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AIR POLLUTION TOLERANCE INDEX OF SELECTED PLANTS IN MACHILIPATNAM, A.P., INDIA

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ABSTRACT

Air pollutants affect the morphological, physiological, and biochemical conditions of plants, with their effects differing significantly across various species. In this study, 25 varied plant species were collected from various activity zones, including heavy traffic areas, industrial sites, commercial districts, residential neighborhoods, and a control zone. The air pollution tolerance indices (APTI) of twenty-five plant species were assessed by analyzing various biochemical parameters of the leaves, including ascorbic acid, chlorophyll, relative water content, and pH of leaf extract. The findings indicate that every examined plant species fall under sensitive category ranging from 14.20 (*Ficus religiosa)* to 8.24 (*Solenostemon scutellarioides).* The results indicate that, all the biochemical parameters show the deterioration with the increase of intensity of pollution.

KEY WORDS: Air Pollution, Air Pollution Tolerance Index (APTI), Plants and Machilipatnam

GRAPHICAL ABSTRACT

Highlights

- Vegetation in the modern world is under pressure from the rise in population and pollution.
- Biochemical markers such as general content of chlorophyll, pH of sheet leaves, relative water content, and ascorbic acid content in vegetation can be contamination indicators.
- Plant species that are resistant to air pollution can soften the same things that lead to environmental stability.
- Stable plant species integration in urban

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landscaping initiatives to effectively improve air quality and combat pollution.

INTRODUCTION

Plants with excellent physiological responses to air pollution are plants with high levels of resistance to contaminated environments. Plants that are resistant to contaminated conditions can be used as targets for air quality improvements to reoptimize healthy air for their needs. Tree selection involves observing the plant's physiology and biochemistry as it develops in polluted air conditions. Tree planting efforts are a solution to overcome the problem of air pollution (Azzahro *et al.,* 2020; Nugrahani, 2023).

The plant takes in air pollutants, possessing the capability to sequester carbon and decrease particulate matter, thereby enhancing overall environmental health. The complex designs of leaves, featuring tiny hairs and small pores, assist in trapping and holding particles, thereby decreasing air pollution levels (Zhao *et al.,* 2017). However, the degree of tolerating a particular level of air pollution varies considerably with the type of species and their adaptability. The indices that assess the tolerance of tree species to air pollution depend on various physiological and biochemical parameters, for example, leaf chlorophyll content, leaf relative water content, leaf extract pH, and ascorbic acid content and thereby aid in the selection of tree species for urban landscaping is Air Pollution Tolerance Index (APTI).

Air pollution causes morphological damage and physiological stress in plants, leading to the disruption of various biochemical elements within them. Tolerant plants can sustain chlorophyll levels when subjected to air pollution conditions (Karmakar and Padhy, 2019). Plants that withstand air pollution will enhance ascorbic acid, which serves as a potent reductant, electron donor, neutralizes free oxygen radicals, and diminishes the toxicity of pollutants. Moreover, elevated leaf pH in a species signifies resilience to air pollution (Bharti *et al.,* 2018). Elevated water levels in plants experiencing stress typically suggest that these plants can withstand air pollution (Banerjee *et al.,* 2021).

MATERIALS AND METHODS

Study Area

Machilipatnam city was chosen as a study area which is situated in Krishna district, Andhra Pradesh, India. It is located at 16.17°N 81.13°E on the southeast coast of India and in the east coast of Andhra Pradesh. According to 2011 census report, it had a population of 1,70,008 which had been increasing further. Due to developmental activities, urbanization, enhancing automobile use and transportation and other activities dust pollution is sharply increasing. Hence, we selected road side plants for studying the impact of dust pollution.

To study the impact of air pollution on road-side plants, leaf samples were collected from four different sites i.e., Control site (S1), Residential site(S2), Heavy traffic site (S3), Commercial site (S4), industrial site along the way from Krishna University to pedana road in Machilipatnam city from 15 plant species.

Description of plants

These collected matured leaf samples were used for the determination of Air Pollution Tolerance Index (APTI) by the formula given by Singh and Rao (1983).

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

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

- Estimation of Biochemical Parameters
  - Estimation of Ascorbic Acid

Ascorbic acid content was measured using spectrophotometric method (Bajaj and Kaur, 1981; Begum and Harikrishna, 2010; Sabri *et al.,* 2015a, 2015b). One gram of the fresh leaf sample was put into a test tube. Oxalic acid – EDTA extracting solution (4 ml) was added followed by orthophosphoric acid (1 ml) and 5% (*v*/v) sulfuric (VI) acid (1 ml). Thereafter, 5% (m/v) Ammonium molybdate (2 ml) and water (3 ml) were added. The solution was allowed to stand for 15 min. The absorbance at 760 nm was measured with a spectrophotometer. Ascorbic acid concentration of the sample was then extrapolated from a standard ascorbic curve.

- **Estimation of Relative Water Content of leaf samples (R)**

Relative Water Content of fresh leaf samples was determined by using the formula (Singh, 1997; Liu and Ding, 2008):

S.No	Name of Plant Species	Family	Common Name
1	*Acacia nilotica*	Fabaceae	Indian gum Arabic
2	*Azadirachta indica*	Meliaceae	Neem Tree
3	*Bauhinia purpurea*	Fabaceae	Orchid Tree
4	*Dalbergia sissoo*	*Fabaceae*	Indian rosewood
5	*Pongamia pinnata*	*Fabaceae*	Indian beech
6	*Prosopis juliflora*	*Fabaceae*	Mesquite
7	*Tectona grandis*	Lamiaceae	Teak
8	*Terminalia catappa*	Combretaceae	Indian Almond
9	*Delonix regia*	*Fabaceae*	Flame-of-the-forest
10	*Syzigium cuminii*	Myrtaceae	Java Plum
11	*Phyllanthus emblica*	Euphorbiaceae	Indian gooseberry
12	*Mangifera indica*	Anacardiaceae	Mango
13	*Cocos nucifera*	Arecaceae	Coconut
14	*Ficus benghalensis*	Moraceae	Banyan
15	*Ficus religiosa*	Moraceae	Bodhi Tree
16	*Moringa oleifera*	Moringaceae	Drumstick Tree
17	*Bougainvillea spectabilis*	Nyctaginaceae	Paper Flower
18	*Hibiscus rosa-sinensis*	Malvaceae	Hibiscus
19	*Ixora coccinea*	Rubiaceae	Flame of the woods
20	*Nerium oleander*	Apocynaceae	Rose Bay
21	*Calotropis procera*	Apocynaceae	Indian milkweed
22	*Tabernaemontana divaricata*	Apocynaceae	Crepe Jasmine
23	*Tabernaemontana*	Apocynaceae	Pin Wheel
24	*Solenostemon scutellarioides*	Lamiaceae	Painted Nettle
25	*Tecoma stans*	Bignoniaceae	Golden Bells

$$\text{RelativeWaterContent}\ (\%) = \frac{Fresh\ Weight - Dry\ Weight}{Turgid\ Weight - Dry\ Weight}\ x\ 100$$

- **Estimation of total Chlorophyll content by acetone method (T)**

Total chlorophyll content was determined by using Arnon (1949) method as follows

Chlorophyll a (mg/l): 12.7(A663)-2.69(A645)
Chlorophyll b (mg/l):22.9(A645) -4.68(A663)
Total Chlorophyll (mg/l):20.2(A645) +8.02(A663)

- **Estimation of pH of Leaf Extract (pH)**

Fresh leaf sample of 0.5g was crushed and homogenized in 50 ml of deionized water, the mixture was centrifuged. Then the supernatant was collected for the detection of pH using pH meter (Rai and Panda, 2014; Tsega and Prasad, 2014).

RESULTS

Classification of plants based on APTI values (Lohe *et al.*, 2015).

Range of APTI	Tolerance Level
30 – 100	Tolerant
17 – 29	Intermediate tolerance
1 – 16	Sensitive
<1	Very Sensitive

Table 1. Ascorbic Acid Content (mg/g)

S.No	Name of plant species	S1	S2	S3	S4
1	*Acacia nilotica*	3.2	2.9	2.5	2.2
2	*Azadirachta indica*	3.8	3.5	3.1	2.7
3	*Bauhinia purpurea*	2.7	2.4	2	1.7
4	*Dalbergia sissoo*	4	3.7	3.3	3
5	*Pongamia pinnata*	3.5	3.2	2.8	2.5
6	*Prosopis juliflora*	2.9	2.7	2.3	2
7	*Tectona grandis*	3.6	3.3	2.9	2.5
8	*Terminalia catappa*	2.8	2.5	2.2	1.9
9	*Delonix regia*	3.3	3	2.7	2.3
10	*Syzigium cuminii*	3.7	3.4	3	2.6
11	*Phyllanthus emblica*	4.2	3.9	3.5	3.1
12	*Mangifera indica*	3.9	3.6	3.2	2.8
13	*Cocos nucifera*	3	2.8	2.5	2.1
14	*Ficus benghalensis*	3.8	3.5	3.1	2.7
15	*Ficus religiosa*	4.3	4	3.8	3.1
16	*Moringa oleifera*	3.7	3.4	3	2.8
17	*Bougainvillea spectabilis*	2.5	2.2	1.9	1.6
18	*Hibiscus rosa-sinensis*	2.9	2.6	2.3	2
19	*Ixora coccinea*	2.5	2.3	2.1	1.9
20	*Nerium oleander*	3.1	2.8	2.4	2.1
21	*Calotropis procera*	2.7	2.5	2.1	1.8
22	*Tabernae montana divaricata*	3.9	3.7	3.5	3.2
23	*Tabernae montana*	3.5	3.3	2.9	2.5
24	*Solenostemon scutellarioides*	2.4	2.1	1.8	1.5
25	*Tecoma stans*	3.3	2.9	2.3	1.9

Table 1 presents the ascorbic acid content of the selected plant species. The highest was recorded by *Ficus religiosa* with 4.3 mg/g and least was reported by *Solenostemon scutellarioides* with 2.4mg/g in S1. While S2 had maximum ascorbic acid content of 3.9mg/g recorded by *Phyllanthus emblica* and least of 2.1 by *Solenostemon scutellarioides*. Highest in S3 was recorded by *Ficus religiosa* (3.8) and least by *Solenostemon scutellarioides* (1.8). *Tabernae montana divaricata* recorded highest ascorbic acid content in S4 with least being 1.5 by *Solenostemon scutellarioides*. A noteworthy observation is that *Solenostemon scutellarioides* has reported least ascorbic acid in all the sites (Figure 1).

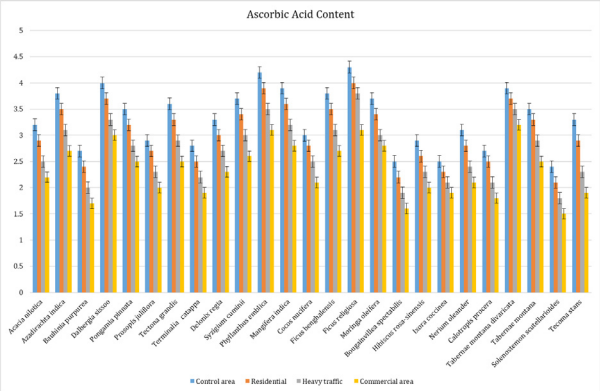

Fig. 1. Average Ascorbic Acid Contentof the selected plant species

Table 2 presents the total chlorophyll content of the selected plant species. The highest was recorded by *Phyllanthus emblica* with 3.9 mg/g and least was reported by *Solenostemon scutellarioides* and *Bauhinia purpurea* with 2.2 mg/g in S1. While S2 had maximum total chlorophyll content of 3.6mg/g recorded by *Phyllanthus emblica* and least of 2.0 by *Solenostemon scutellarioides* and *Bauhinia purpurea*.

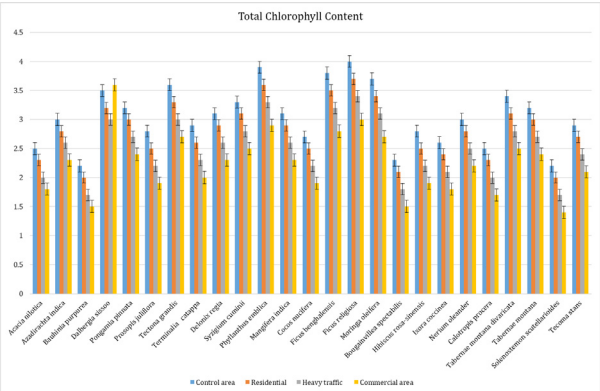

Fig. 2. Average total chlorophyll content of the selected plant species

Table 2. Total Chlorophyll Content(mg/g)

S.No	Name of plant species	S1	S2	S3	S4
1	*Acacia nilotica*	2.5	2.3	2	1.8
2	*Azadirachta indica*	3	2.8	2.6	2.3
3	*Bauhinia purpurea*	2.2	2	1.7	1.5
4	*Dalbergia sissoo*	3.5	3.2	3	3.6
5	*Pongamia pinnata*	3.2	3	2.7	2.4
6	*Prosopis juliflora*	2.8	2.5	2.2	1.9
7	*Tectona grandis*	3.6	3.3	3	2.7
8	*Terminalia catappa*	2.9	2.6	2.3	2
9	*Delonix regia*	3.1	2.9	2.6	2.3
10	*Syzigium cuminii*	3.3	3.1	2.8	2.5
11	*Phyllanthus emblica*	3.9	3.6	3.3	2.9
12	*Mangifera indica*	3.1	2.9	2.6	2.3
13	*Cocos nucifera*	2.7	2.5	2.2	1.9
14	*Ficus benghalensis*	3.8	3.5	3.2	2.8
15	*Ficus religiosa*	4	3.7	3.4	3
16	*Moringa oleifera*	3.7	3.4	3.1	2.7
17	*Bougainvillea spectabilis*	2.3	2.1	1.8	1.5
18	*Hibiscus rosa-sinensis*	2.8	2.5	2.2	1.9
19	*Ixora coccinea*	2.6	2.4	2.1	1.8
20	*Nerium oleander*	3	2.8	2.5	2.2
21	*Calotropis procera*	2.5	2.3	2	1.7
22	*Tabernae montana divaricata*	3.4	3.1	2.8	2.5
23	*Tabernae montana*	3.2	3	2.7	2.4
24	*Solenostemon scutellarioides*	2.2	2	1.7	1.4
25	*Tecoma stans*	2.9	2.7	2.4	2.1

Highest in S3 was recorded by *Ficus benghalensis* (3.4) and least by *Solenostemon scutellarioides* and *Bauhinia purpurea* (1.7). *Phyllanthus emblica* (2.9) recorded highest total chlorophyll content in S4 with least being 1.4 by *Solenostemon scutellarioides*. A noteworthy observation is that *Solenostemon scutellarioides* has reported least ascorbic acid in all the sites (Figure 2).

Table 3 presents the relative water content of the selected plant species. The highest 93% was recorded by *Prosopis juliflora* and least was reported by *Bougainvillea spectabilis* with 84% in S1. While S2 had maximum relative water content of 91% recorded by *Ficus religiosa* and least of 80% by *Bougainvillea spectabilis*. Highest in S3 was recorded by *Ficus religiosa* (88%) and least by *Bougainvillea spectabilis* (75%). *Ficus religiosa* recorded highest relative water content (84%) in S4 with least being 71% by *Bougainvillea spectabilis*. A noteworthy observation is that *Bougainvillea spectabilis* has reported least relative water content at all the sites, while *Ficus religiosa*reported the highest in sites S2, S3 and S4 (Figure 3).

Table 4 presents the pH of leaf extract of the selected plant species. The highest was recorded by

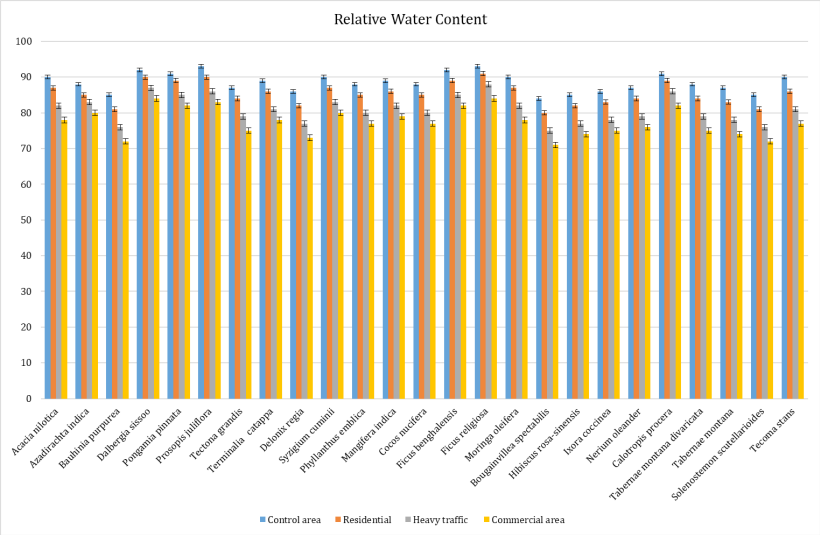

Fig. 3. Average relative water content of the selected plant species

Ficus religiosa with 7.4 and least was reported by *Bauhinia purpurea* and *Solenostemon scutellarioides* with 6.2 in S1. While S2 had maximum pH of leaf extract recorded by *Ficus religiosa* (7.1) and least of 2.1 by *Bauhinia purpurea, Tabernae montana* and *Solenostemon scutellarioides*. Highest in S3 was recorded by *Ficus benghalensis* (6.9) and least by *Bauhinia purpurea* and *Solenostemon scutellarioides* (5.7). *Ficus benghalensis* recorded highest pH of leaf extract (6.6) in S4 with least being 5.3 by *Calotropis procera*. A noteworthy observation is that *Bauhinia*

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Table 3. Relative Water Content(%)

S. No.	Name of plant species	S1	S2	S3	S4
1	*Acacia nilotica*	90	87	82	78
2	*Azadirachta indica*	88	85	83	80
3	*Bauhinia purpurea*	85	81	76	72
4	*Dalbergia sissoo*	92	90	87	84
5	*Pongamia pinnata*	91	89	85	82
6	*Prosopis juliflora*	93	90	86	83
7	*Tectona grandis*	87	84	79	75
8	*Terminalia catappa*	89	86	81	78
9	*Delonix regia*	86	82	77	73
10	*Syzigium cuminii*	90	87	83	80
11	*Phyllanthus emblica*	88	85	80	77
12	*Mangifera indica*	89	86	82	79
13	*Cocos nucifera*	88	85	80	77
14	*Ficus benghalensis*	92	89	85	82
15	*Ficus religiosa*	93	91	88	84
16	*Moringa oleifera*	90	87	82	78
17	*Bougainvillea spectabilis*	84	80	75	71
18	*Hibiscus rosa-sinensis*	85	82	77	74
19	*Ixora coccinea*	86	83	78	75
20	*Nerium oleander*	87	84	79	76
21	*Calotropis procera*	91	89	86	82
22	*Tabernae montana divaricata*	88	84	79	75
23	*Tabernae montana*	87	83	78	74
24	*Solenostemon scutellarioides*	85	81	76	72
25	*Tecoma stans*	90	86	81	77

Table 4. pH of Leaf Extract

S.No	Name of plant species	S1	S2	S3	S4
1	*Acacia nilotica*	6.5	6.3	6	5.8
2	*Azadirachta indica*	7	6.8	6.5	6.2
3	*Bauhinia purpurea*	6.2	6	5.7	5.5
4	*Dalbergia sissoo*	6.8	6.6	6.3	6
5	*Pongamia pinnata*	6.7	6.5	6.2	6
6	*Prosopis juliflora*	6.4	6.2	6	5.7
7	*Tectona grandis*	6.9	6.7	6.4	6.1
8	*Terminalia catappa*	6.6	6.4	6.1	5.9
9	*Delonix regia*	7.1	6.9	6.6	6.3
10	*Syzigium cuminii*	7.1	6.9	6.6	6.3
11	*Phyllanthus emblica*	7.2	7	6.7	6.4
12	*Mangifera indica*	6.5	6.4	6.3	6
13	*Cocos nucifera*	6.5	6.3	6	5.8
14	*Ficus benghalensis*	7.3	7	6.9	6.6
15	*Ficus religiosa*	7.4	7.1	6.7	6.5
16	*Moringa oleifera*	7.1	6.8	6.6	6.3
17	*Bougainvillea spectabilis*	6.6	6.3	6.1	5.9
18	*Hibiscus rosa-sinensis*	6.4	6.1	5.9	5.7
19	*Ixora coccinea*	6.7	6.3	6	5.8
20	*Nerium oleander*	6.8	6.4	6.1	5.9
21	*Calotropis procera*	6.5	6.2	5.8	5.3
22	*Tabernae montana divaricata*	6.9	6.7	6.4	6
23	*Tabernae montana*	6.3	6	5.8	5.4
24	*Solenostemon scutellarioides*	6.2	6	5.7	5.5
25	*Tecoma stans*	6.6	6.3	5.9	5.7

purpurea and *Solenostemon scutellarioides* has reported least pH of leaf extract in three sites, i.e S2, S3 and S4 (Figure 4).

Table 5 presents the APTI values of the selected plant species. The highest was recorded by *Ficus religiosa* with 4.3mg/g and least was reported by *Solenostemon scutellarioides* with 2.4 mg/g in S1. While S2 had maximum ascorbic acid content of 3.9 mg/g recorded by *Phyllanthus emblica* and least of 2.1 by *Solenostemon scutellarioides*. Highest in S3 was recorded by *Ficus religiosa* (3.8) and least by *Solenostemon scutellarioides* (1.8). *Tabernae montana divaricata* recorded highest ascorbic acid content in S4 with least being 1.5 by *Solenostemon scutellarioides*. A noteworthy observation is that *Solenostemon scutellarioides* has reported least ascorbic acid in all the sites (Figure 5).

Table 5 presents the APTI values of the selected plant species. The highest was recorded by *Ficus benghalensis*in all sites (S1-14.20; S2-13.42; S3-12.64; S4-11.35) and least was reported by *Solenostemon*

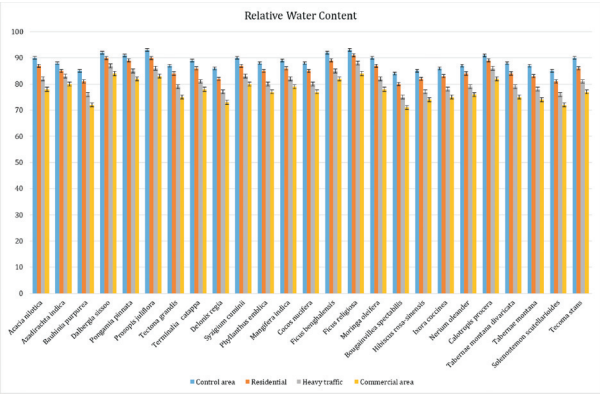

Fig. 4. Average leaf extract pH of the selected plant species

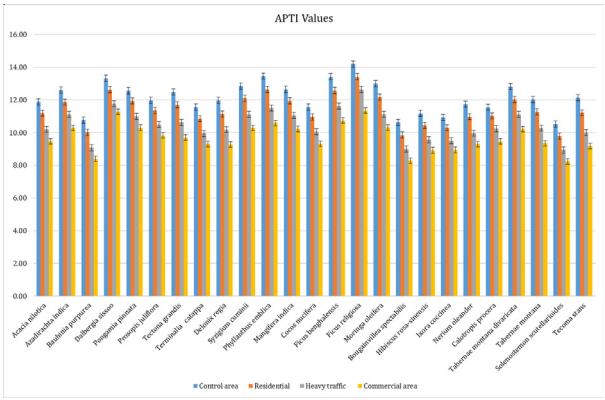

Fig. 5. Average APTI values of the selected plant species

Table 5. Air pollution tolerance index (APTI) of plants studied at Machilipatnam

S.No	Name of plant species	S1	S2	S3	S4
1	*Acacia nilotica*	11.88	11.19	10.20	9.47
2	*Azadirachta indica*	12.60	11.86	11.12	10.30
3	*Bauhinia purpurea*	10.77	10.02	9.08	8.39
4	*Dalbergia sissoo*	13.32	12.63	11.77	11.28
5	*Pongamia pinnata*	12.57	11.94	10.99	10.30
6	*Prosopis juliflora*	11.97	11.35	10.49	9.82
7	*Tectona grandis*	12.48	11.70	10.63	9.70
8	*Terminalia catappa*	11.56	10.85	9.95	9.30
9	*Delonix regia*	11.97	11.14	10.18	9.28
10	*Syzigium cuminii*	12.85	12.10	11.12	10.29
11	*Phyllanthus emblica*	13.46	12.63	11.50	10.58
12	*Mangifera indica*	12.64	11.95	11.05	10.22
13	*Cocos nucifera*	11.56	10.96	10.05	9.32
14	*Ficus benghalensis*	13.42	12.58	11.63	10.74
15	*Ficus religiosa*	14.20	13.42	12.64	11.35
16	*Moringa oleifera*	13.00	12.17	11.11	10.32
17	*Bougainvillea spectabilis*	10.63	9.85	9.00	8.28
18	*Hibiscus rosa-sinensis*	11.17	10.44	9.56	8.92
19	*Ixora coccinea*	10.93	10.30	9.50	8.94
20	*Nerium oleander*	11.74	10.98	9.96	9.30
21	*Calotropis procera*	11.53	11.03	10.24	9.46
22	*Tabernae montana divaricata*	12.82	12.03	11.12	10.22
23	*Tabernae montana*	12.03	11.27	10.27	9.35
24	*Solenostemon scutellarioides*	10.52	9.78	8.93	8.24
25	*Tecoma stans*	12.14	11.21	10.01	9.18

scutellarioides in all sites (S1-10.52; S2-9.78; S3-8.93; S4-8.24) (Figure 5).

DISCUSSION

Total Chlorophyll

Chlorophyll is crucial in the photosynthetic system, capturing sunlight, facilitating electron transfer during photosynthetic growth, and participating in the biological processes of plants (Hu *et al*., 2021). Qadir and Siddiqui (2014) noted that plants subjected to air pollution gradually show a reduction in TCh levels and the occurrence of leaf chlorosis, which may be linked to a decline in photosynthetic performance.

Genetic factors are among the reasons for variations in chlorophyll content, which is reflected in the leaves' morphological and anatomical structure. Zakiyah *et al.* (2018) noted that environmental factors, including light intensity, temperature, air humidity, and air pollution, influence chlorophyll levels. As stated by Ergantara and Khikmawati (2020), air pollution can diminish chlorophyll levels in plants since it can harm leaf cuticles, thereby impeding plant respiration and photosynthesis. Tolerant plants can counteract incoming pollutants to prevent damage to chlorophyll.

As stated by Gautam and Shukla (2020), the variation in biochemical component content in plants may vary based on pollution levels and types of plant species. The degree of SO_2 particle contamination affects chlorophyll levels since SO_2 damages chloroplasts. Lee *et al.* (2020) noted that high concentrations of SO_2 can penetrate plant tissues, subsequently harming thylakoid function and interfering with the electron transport chain. SO_2 pollutant particles are acidic, so in high concentrations, they will enter through the stomata and influence the pH of the cell cytoplasm. According to the research conducted by Hamid et al. (2022), when plants are exposed to SO_2, they generate significant amounts of H+. If this H+ reacts with SO_2, it forms H_2SO_4, leading to a reduction in pH. Plants with elevated pH levels in their leaf extracts are those that efficiently absorb pollutants like SO_2 and NO_2.

Leaf Extract pH

The pH of leaves also contributes to enhancing the production of ascorbic acid. As stated by Bui *et al.* (2021), the pH of the plant influences ascorbic acid, with higher pH levels accelerating the transformation of hexose sugar into ascorbic acid, leading to variations in ascorbic acid concentrations in situations of air pollution stress. Ascorbic acid helps to decrease Reactive Oxygen Species (ROS) in plant cells. According to Salsabila *et al.* (2020), plants with a low pH are more susceptible to air pollution. This is due to the fact that in the plant's physiological processes, pH is vital for the functioning of most enzymes in biological functions, including photosynthesis. Enzyme function will be more effective if the pH levels within the cell are not excessively acidic.

Kumar and Nandini (2013) observed that plants exhibiting lower leaf extract pH are more susceptible than those with greater pH, while plants with a leaf extract pH of 7 show resilience to air pollution stresses. The pH of leaf extract is significant in physiological processes. Achakzai *et al.* (2017) found that a majority of the enzymes participating in biological processes needed elevated pH levels to function effectively. Plants with low pH levels are more sensitive to air pollution. Escobedo *et al.* (2008) stated that elevated pH could enhance the transformation of hexoses into vitamin C.

Ascorbic Acid Content

Ascorbic acid present in plant leaves serves various roles including cell division and photosynthesis, carbon fixation, safeguard against reactive oxygen species (Sahu *et al.*, 2020) and additionally assist in the growth of root, shoot, leaf, and fruit of woody plants (Bilska *et al*., 2019). Reactive oxygen species or free radical generation may result from low levels of ascorbic acid in plants when subjected to air pollution (Rai and Panda, 2014). Tripathi and Gautam (2007) noted that the level of AAC rose with air pollution in every plant species, likely because of the heightened generation of reactive oxygen species (ROS) during photo-oxidation.

The level of ascorbic acid will be elevated when the plant is under drought stress, indicating it has reduced relative water content. A substantial quantity of water serves as a physiological defense mechanism in the plant in reaction to pollutants affecting elevated transpiration (Sa'idah *et al*., 2024).

Relative Water Content

The rise in temperature in the dry season and the effects of air pollution affect the water content of

plants. According to a study by Lohe *et al.* (2015) about how seasons impact relative water content, it is found that the relative water content in leaves peaks during the rainy season, decreases in winter, and is at its lowest during summer. The amount of water in plants serves as a measure of their resilience to drought conditions. Plants that demonstrate high relative water content under polluted conditions can be classified as species tolerant to pollutants.

Rai and Panda (2014) stated that a high RWC in a stressed environment suggests that the plant species can withstand that condition. Although the plant species exhibit a low RWC value when cultivated in areas with air pollution, their transpiration rate decreases, impairing their ability to transport water from roots to leaves through transpiration pull. An increased RWC in the contaminated area indicates the physiological equilibrium and adaptive reaction to air pollution (Tsega and Prasad, 2014).

APTI Values

APTI values reflect the classification of plants' tolerance to air pollution, determined by the effects of pollutants on the alterations in biochemical components within plants, particularly in their leaves. According to the tolerance criteria established by Kalyani and Singaracharya (1995) and Lohe *et al*., (2015), APTI values from 1 to 16 indicate sensitive species; hence, all the plant species tested are classified as sensitive based on these criteria. Singh *et al.* (1991) indicated that plants with the highest APTI values exhibited a favourable response to air pollution, whereas those with the lowest APTI values are more vulnerable to air pollution. Fatima *et al.* (2020) evaluated the APTI of plants at the Anwarul campus in Hyderabad. They assessed APTI to establish the sensitivity and resilience of plants employed as bio-indicators in pollution stress conditions. Tak and Kakde (2020) studied the APTI and air pollution tolerance index (API) of plant species cultivated in an industrial area.

Air pollution is one of the biggest problems in the world today. Over the last few decades, the number of people living in cities, the development of industry, and the number of cars has led to a deterioration of the air quality worldwide Biochemical factors and the stomatal function in plants are used to determine plant resistance to air pollution. It is also quite unusual that different plant species display different levels of sensitivity to air pollution stress, but on the basis of the results of this study, all the plant species are classified as sensitive and all the species have different levels of sensitivity to pollution in the different activity zones/sites.

CONCLUSION

Air pollution is a major and critical problem globally. Over the past few decades, the increase in urban dwellers, industrial development, and a rising number of vehicles has resulted in a decline in air quality worldwide. Biochemical factors and stomatal function in plants contribute to assessing plant resistance to air pollution. While it is typical for various plant species to exhibit varying degrees of tolerance to air pollution stress, the findings of this study indicated that all the plant species are categorized as sensitive, yet they have shown differing levels of sensitivity based on the extent of air pollution in different activity zones/sites.

Machilipatnam has got approval for a port and construction of the port is underway. Given that there is a strong probability of increased load on the plants in the near future, and the potential for adverse health effects, it is therefore advisable to carry out further investigation of the seasonal variation of dust pollution, particulate matter and the general air quality. This study presents basic information on the native and indigenous plants of the area with regard to their APTI and offers useful information for the choice of plants for establishment of green belts for dust control and environmental improvement. Future work should also involve the assessment of other biochemical and physiological characteristics of the plants in order to enhance the screening process for plant selection for urban landscaping and pollution control purposes.

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Author Contributions

Y. Avasn Maruthi (YMR) led the investigation and provided mentorship. Dr. V. Saritha was responsible for writing, reviewing, and editing. Dr. Rama Sekhara Reddy and Ms. S. Sudha Rasmi contributed to the preparation of results. Ms. Tharfain Fathema

worked on the practical components.

Declaration of Competing Interest

The authors have no conflicts of interest to disclose.

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