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Evaluation of Selected Plant Species as a Bio-Indicators of Particulate Automobile Pollution using Air Pollution Tolerance Index (APTI) Approach

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Abstract:** This study focuses on the assessment of 2air pollution tolerance index (APTI) of 21plant species commonly found along roadsides in Ambo town, west showa, Ethiopia. The plants were evaluated in terms of APTI by analyzing four different biochemical parameters: leaf relative water content (RWC), ascorbic acid content (AA), total leaf chlorophyll (TCh) and pH of leaf extract. From Air pollution tolerance index (APTI) results it was noted that only two (9.52%) out of total 21 plant species designated as "Tolerant" and 9 species (42.85%) were designated as "Intermediate" and rest of the 10 species (47.61%) were categorized as "Sensitive". Highest air pollution tolerance index was found with Jacaranda mimosifolia (35.28) followed by Schinus molle (35.21) which were designated as "tolerant" species whereas least air pollution tolerance index was associated with Croton macrstachs (12.28) followed by Olea Africana (13.25) which are designated as "sensitive" species. Species with lower APTI value are considered sensitive species, which can be used as a biological indicator for further monitoring of air quality. Species with higher APTI value are tolerant species and thus, can be planted for pollution abatement in order to control and reduce environmental pollution.

***Keywords:** Air pollution tolerance index (APTI); biochemical parameters; bioindicator, particulate pollution,*

I. INTRODUCTION

Air pollution refers to the number of harmful substances in the atmosphere of concentration and residence time more than the allowed range, which is beyond the capability of diffusion and dilution resulting in air quality deterioration, brought bad influence directly or indirectly to human health and ecological environment [1] . It is one of the severe problems facing the world today due to the continual change in concentration levels of some gaseous and trace metals in the environment resulting from man's activities such as road transportation, vehicular traffic and industries [2]. W.H.O has estimated that approximately 2 million and 1.3 million deaths worldwide mostly in developing countries have occurred due to indoor and outdoor air pollution [3]. Air pollution has been ranked in the top 10 causes of deaths in world, in global burden of diseases [4]. The distribution of air pollution diseases resulting in premature deaths is depicted as stroke (25.48%), chronic obstructive pulmonary disease (17.32%), ischemic heart disease (48.6%), lower respiratory infections (6.4%), and trachea, bronchus and lung cancer (2.02%) [4] . Air pollutants like sulfur dioxide, ozone, particulate matters, and nitrogen oxide can alter the whole physiological process of plants, thereby affecting patterns of growth [5]. In recent years, increasing efforts are being made to use plants for detection of air quality. Biomonitoring is generally defined as the systematic use of living organisms or their responses to determine the condition or changes of the environment. Green plants have been used as air pollution indicators for many years. An indicator plant is one which exhibits symptomatology when exposed to phytotoxic concentrations of a pollutant or pollutant mixture. Green plants can also act as indicators of air pollution by accumulating the pollutant or some detectable metabolic product of the pollutant in their tissues [6]. It has been well established that vegetation canopies can act as sink for the air pollutants on not only gaseous pollutants but also the particulate pollutants [7].

The APTI method is useful for urban planners, landscape architects, and policy makers to select plant species tolerant to air pollution [5] . Air pollution tolerance index has also been used to categorize plants species in their order of tolerance to air pollution [8]. APTI requires determination of four biochemical parameters i.e. Ascorbic Acid (AA), pH, Relative Water Content (RWC) and Total Chlorophyll Content (TCH). Ambo town is one of the fast growing cities in terms of increasing population and transportation and literally there were no studies on air pollution status and data on air pollution tolerance capability of plants species growing in Ambo town. Hence in present study, we have explored selected common tree species growing on road side in Ambo city and evaluated their air pollution tolerance levels using APTI approach.

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II. MATERIALS AND METHODS

A. Description Of The Study Area

The study was conducted in Ambo town, West Showa zone of Oromia Region at about 114 km from capital city of addis ababa, East Africa. It was located in the western part of the country (8°47'N-9°25'Nand 37°32'E-38°3'E) on the road to Nekemte.

B. Sample Collection

The procedure adopted by Agbaire and Esiefarienrhe (2009) [5] was used for collection of leaf samples of selected plant species with minor modifications. A total of 21 road side plant species growing in Ambo town were selected randomly to evaluate their APTIs. Samples were collected from a height of approximately 1 m from the ground in four directions. The fully expanded leaves from all the sites were collected in the polythene bags and transported to chemistry laboratory, Ambo university for further analysis. Before analysis, leaves were washed out thoroughly with distilled water. Three replicates were used for each plant. Some portion of leaf samples were kept aside without washing for the estimation of dust holding capacity.

C. Estimation Of Biochemical Parameters

Estimation of different biochemical parameters like ascorbic acid, total chlorophyll content, relative water content, leaf pH were carried out according to standard procedures. APTI of tree species was calculated by the following formula proposed by Singh and Rao (1983) [9]

APTI = A (T + P) + R / 10

Where:

A= ascorbic acid contents in mg/g of leaves

T = total chlorophyll in mg/g fresh weight

P = pH of leaf extract

R = relative water content (%)

D. Apti Index

Based on the APTI values the plants were conveniently grouped into categories as mentioned in the following [10]. APTI values Response are –

No	APTI values	Response
1	30-100	Tolerant
2	17-29	Intermediate
3	1-16	Sensitive
4	< 1	Very sensitive

III. RESULTS AND DISCUSSIONS

Family status of plant species selected for the present study was shown in table I. A total of 21 road side plant species in Ambo town were randomly selected for this purpose. Each species was identified based on its local as well as scientific name. Four species namely Eucalyptus camaldulensis, Callistemon citrinus, Eucalyptus globulus and Psidum guajava belongs to Myrtaceae family and two species Jacaranda mimosifolia and Spathodea nilotica belongs to Bignoniaceae family. Juniperus procera and Cupressus macrocarpa belongs to Cupressaceae family. Rest of the plant species belongs to different families as shown in the below table.

TABLE I: Table showing family status of selected plant species

S.NO.	PLANT SPECIES		
	LOCAL NAME (Amharic)	SCIENTIFIC NAME	FAMILY NAME
1	Jacarandaa	Jacaranda mimosifolia	Bignoniaceae
2	Koshommii	Dovyalis abyssinica	Salicaceae
3	Bargamo diimaa	Eucalyptus camaldulensis	Myrtaceae
4	Niimii	Azadirachta indica	Meliaceae
5	Waddessa	Cordia Africana	Boraginaceae
6	Bottle brush	Callistemon citrinus	Myrtaceae

7	Dhummuugaa	Justicia schimperiana	Acanthaceae
8	Eebicha	Vernonia amygdalina	Daisy family
9	Giraviliyaa	Grevillea robusta	Proteaceae
10	Ispatuliyaa	Spathodea nilotica	Bignoniaceae
11	Qunda barbaree	Schinus mole	Anacardiaceae
12	Laafto faranji	Acacia melanoxylon	Fabaceae
13	Ejersa	Olea Africana	Oleaceae
14	Bargamo adii	Eucalyptus globulus	Myrtaceae
15	Laafto	Acacia abyssinica	Leguminosae
16	Gaattira habashaa	Juniperus procera	Cupressaceae
17	Meexxii	Phoenix reclinate	Arecaceae
18	Shuwaashuwwee	Cupressus macrocarpa	Cupressaceae
19	Bakkannisa	Croton macrostachyus	Euphorbiaceae
20	Zayitunaa	Euclea schimperi	Ebenaceae
21	Mi'eessaa	Psidum guajava	Myrtaceae

TABLE II: Table showing average ascorbic acid content (mg/gm) of selected plant species

S.NO.	SCIENTIFIC NAME	TRIALS			AVERAGE ASCORBIC ACID CONTENT (mg/gm)
		T1	T2	T3	
1	Jacaranda mimosifolia	8.00	7.91	8.09	8.00
2	Dovyalis abyssinica	2.09	1.65	1.65	1.89
3	Eucalyptus camaldulensis	3.39	2.96	3.39	3.24
4	Azadirachta indica	7.74	8.17	7.74	7.88
5	Cordia Africana	3.83	3.83	4.26	3.97
6	Calistemon citrinus	5.30	5.22	5.3	5.28
7	Justicia schimperiana	2.52	2.09	2.09	2.23
8	Vernonia amygadalina	4.87	4.96	5.04	4.96
9	Gravillea robusta	6.43	5.91	5.99	6.11
10	Spathodeia nilotica	4.26	3.83	4.26	4.11
11	Schinus molle	6.43	6.43	6.87	6.58
12	Acacia melanoxylon	5.13	4.7	4.7	4.84
13	Olea Africana	3.83	4.26	4.17	4.09
14	Eucalyptus globules	5.13	5.13	5.56	5.28
15	Acacia abyssinica	9.48	9.48	9.04	9.33
16	Juniperus procera	13.39	12.96	12.96	13.10
17	Phoenex reclinata	2.96	2.96	3.39	3.10
18	Cupressus macrocarpa	3.39	4.26	3.39	3.65
19	Croton macrstachs	4.26	3.83	3.74	3.94
20	Euclea shimperi	8.17	8.61	8.61	8.46
21	Psidum gusigava	9.91	9.48	9.48	9.63

Table II shows the average ascorbic acid content of selected plant species and results have shown that there was a significant variation in ascorbic acid content among different plant species. The ascorbic acid content ranges from a minimum of 1.89 mg/gm to a maximum of 13.10 mg/gm. Highest ascorbic acid content was found in Juniperus procera (13.10 mg/gm) and least ascorbic acid content was associated with Dovyalis abyssinica (1.89 mg/gm). Appreciable amounts of ascorbic acid content was found in Psidum

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gusigava, Acacia abyssinica and Euclea shimperi as indicated by their values of 9.63, 9.33 and 8.46 mg/gm respectively. Moderate ascorbic acid content was found in Azadirachta indica (7.88 mg/gm), Schinus molle (6.58 mg/gm) and Gravillea robusta (6.11 mg/gm) species. Low ascorbic acid levels were found the in the leaves of Justicia schimperiana and Phoenex reclinata at the tune of 2.23 and 3.10 mg/gm respectively. This is in excellent agreement with the studies conducted by Deepalakshmi et al, 2013[11] who reported that plant species with high amount of ascorbic acid are considered to be tolerant to intermediate tolerant to air pollutants. The ascorbic acid content in Azadirachta indica (7.88 mg/gm) obtained in the present study is in good agreement with the values obtained in another study conducted by Mohammed et al., (2015) [10] who reported that ascorbic acid content in Azadirachta indica to be as 8.29 mg/gm. Ascorbic acid is an antioxidant that increases the resistance of plants against air pollutants [11] .This argument was strongly supported by results of the present study as the species designated as “Tolerant” and “Intermediate tolerant” registered high amount of ascorbic acid content when compared to sensitive plants.

TABLE III: Table showing average relative water content (RWC) of plant species

S.NO.	SCIENTIFIC NAME	Average Fresh weight(g)	Average Turgid weight(g)	Average Dry weight(g)	AVERAGE RWC (%)
1	Jacaranda mimosifolia	5.00	5.43	1.37	89.40
2	Dovyalis abyssinica	5.00	5.45	1.06	89.75
3	Eucalyptus camaldulensis	5.00	5.78	1.66	81.07
4	Azadirachta indica	5.00	6.20	1.04	76.74
5	Cordia Africana	5.00	5.90	1.40	80.00
6	Calistemon citrinus	5.00	5.61	1.66	84.56
7	Justicia schimperiana	5.00	5.86	0.72	83.27
8	Vernonia amygadalina	5.00	5.52	0.81	88.96
9	Gravillea robusta	5.00	5.49	1.64	87.27
10	Spathodeia nilotica	5.00	6.10	0.85	79.05
11	Schinus molle	5.00	5.15	1.09	96.31
12	Acacia melanoxylon	5.00	5.56	2.09	83.86
13	Olea Africana	5.00	6.07	2.28	71.77
14	Eucalyptus globules	5.00	6.46	2.34	64.56
15	Acacia abyssinica	5.00	6.59	1.36	69.60
16	Juniperus procera	5.00	6.18	1.83	72.87
17	Phoenex reclinata	5.00	5.57	1.61	85.61
18	Cupressus macrocarpa	5.00	5.12	1.89	96.28
19	Croton macrstachs	5.00	8.33	0.875	55.33
20	Euclea shimperi	5.00	6.67	1.56	67.32
21	Psidum gusigava	5.00	6.12	1.88	73.58

Average relative water content of selected plant species is depicted in table III and highest relative water content was registered with the leaves of Schinus molle (96.31%) and Cupressus macrocarpa (96.28%) followed by Dovyalis abyssinica (89.75%), Jacaranda mimosifolia (89.40%), Vernonia amygadalina (88.96%) and Gravillea robusta (87.27%). Least relative water content was found in the leaves of Croton macrstachs at the tune of 55.33%. Other species have shown moderate relative water content levels as indicated in the above table. When the plants exposed to air pollution, usually their transpiration rates are high. Under these conditions, the relative water content within the plant body helps to maintain its physiological balance. Therefore, the high relative water content in the plants possibly are more tolerant to pollutants [12]. High relative water content found in plants like Schinus molle (96.31%), Cupressus macrocarpa (96.28%), Dovyalis abyssinica(89.75%), Jacaranda mimosifolia (89.40), Vernonia amygadalina (88.96%) and Gravillea robusta (87.27%) in the present study supports above argument. Low relative water content levels observed in the present study in species like Azadirachta indica (76.74%), Spathodeia nilotica (79.05%), Olea Africana (71.77%), Eucalyptus globules (64.56%), Acacia abyssinica (69.60%), Euclea shimperi (67.32%) and Croton macrstachs (55.33%) exhibited either sensitive or intermediate tolerance levels

TABLE IV: Table showing average leaf extract pH of plant species

S.NO.	SCIENTIFIC NAME	Trials			AVERAGE PH
		T1	T2	T3	
1	Jacaranda mimosifolia	7.07	7.12	7.12	7.10
2	Dovyalis abyssinica	5.85	5.85	5.82	5.84
3	Eucalyptus camaldulensis	5.04	4.90	4.87	4.94
4	Azadirachta indica	5.67	5.65	5.66	5.66
5	Cordia Africana	5.82	5.71	5.68	5.74
6	Calistemon citrinus	4.88	4.92	4.90	4.90
7	Justicia schimperiana	4.47	4.43	4.41	4.44
8	Vernonia amygadalina	6.80	6.74	6.72	6.75
9	Gravillea robusta	5.67	5.67	5.63	5.65
10	Spathodeia nilotica	6.36	6.33	6.26	6.32
11	Schinus molle	7.22	7.31	7.32	7.28
12	Acacia melanoxylon	6.09	6.08	6.09	6.09
13	Olea Africana	4.91	5.25	5.22	5.13
14	Eucalyptus globules	4.66	4.62	4.60	4.63
15	Acacia abyssinica	5.94	5.95	5.95	5.95
16	Juniperus procera	5.02	5.01	5.01	5.01
17	Phoenex reclinata	6.03	6.18	6.19	6.13
18	Cupressus macrocarpa	5.69	5.76	5.78	5.74
19	Croton macrstachs	6.42	6.41	6.41	6.41
20	Euclea shimperi	5.35	5.34	5.35	5.35
21	Psidum gusigava	5.72	5.76	5.77	5.75

Average pH in the leaf extract of selected plant species were portrayed in table IV. The results have shown that pH of almost all species were found to be in acidic nature except two species whose pH was found to be in slightly alkaline range of 7.10 (Jacaranda mimosifolia) and 7.28 (Schinus molle). A very high acidic nature found in the leaf extracts of Justicia schimperiana (4.44), Eucalyptus camaldulensis (4.94), Calistemon citrinus (4.90), Eucalyptus globules (4.63) and the pH values of Vernonia amygadalina, Spathodeia nilotica, Acacia melanoxylon, Phoenex reclinata and Croton macrstachs were found to be 6.75, 6.32, 6.09, 6.13 and 6.41 respectively. High pH may increase the efficiency of conversion from hexose sugar to ascorbic acid there by increases tolerance against air pollution while low leaf extract pH showed good correlation with sensitivity to air pollution also reduce photosynthesis process in plants [13]. Above statement was strongly supported in the present study by the fact that the species like Jacaranda mimosifolia and Schinus molle which are designated as "tolerant" registered high leaf pH extract of 7.1 and 7.28 respectively. Whereas the species like Eucalyptus camaldulensis, Cordia Africana, Justicia schimperiana, Eucalyptus globules which are designated as "sensitive" recorded lower leaf pH extract values of 4.94, 5.73, 4.44, 4.63 respectively. The development of detoxification mechanism which is necessary for the tolerance in the plant species can be indicated by its alkalinity [14] and this was in good agreement with the present study where tolerant species like Jacaranda mimosifolia and Schinus molle both exhibited alkaline nature of leaf pH extract.

TABLE V: Table showing average photo synthetic pigment of plant species

S.NO.	SCIENTIFIC NAME	Average Chl_a (mg/gm)	Average Chl_b (mg/gm)	Average Carotenoied (mg/g)	Average Photo synthetic pigment (mg/gm)
1	Jacaranda mimosifolia	16.83	1.48	7.20	25.51
2	Dovyalis abyssinica	31.06	6.29	15.54	52.89
3	Eucalyptus camaldulensis	11.26	1.35	3.87	16.48
4	Azadirachta indica	15.68	0.22	4.54	20.44
5	Cordia Africana	11.62	0.21	3.85	15.68
6	Calistemon citrinus	13.86	0.53	5.26	19.65
7	Justicia schimperiana	19.15	0.45	6.17	25.77
8	Vernonia amygadalina	11.26	1.35	3.87	16.48
9	Gravillea robusta	9.99	0.97	3.41	14.37
10	Spathodeia nilotica	9.19	0.40	3.44	13.03
11	Schinus molle	20.16	4.51	6.93	31.6
12	Acacia melanoxylon	6.38	0.65	3.72	10.75
13	Olea Africana	6.82	0.21	2.70	9.73
14	Eucalyptus globules	6.12	0.23	2.56	8.91
15	Acacia abyssinica	0.64	0.35	4.26	5.25
16	Juniperus procera	6.50	0.30	2.39	9.19
17	Phoenex reclinata	13.60	0.12	5.27	18.99
18	Cupressus macrocarpa	7.13	0.69	2.51	10.33
19	Croton macrstachs	7.23	0.42	3.07	10.72
20	Euclea shimperi	12.09	0.38	4.61	17.08
21	Psidum gusigava	11.38	0.77	4.31	16.46

Results of average photosynthetic pigment content in selected plant species were shown in table V. It was observed that highest photosynthetic pigment content was associated with Dovyalis abyssinica (52.89 mg/gm) followed by Schinus molle (31.6 mg/gm) whereas least pigment content was found in Acacia abyssinica (5.25 mg/gm). Other species like Olea Africana, Eucalyptus globules, Juniperus procera also registered comparatively low chlorophyll content at the tune of 9.73, 8.91 and 9.19 mg/gm respectively. Other species showed moderate pigment content ranging from 10.33 mg/gm (Cupressus macrocarpa) to 25.77 mg/gm in Justicia schimperiana. Joshi and Swami (2007) [15] reported that one of the most common impacts of air pollution is the gradual disappearance of chlorophyll and concomitant leaf chlorosis which may be associated with a consequent decrease in photosynthetic capacity. It also varies with the tolerance as well as sensitivity of the plant species i.e. higher the sensitive nature of the plant species, lower the chlorophyll content. Higher levels of total chlorophyll was observed in the present study in Dovyalis abyssinica (52.89 mg/gm) followed by Schinus molle (31.6 mg/gm) may be due to its tolerance nature against pollution (Jyothi and Jaya, 2010) [18]. Very low levels of chlorophyll content observed in the present study in plant species like Acacia abyssinica (5.25 mg/gm), Olea Africana (9.73 mg/gm), Eucalyptus globules (8.91 mg/gm), Juniperus procera (9.19 mg/gm) can be attributed due to high level of automobile pollution and this is in good agreement with previous studies (SaralaThambavani at al., 2011) [17] who reported that high levels of automobile pollution decreased chlorophyll content in higher plants near roadsides.

TABLE VI: Table showing air pollution tolerance (APTI) of plant species

S.NO.	SCIENTIFIC NAME	RWC (%)	PH	TC (mg/gm)	ASCORBIC ACID (mg/g)	APTI	REMARK
1	Jacaranda mimosifolia	89.40	7.1	25.51	8.00	35.28	Tolerant
2	Dovyalis abyssinica	89.75	5.66	52.89	1.89	20.04	Intermediate
3	Eucalyptus camaldulensis	81.07	4.94	16.48	3.24	15.04	Sensitive
4	Azadirachta indica	76.74	5.84	20.44	7.88	28.38	Intermediate
5	Cordia Africana	80.00	5.73	15.68	3.97	16.49	Sensitive
6	Calistemon citrinus	84.56	4.90	19.65	5.28	21.41	Intermediate
7	Justicia schimperiana	83.27	4.44	25.77	2.23	15.06	Sensitive
8	Vernonia amygadalina	88.96	6.75	16.48	4.96	20.41	Intermediate
9	Gravillea robusta	87.27	5.65	14.37	6.11	20.95	Intermediate
10	Spathodeia nilotica	79.05	6.32	13.03	4.11	15.85	Sensitive
11	Schinus molle	96.31	7.28	31.6	6.58	35.21	Tolerant
12	Acacia melanoxylon	83.86	6.09	10.75	4.84	16.53	Sensitive
13	Olea Africana	71.77	5.12	9.73	4.09	13.25	Sensitive
14	Eucalyptus globules	64.56	4.63	8.91	5.28	13.60	Sensitive
15	Acacia abyssinica	69.60	5.95	5.25	9.33	17.40	Intermediate
16	Juniperus procera	72.87	5.01	9.19	13.10	25.88	Intermediate
17	Phoenex reclinata	85.61	6.13	18.99	3.10	16.34	Sensitive
18	Cupressus macrocarpa	96.28	5.74	10.33	3.65	15.49	Sensitive
19	Croton macrstachs	55.33	6.41	10.72	3.94	12.28	Sensitive
20	Euclea shimperi	67.32	5.34	17.08	8.46	25.69	Intermediate
21	Psidum gusigava	73.58	5.75	16.46	9.63	28.74	Intermediate

Air pollution tolerance index of selected plant species in the study area was presented in Table VI. From the above table it was noted that only two (9.52%) out of total 21 plant species designated as “Tolerant” and 9 species (42.85%) were designated as “Intermediate” and rest of the 10 species (47.61%) were categorized as “Sensitive”. Highest air pollution tolerance index was found with Jacaranda mimosifolia (35.28) followed by Schinus molle (35.21) which were designated as “tolerant” species whereas least air pollution tolerance index was associated with Croton macrstachs (12.28) followed by Olea Africana (13.25) which are designated as “sensitive” species. Species like Dovyalis abyssinica, Azadirachta indica, Calistemon citrinus, Vernonia amygadalina, Gravillea robusta, Acacia abyssinica, Juniperus procera, Euclea shimperi, and Psidum gusigava found to exhibit “intermediate” tolerance levels. Air Pollution Tolerance Index (APTI) of plants plays a major role in determining the resistivity and susceptibility to pollution loads. Air pollution tolerant index is an index denotes capability of a plant to combat against air pollution. Many reports have indicated that the species with low air pollution index values are sensitive to air pollution and species with high air pollution index values are tolerant to air pollution [18]. In the present study, the species like Jacaranda mimosifolia (35.28), Schinus molle (35.21) which showed high air pollution tolerance index designated as “tolerant” while species like Eucalyptus camaldulensis (15.04), Cordia Africana (16.49) , Justicia schimperiana (15.06) , Spathodeia nilotica (15.85), Acacia melanoxylon (16.53) , Olea Africana (13.25) , Eucalyptus globules (13.60), Phoenex reclinata (16.34) , Cupressus macrocarpa (15.49) , Croton macrstachs (12.28) which are designated as “sensitive” showed low air pollution index values compared to tolerant species.

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TABLE VII: Table showing descriptive statistics

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
ASCORBIC ACID (mg/g)	21	1.89	13.10	5.6986	2.81430
TC(mg/gm)	21	5.25	52.89	17.5862	10.32423
RWC(%)	21	55.33	96.31	79.8648	10.52020
PH	21	4.44	7.28	5.7514	.76525
APTI	21	12.28	35.28	20.4438	6.90838
Valid N (listwise)	21				

Results of descriptive statistical analysis was presented in table VII. The maximum APTI was found to be 35.28 and minimum APTI was 12.28 with a mean of 20.44. Maximum content of ascorbic was found to be as 13.10 mg/gm with a minimum value of 1.89 mg/gm. The mean value of ascorbic acid was recorded as 5.6 mg/gm. Maximum and minimum total chlorophyll content were found to be as 5.25 and 52.89 mg/gm respectively with a mean value of 17.58. Maximum relative water content was found to be at the tune of 96.31 and minimum was found to be as 55.33% with a mean value of 79.86%. Maximum and minimum values of pH were found to be 7.28 and 4.44 respectively with a mean value of 5.7.

TABLE VIII: Table showing results correlation matrix

Correlations

		APTI	RWC	PH	TC	AA
APTI	Pearson Correlation	1	.316	.459*	.373	.620**
	Sig. (2-tailed)		.162	.036	.096	.003
	N	21	21	21	21	21
RWC	Pearson Correlation	.316	1	.329	.496*	-.279
	Sig. (2-tailed)	.162		.145	.022	.221
	N	21	21	21	21	21
PH	Pearson Correlation	.459*	.329	1	.169	.079
	Sig. (2-tailed)	.036	.145		.465	.733
	N	21	21	21	21	21
TC	Pearson Correlation	.373	.496*	.169	1	-.312
	Sig. (2-tailed)	.096	.022	.465		.168
	N	21	21	21	21	21
AA	Pearson Correlation	.620**	-.279	.079	-.312	1
	Sig. (2-tailed)	.003	.221	.733	.168	
	N	21	21	21	21	21

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table VIII represents analysis of correlation matrix of selected biochemical parameters. Results have indicated that there exists a definite correlation among various biochemical parameters and APTI. A significant correlation was identified between APTI and pH as well as APTI and ascorbic acid content. A strong relation was observed between APTI and ascorbic acid content as evident from the significant value of 0.003 at 0.01 level. Correlation between APTI and pH was found to be significant (0.036) at 0.05 level. Among various biochemical parameters, correlation between relative water content and total chlorophyll was found to be significant (0.022) at 0.05 level. The correlation between relative water content and ascorbic acid content was found to be negative (-0.279). The correlation between total chlorophyll content and ascorbic acid content was found to negative (-0.312). Ascorbic acid was found to be negatively correlated with both relative water content (-0.279) and total chlorophyll content (-0.312). A positive but insignificant correlation was observed between pH and other biochemical parameters like ascorbic acid, total chlorophyll content, and relative water content.

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IV. RESULTS OF REGRESSION PLOT ANALYSIS

Regression plot analysis was carried out between APTI and other biochemical parameters to know how APTI was influenced by a change in biochemical parameters and results were represented in below graphs and tables.

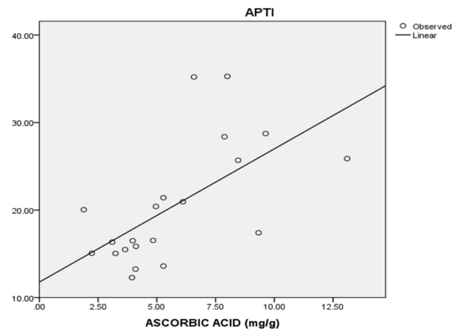

Fig I: Regression plot showing relation between APTI and ascorbic acid

Model Summary and Parameter Estimates
Dependent Variable: APTI

Equation	Model Summary					Parameter Estimates	
	R Square	F	df1	df2	Sig.	Constant	b1
Linear	.385	11.880	1	19	.003	11.767	1.523

The independent variable is ASCORBIC ACID (mg/g).
Table Ia: Table showing parameter estimates of Fig I

Fig I shows Regression plot between APTI and ascorbic acid content. From the graph, it was observed that a strong positive relation exists between these two parameters. From the table 1a, the R-square value was found to 0.3813 with F and significance values of 11.880 and 0.003 respectively.

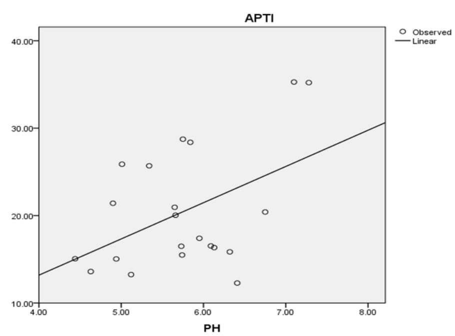

Fig II: Regression plot showing relation between APTI and PH

Model Summary and Parameter Estimates
Dependent Variable: APTI

Equation	Model Summary					Parameter Estimates	
	R Square	F	df1	df2	Sig.	Constant	b1
Linear	.211	5.074	1	19	.036	-3.393	4.145

The independent variable is PH.
Table IIa: Table showing parameter estimates of Fig II

Fig II represents analysis of Regression plot between APTI and pH. From the graph, it was evident that a positive relation exists between these two parameters. From the table IIa, the R-square value was found to 0.211 with F and significance values of 5.074 and 0.036 respectively.

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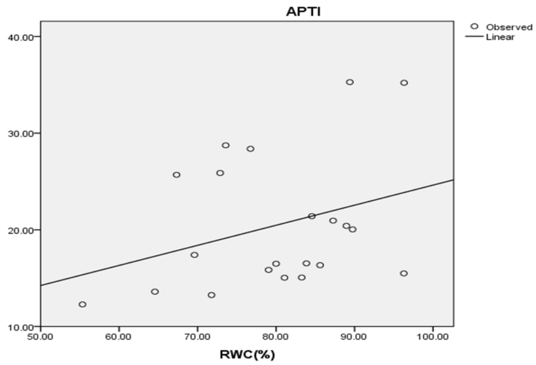

Fig III: Regression plot showing relation between APTI and Relative water content (RWC)

Model Summary and Parameter Estimates
Dependent Variable: APTI

Equation	Model Summary					Parameter Estimates	
	R Square	F	df1	df2	Sig.	Constant	b1
Linear	.100	2.113	1	19	.162	3.852	.208

The independent variable is RWC(%).
Table IIIa: Table showing parameter estimates of Fig III

Fig III depicts results of Regression plot between APTI and relative water content (RWC). From the graph, it was clear that even though a positive relation exists between these two parameters, the relation was found to be insignificant. From the table IIIa, the R-square value was found to 0.100 with F and significance values of 2.113 and 0.162 respectively.

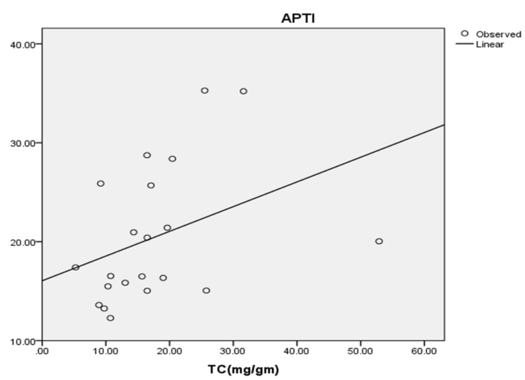

Fig IV: Regression plot showing relation between APTI and Total chlorophyll (TC)

Model Summary and Parameter Estimates
Dependent Variable: APTI

Equation	Model Summary					Parameter Estimates	
	R Square	F	df1	df2	Sig.	Constant	b1
Linear	.139	3.076	1	19	.096	16.051	.250

The independent variable is TC(mg/gm).
Table IVa: Table showing parameter estimates of Fig IV

Results of the regression plot analysis between APTI and total chlorophyll content was shown in Fig IV and it was found that there exists a positive relation between these two parameters. From the table IVa, the R-square value was found to 0.139 with F and significance values of 3.076 and 0.096 respectively. From the R-square value, it can be concluded that the relation between these two parameters was insignificant.

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V. CONCLUSIONS

The results of this study suggest that plants have the potential to serve as excellent quantitative and qualitative indices of pollution since biomonitoring of plant is an important tool to evaluate the impacts of air pollution on plants. APTI is the inherent quality of plants to counter air pollution stress, which is presently a primary concern, particularly in industrial areas. Therefore, the APTI needs to be monitored and checked in predominant species that are present in polluted and non-polluted areas. These tolerant plants can be used for afforestration in urban area and nearby traffic intersections to mitigate air pollution including traffic pollution.

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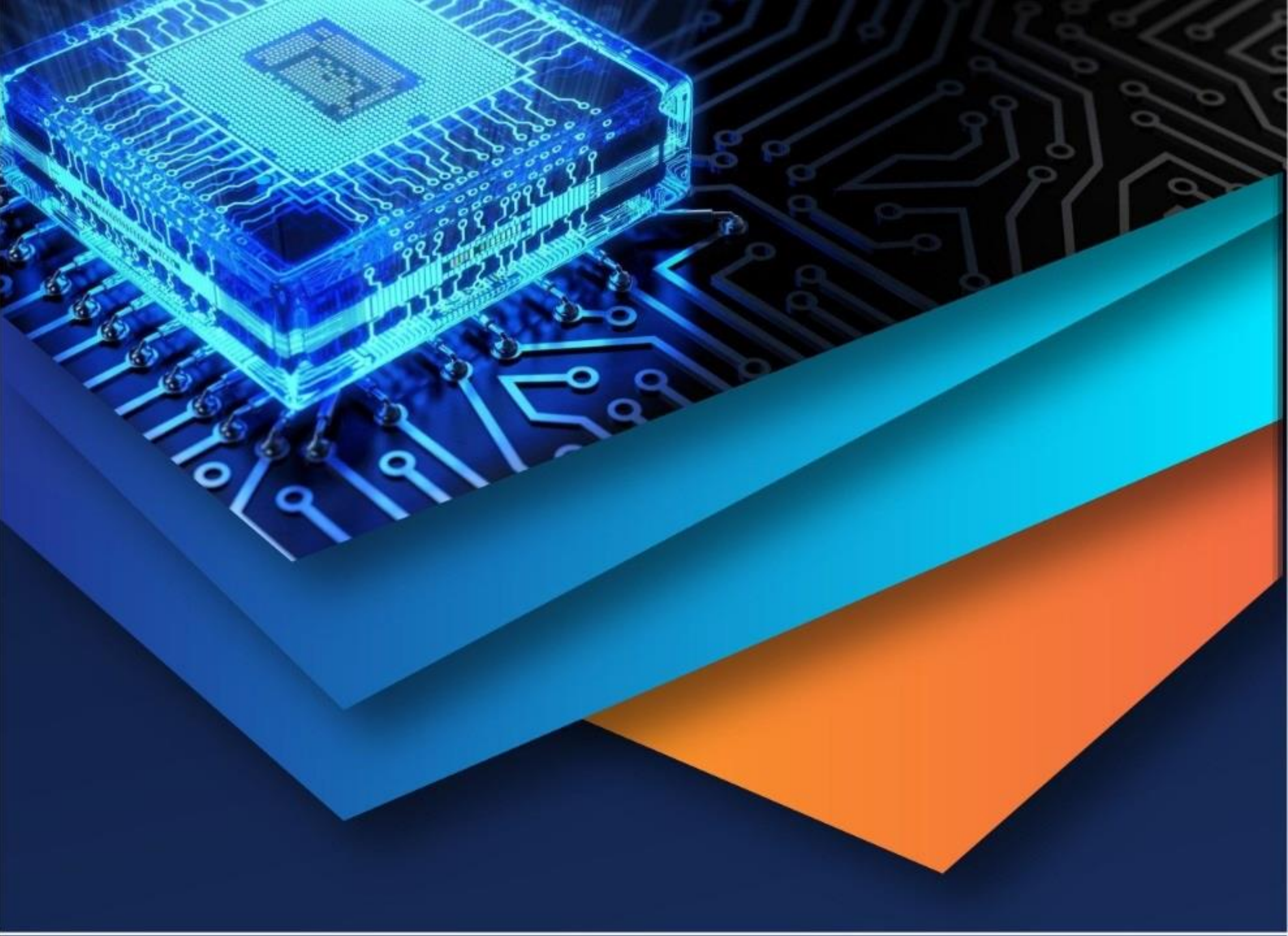

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