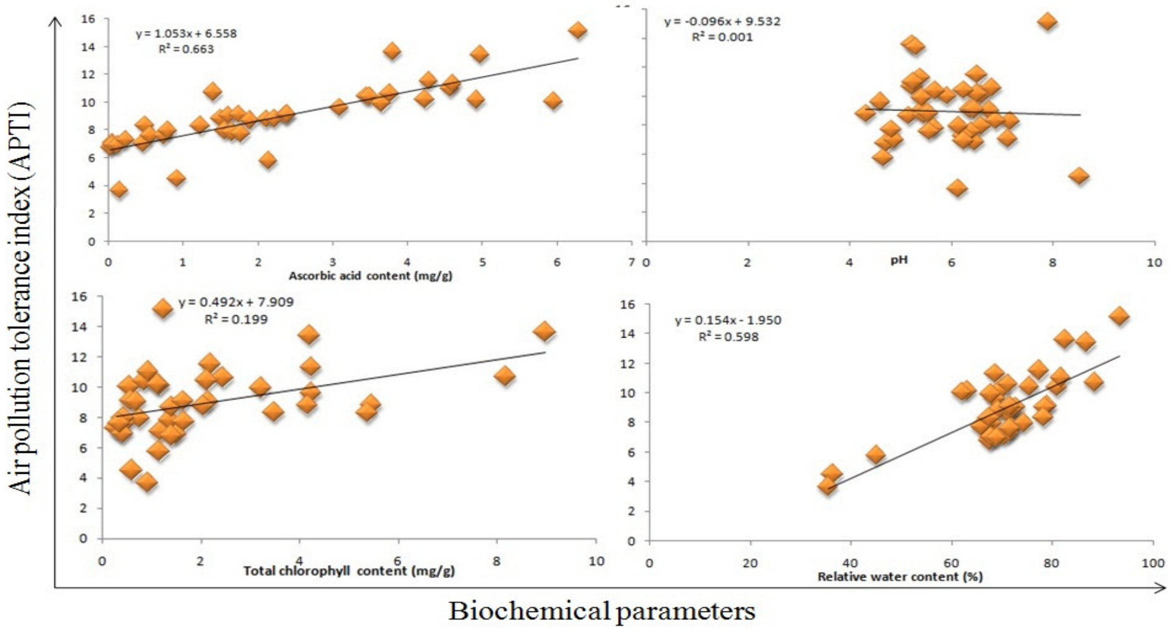


Fig.-8: Linear Regression Analysis of Individual Variables with APTI Values.

Pearson's Correlation

The correlation analysis study involving statistical calculation coefficient 'r'. In the present study correlation ship of APTI has been worked out with the rest of the analyzed parameters. Table 4 present the correlation coefficient matrices. Pearson's correlation coefficient matrix revealed significant positive correlation at $p < 0.05$ between APTI and ascorbic acid ($r = 0.815$) [67], relative water content ($r = 0.773$), and chlorophyll ($r = 0.447$) respectively. There was a significant negative correlation (at $p < 0.05$) of APTI and pH ($r = -0.038$) content of the leaves.

Table-4: Pearson's Correlation Coefficient (r) Matrices between Biochemical Parameters.

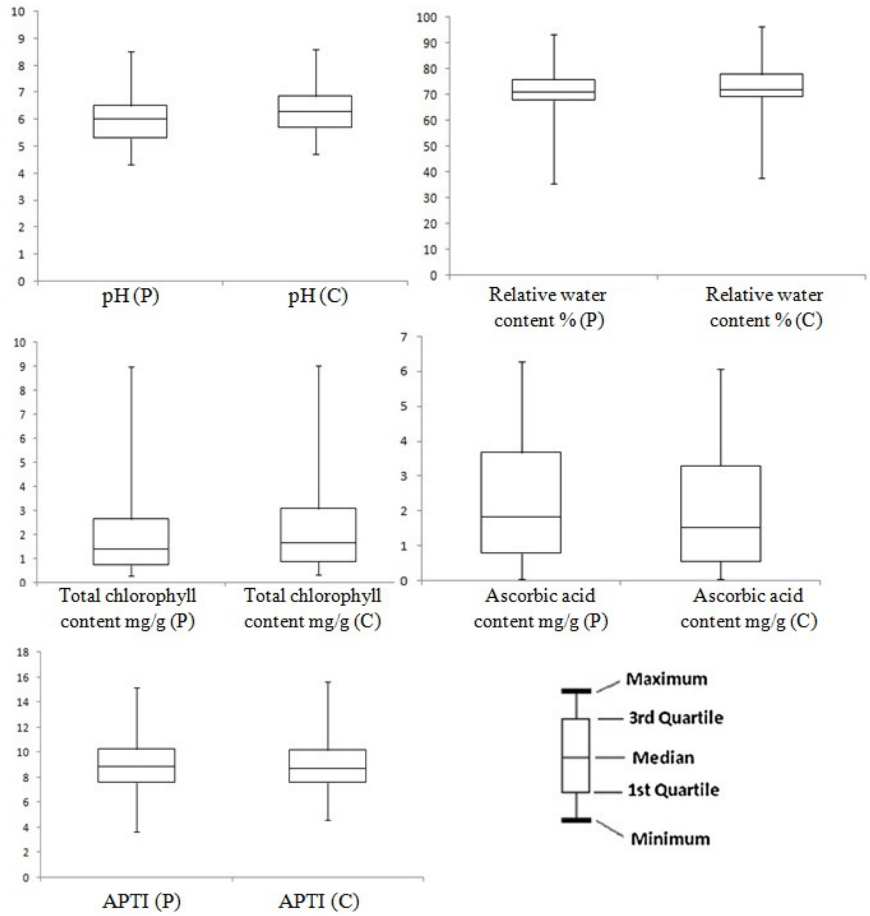
	pH	Relative water Content (%)	Chlorophyll (mg/g)	Ascorbic acid (mg/g)	APTI
pH	1				
Relative water Content (%)	-0.073	1			
Chlorophyll (mg/g)	-0.281	0.317	1		
Ascorbic acid (mg/g)	-0.018	0.325	0.178	1	
APTI	-0.038	0.773	0.447	0.815	1

A significant positive correlation of APTI is observed with ascorbic acid quantity and relative water content of the plant leaves.

Box and Wisker Plot

A boxplot can display differences between different values in the parameter without making any assumptions of the underlying statistical distribution. The data is positively skewed in pH, Total chlorophyll, Ascorbic acid, and APTI, with value 0.528, 1.802, 0.557, 0.348 respectively. Relative value content (%) revealed negative skewness with value -1.308 (Figure-9). The kurtosis values for pH, Relative water content, chlorophyll, and APTI are 0.450, 3.531, 3.193, and 1.020. In ascorbic acid the value is -0.678.

Linear regression, Pearson's correlation and Box and Whisker Plot analysis depict a strong positive association between APTI and Ascorbic acid content. Ascorbic acid content was found to be the most determining and significant factor on which tolerance of plant species depends. A number of previous studies have also shown a similar correlation between APTI and other biochemical parameters.[69-72]



P = Polluted site, C = Control site
Fig.-9: A Box and Whisker Plot for Sampling Session.

CONCLUSION

The different biochemical parameters considered in calculating the APTI react differently in the studied plant species, however, ascorbic acid content was found to be the most important factor providing tolerance to the plants against air pollution. *Calotropis gigantean ,Syzygium cumini ,Plumeria rubra ,Albizia lebbeck ,Delonix regia.* plants were found to be most tolerant of air pollution. Among the forty species of plant *Syzygium cumini* (Java plum, *Thevetia peruviana* (Yellow oleander), *Tectona grandis* (Teak), *Grevillea robusta* (Australian silver oak), *Alstonia scholaris* (Devil tree), *Olea paniculata* (Native olive), *Delonix regia* (Flame tree), *Casuarine equisetifolia* (Australian pine tree), and Pinus roxbughi Sarg (Chir pine) are the best performer on API score and can be used in green belt design to assist in air pollution management and ecological services.

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