International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 11 Issue 09, September 2022

Air Pollution Tolerance Index (APTI): An Important Determinant for the Development of Green Space in Bengaluru City

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***Abstract*:- Air Pollution Tolerance Index (APTI) is one of the green technology-based tools used for analysing air pollution of a particular area which leads to develop an idea about the air quality. Air pollution tolerance index (APTI) is an intrinsic quality of trees to control pollution problems, which is currently of major concern of urban localities. The trees having higher tolerance index rate are tolerant towards air pollution and can be used as a source to control air pollution, whereas the trees having less tolerance index can be used as an indicator to know the rate of air pollution. The present work is based on the assessment of APTI using physicochemical parameters such as pH of leaf extractives, Relative Water Content (RWC), Total chlorophyll and ascorbic acid content of different plants for mitigating air pollution. The objective of the study is to determine the inherent quality of plants to tolerate air pollution and identify the plant species for the pollution mitigation. In the present study, 10 different plant species were taken from the highly polluted road side area as Experimental site (Polluted area) and the same species present in the residential colony which may be considered as control site (Non polluted area). The results indicate that, all the biochemical parameters show the deterioration with the increase of intensity of pollution. Tolerant plants species serve as suitable sinks to survive the air pollution and the sensitive plant species may be used as a bio-indicator of air quality.**

Keywords: Air pollution tolerance index, Total chlorophyll content, Ascorbic acid, pH, Relative water content, Bengaluru city

INTRODUCTION

As we know air pollution is becoming a serious threat to environment due to increasing urbanization and industrialization (Rajput and Agarwal, 2004). It is one of the major problems in many developing cities around the world which alters metabolism in any organisms. Over the years there has been a continuous growth in human population, road transportation, vehicular traffic and increase in industrialization are the primary cause behind the rise in environmental air pollution in urban areas. Air pollution can be defined as the human introduction into the atmosphere of chemicals, particulate matter or biological materials that cause harm or discomfort to living organisms or damage the environment.

Continuous impact of air pollutants on plant species around us is one of major environmental issue. Plants are playing a major role in improving air quality by exchanging gases as they act as sink for air pollution. Plants are an integral basis for all ecosystems and also most likely to be affected by airborne pollution which are identified as the organisms with most potential to receive impacts from ambient air pollution. Also, the effects are most often apparent on the leaves which are usually the most abundant and most obvious primary receptors of large number of air pollutants. Air pollutants, affects not only theambient air quality of urban, but also public health and associated with respiratory and cardiovascular problem(Harrison et.al, 1997 & Katsouyanni et al., 2001).The World Health Organization (WHO) estimates 1.3 million annual deaths worldwide, with an increased risk of respiratory and cardiovascular diseases (WHO , 2005) .Plants play an important role in purification of atmosphere and considered a natural tool for reducing the air pollution by absorbing toxic substances and capturing particulate matter.

Plants expertise a good array of symptoms once exposed to pollutants throughout chemical process, respiration, catalyst reactions, membrane disruption, stomata behaviour and ultimately death. In plants, air pollution results in yellowing of leaves (chlorosis), browning of leaves (necrosis), reduced chlorophyll pigment, physiological changes, mutations, biochemical alterations, chromosomal damage and palynological abnormalities, such as reduced pollen viability and pollen size. The pollution level and prevailing environmental conditions of any particular area can be better studied by plant species grown at that site as plants are the first recipients of any type of pollution. Plants are reported to be one of the best air pollution monitoring methods used nowadays (Esfahani et al., 2013, Miria and Khan, 2013).

In India, the economic loss of plants as results of pollution isn't documented yet; however there are reports that it will damage the crops (Datta, et al., 2009) The ensuing changes in the thermal properties of surface materials and also the lack of proper evapotranspiration in urban areas result in the urban heat island (UHI) impact (Wong et al., 2010, Sung, 2013). Our primary motive should be to reintroduce greenery all around into urban landscapes by bringing nature into town. Tall buildings and slender roads in urban areas should be covered with a blanket of plants. It hinders spreading of air pollutants in cities (Wong, et al., 2010).

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Climate change impact has conjointly added additional stress. With vast increase in use of private vehicles the roads are covered with bed of cars in peak hours of traffic, this affects the human health as both air and noise pollution. Urban air typically contains high levels of pollutants that square measure harmful to living being (Kanakidou et al., 2011). Urban forests are developed around rivers banks, roads and railways, parks, gardens, playgrounds, cemeteries, roadside, etc. Some plants square measures relatively add tolerant to air pollutants. Mitigation of air pollutants with the high vegetation cover is viable for air pollution. But due to absence of knowledge about tolerance limit of plants we fail to plant acceptable plants in our surroundings. The pollution tolerance index (APTI) is predicated on four major biochemical properties of leaves that are ascorbic acid, relative water content, total chlorophyll and leaf extract hydrogen ion concentration (Singh & Rao, 1983). A plant's tolerance to air pollutants varies with these parameters. The intensity of the pollutant in the atmosphere is directly proportional to the change in the biochemical parameter such as pH, relative water content, ascorbic acid and total chlorophyll (Indira, Shamshad and Paul, 2015) . It is possible to evaluate the overall effect of pollutants as total pollution by measuring changes in the plants (Agbaire , 2009). Studies have shown the impacts of air pollution on ascorbic acid content (Hoque et al., 2007), Chlorophyll content (Flowers et al., 2007)leaf extract pH (Klumpp et al., 2000) and relative water content (Agrawal, 1991,Rao, 1979). The Bengaluru city is experiencing a steady increase in the population and the decline of green areas as a result of urbanization in addition to the increase of various human activities and which led to the deterioration of air quality. Therefore, the present study was conducted to determine the tolerance of some plants to plant around and within the city in order to reduce air pollutants.

1. MATERIALS AND METHODS

2.1 Study Area

Area considered for this research is the Southern Deccan Plateau, in east-Bengaluru, Karnataka, India's. It is the 3rd most populous city and 5th most urban accumulation city. The region is located at the center of the Mysore Plateau with a 900m average elevation. Located on 12.97°N 77.56°E, the area is spread over a 741km^2 coverage area (Figure1).

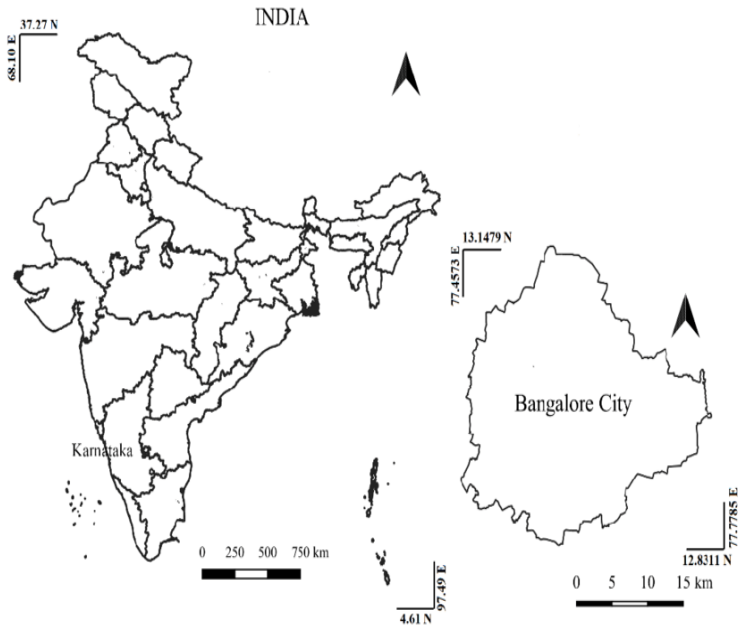

Fig. 1: Study Area- Bangalore city, Karnataka state, India

(Source: Pilinja Subrahmnaya, Prakash and Aithal, Dr Bharath, 2021)

The soil here is generally red loamy to red sandy in nature and is ideal for growing plants. The pH is often in the alkaline range and has low levels of organic matter, which results in low fertility. The weather in the city is pleasant and without extremes. Bengaluru's climate is tropical savanna, with distinct dry and wet seasons. April is the hottest month, and December is the coolest; the vegetation in the area involves a large canopy of trees. The climatic feature of this city is favourable to herbs, trees and shrubs plantation. Mostly ground vegetation is dominant in the monsoon season. The flowering of plants is seen until the end of January. Estimation shows that there are 41.71Lakh vehicles in Bengaluru, out of which two-wheelers count up to 28.81 Lakh, cars- 7.92 Lakh, autos- 1.62 Lakh and other 3.36 Lakh vehicles.

2.2 Experimental sites: Two sites were selected for Urban site and Rural sites from Silicon City, Bengaluru. Polluted area samples were collected from St. John Hospital area (Urban area) on viewing the effect of air pollution due to industrial growth coupled

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ISSN: 2278-0181
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with vehicular emissions. Common trees that grow naturally in this area are Neem, Ashoka, Honge etc. For non-polluted or less polluted area we selected Anekal Taluk (Rural area), less industrial and vehicular pollution.

2.3 Plants selected for the study

The plant species selected for the investigation include-

Table 1: Plants are chosen for this study

The species of plants used for this investigation include:

SL NO	SPECIES	COMMON NAME	FAMILY
1.	*Ficus benghalensis*	Banyan	Moraceae
2.	*Polyalthia longifolia*	Ashoka	Annonaceae
3.	*Psidium guajava*	Guava	Myrtaceae
4.	*Pongamia pinnata*	Honge	Fabaceae
5.	*Mangifera indica*	Mango	Anacardiaceae
6.	*Azadirachta indica*	Neem	Meliaceae
7.	*Spathodea campanulata*	African tulip	Bignoniaceae
8.	*Muntingia calabura*	Jamaika cherry	Muntingiaceae
9.	*Plumeria obtuse*	Plumeria	Apocynaceae
10.	*Artocarpus heterophyllus*	Jack fruit	Moraceae

2.4 Sample collection and preparation of Extracts

Ten plant species were selected in all areas of the study as shown in Table 1 during the summer season (June). The leaves were collected randomly during the early morning and at a height of 1.5 to 2 meters. They were stored in a polythene bag and transferred to the laboratory for biochemical analysis and dust deposited on the leaves.

2.4.1 Measurement of dust deposition on the leaves

The area of individual leaf was calculated by tracing the outline of leaves on graph paper (8,9).The amount of dust deposition of leaf was calculated by the following equation (Prusty et.al, 2005):

W = W2 – W1 / A

Where,

W= Amount of dust (mg/cm2). W2=weight of leaf with dust. W1= weight of leaf without dust. A=Total area of leaf in cm2.

Bio-chemical analyses

2.5 Biochemical Parameters:

2.6 2.5.1 Biochemical Parameters

2.5.1 pH: A total of 100mg of leaves were collected, and in 10ml de-ionized water, these were homogenised, after which, for 3 minutes, these were centrifuged at 2,500rpm. The pH level of filter leaf extract is estimated with a digital pH meter, its glass electrode immersed in leaf filtrate homogenised solution. A pH4 and pH9 buffer solution was used to calibrate the glass electrode [27].

2.5.2 Relative Water Content: Collected fresh leaves were weighed, and their initial weight was noted. Leaf samples were dipped overnight in distilled water, their weight was measured again after thoroughly blotting with a dry sheet. Dry weight was then estimated after incubation at 70°C in hot air oven, and a re-weight of dry weight was done. The below given standard equation was applied for estimating the RWC [25].

$$\boldsymbol{RWC} = [(\boldsymbol{FW} - \boldsymbol{DW})/(\boldsymbol{TW} - \boldsymbol{DW})] \times \mathbf{100}$$

Where,

DW: Dry Weight

FW: Fresh Weight

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
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TW: Turgid Weight

2.5.3 Ascorbic acid content: With the help of 2,6-dichlorophenol indophenol dye, the ascorbic content of sampled were estimated using Titrimetric Technique [23]. Using 4 percent oxalic acid, 500mg of leaf sample was extracted, and resulting extract were then titrated against the dye. The indication was detected with the appearance of pink colour. This value was subtracted with blank.

2.5.4 Carotenoids Content and Total chlorophyll: Arnon's Technique was used to measure the Total carotenoids and chlorophyll content [3]. 100mg of freshly collected leaves were grounded and extracted using 10ml acetone (80%) for 15min and centrifuged for 3min at 2500 rpm. After this supernatant was collected, and absorbance was estimated at 645nm for chlorophyll-A and 663nm for chlorophyll-B; for carotenoids, 480nm and 510nm with a spectrophotometer. The below-given formulae were applied for estimating the Chlorophyll content:

(a) "Total chlorophyll: Chlorophyll A + Chlorophyll B; CTc: 20.2 (D645) + 8.02 (D 663)

(b) Total chlorophyll content: 0.1CT × (Leaf Dry Weight/Leaf Fresh Weight); Carotenoids= 7.6 × 480 OD –1.49 × 510 OD"

2.5.6 APTI Calculation: For selected plants, their APTI was estimated with the equation given below [27].

$$\boldsymbol{APTI = (A\,[T + P] + R)/10}$$

With,

P: Leaf Extract pH,

T: Total Chlorophyll (mg/gm),

A: Ascorbic Acid Content (mg/gm),

R: Percentage of relative water content in a leaf.

As per values of APTI, plants were grouped conveniently into groups formed in a study by Kalyani and Singaracharya, 1995; the responses as per APTI values are:

<1 = Very sensitive

16-1 = Sensitive

29-17 = Intermediate

30-100 = Tolerant

Statistical analysis

Obtained data was presented as mean of three replicates ± standard deviation and Pearson correlation for comparison between sites of each bio-chemical parameter of plant the results were statistically analysed by using a one-way ANOVA by using SPSS software(version 22).

Table 2: Variation of pH (Mean ±S.D) of studied plants sites in Bengaluru city

S. N.	Name of the plant	pH			
		Rural site	Urban site	F value	P value
1.	*Ficus benghalensis*	5.2± 0.20	4.9± 0.62	3.548	0.096[b]
2.	*Polyalthia longifolia*	6.0± 0.15	5.20± 0.06	5.265	0.046[a]
3.	*Psidium guajava*	6.2± 0.23	5.6± 0.12	1.189	0.368[b]
4.	*Pongamia pinnata*	5.1± 0.12	4.32± 0.15	20.489	0.002[b]
5.	*Mangifera indica*	5.8± 0.15	5.4± 0.22	36.057	0.000[a]
6.	*Azadirachta indica*	6.0± 0.06	5.7± 0.20	1.624	0.241[b]
7.	*Spathodea campanulata*	7.2± 0.16	6.6± 0.14	14.5	0.006[a]
8.	*Muntingia calabura*	7.0± 0.21	6.5± 0.21	4.353	0.068[b]
9.	*Plumeria obtuse*	5.8± 0.10	5.1± 0.20	14.516	0.005[a]
10.	*Artocarpus heterophyllus*	6.8± 0.21	6.2± 0.62	4.935	0.054[b]

[a] significant at P < 0.05; [b] non- significant at P < 0.05

Table 3: Variation of Relative Water Content% (Mean ±S.D) of studied plants sites in Bengaluru city

S. N.	Name of the plant	Relative Water Content			
		Rural site	Urban site	F value	P value
1.	*Ficus benghalensis*	24.63± 1.21	20.12± 1.23	7.152	0.026[a]

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2.	*Polyalthia longifolia*	80.89± 2.31	75.67± 1.48	3.405	0.103[b]
3.	*Psidium guajava*	32.52± 1.41	29.72± 1.63	13.828	0.006[a]
4.	*Pongamia pinnata*	96.63± 1.63	90.70± 1.82	26.953	0.001[a]
5.	*Mangifera indica*	33.49± 1.46	29.50± 1.67	12.478	0.007[a]
6.	*Azadirachta indica*	81.2± 1.84	75.3± 2.36	4.353	0.068[b]
7.	*Spathodea campanulata*	50.35± 1.38	44.52± 1.46	14.516	0.005[a]
8.	*Muntingia calabura*	82.90± 1.43	72.92± 1.36	5.041	0.052[b]
9.	*Plumeria obtuse*	92.78± 2.16	86.3± 1.86	22.59	0.002[a]
10.	*Artocarpus heterophyllus*	17.45±2.23	12.3± 1.47	38.034	0.000[a]

[a] significant at P < 0.05; [b] non- significant at P < 0.05

Table 4: Variation of Total Chlorophyll Content (mg/g) (Mean ±S.D) of studied plants sites in Bengaluru city

S. N.	Name of the plant	Total Chlorophyll			
		Rural site	Urban site	F value	P value
1.	*Ficus benghalensis*	4.4±0.03	3.5±0.14	41.179	0.000a
2.	*Polyalthia longifolia*	12.6±0.23	9.06±0.09	15.038	0.005a
3.	*Psidium guajava*	6.4±0.07	4.05±0.21	30.099	0.001a
4.	*Pongamia pinnata*	0.21±0.08	0.15±0.32	173.961	0.000a
5.	*Mangifera indica*	6.03±0.34	5.05±0.34	103.206	0.000a
6.	*Azadirachta indica*	3.29±0.37	1.39±0.36	39.154	0.000a
7.	*Spathodea campanulata*	7.25±0.07	5.12±0.26	61.172	0.000a
8.	*Muntingia calabura*	15.7±0.24	10.8±0.24	12.478	0.007a
9.	*Plumeria obtuse*	13.8±0.31	9.36±31	4.353	0.068b
10.	*Artocarpus heterophyllus*	5.9±0.26	1.05±28	14.516	0.005a

[a] significant at P < 0.05; [b] non- significant at P < 0.05

Table 5: Variation of Total Ascorbic acid Content (mg/g) (Mean ±S.D) of studied plants sites in Bengaluru city

S. N.	Name of the plant	Ascorbic acid			
		Rural site	Urban site	F value	P value
1.	*Ficus benghalensis*	0.62± 0.55	0.34± 0.23	37.199	0.000[a]
2.	*Polyalthia longifolia*	8.99± 0.62	5.34± 0.31	5.041	0.052[b]
3.	*Psidium guajava*	0.82± 0.46	0.54± 0.29	22.59	0.002[a]
4.	*Pongamia pinnata*	47.36± 0.26	39.5± 0.25	59.034	0.000[a]
5.	*Mangifera indica*	0.93± 0.41	0.64± 0.28	14.2	0.005[a]
6.	*Azadirachta indica*	3.08± 0.37	2.5± 0.26	4.935	0.054[b]
7.	*Spathodea campanulata*	0.55± 0.26	0.38± 0.14	14.39	0.005[a]
8.	*Muntingia calabura*	0.68± 0.61	0.56± 0.16	8.246	0.026[a]
9.	*Plumeria obtuse*	14.05± 0.46	10.6± 0.32	4.205	0.103[b]
10.	*Artocarpus heterophyllus*	0.72± 0.43	0.52± 014	11.828	0.006[a]

[a] significant at P < 0.05; [b] non- significant at P < 0.05

Table 6: Variation of Air Pollution Tolerance Index (APTI)(Mean ±S.D) of studied plants sites in Bengaluru city

S. N.	Name of the plant	Ascorbic acid			
		Rural site	Urban site	F value	P value
1.	*Ficus benghalensis*	3.05± 0.08	2.29± 0.18	7.073	0.026[a]
2.	*Polyalthia longifolia*	24.81± 0.04	15.18± 0.37	1.064	0.402[b]
3.	*Psidium guajava*	4.28± 0.41	3.49± 0.41	22.59	0.002[a]
4.	*Pongamia pinnata*	34.84± 0.06	26.72± 26	59.034	0.000[a]
5.	*Mangifera indica*	4.44± 0.14	3.61± 0.18	0.754	0.511[b]
6.	*Azadirachta indica*	10.98± 0.23	9.30± 0.12	4.935	0.054[b]
7.	*Spathodea campanulata*	5.82± 0.31	4.89± 0.08	1.023	0.415[b]
8.	*Muntingia calabura*	9.83± 0.37	8.26± 0.34	23.2	0.005[a]
9.	*Plumeria obtuse*	36.81± 0.31	23.9± 0.49	6.923	0.054[b]
10.	*Artocarpus heterophyllus*	2.60± 0.23	1.71± 0.11	12.32	0.005[a]

[a] significant at P < 0.05; [b] non- significant at P < 0.05

Table 7: Correlation between different biochemical parameters and APTI values

	Total chlorophyll (mg/g)	pH	Relative Water Content (%)	Ascorbic acid(mg/g)	Air pollution tolerance index (APTI)
Total chlorophyll (mg/g)	1	.454**0	.1732	.1530	0.447**0
pH		1	.277*0	.367**0	0.664**0
Relative Water Content (%)			1	-0.589-**	-0.241
Ascorbic acid (mg/g)				1	.883**0
Air pollution tolerance index (APTI)					1

**. Correlation is significant at the 0.01 level .

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
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*. Correlation is significant at the 0.05 level.

RESULT AND DISCUSSION

After performing and analysing all Bio-chemical parameters of samples and resultant APTI, following result has been concluded.

pH:-

The results of the study showed low pH in Urban site compared to the rural site. The pH of the leaf extracts ranged from 4.32 to 5.1 (Table 2). Maximum leaf extract pH wasfound in *Spathodea campanulata* at both the study sites, whereas, minimum was observed in *Pongamia pinnata* at both the sites. Accumulation of dust obstruct the light for photosynthesis and also and also chunk the stomata pores for dissipation of air, thus effects the natural metabolism of plants. Chlorophyll is one of the main components of plants which represent their productivity. Chlorophyll content has been shown to decrease under pollution stress (Bora and Joshi, 2014)

Presence of acidic pollutants such as SOx and NOx in ambient air, cause lowering of leaf extracts pH. Plants were found to be highly vulnerable to these pollutants, and the sensitive ones act as an indicator of gaseous air pollutants (Joshi, Bora & Haridwar, 2011). In present study a positive correlation was found between pH of leaf extract and ascorbic acid and ($r = 0.367$; $p<0.05$) (Table 2) thus high pH at rural site assisted the tolerance capacity of plants towards air pollutants by increasing the rate of conversion of hexose sugar to ascorbic acid whereas, lower pH at urban has caused reduction in photosynthesis rate by disturbing the gaseous exchange through stomata (Escobedo et.al, 2008.)

Relative Leaf Water Content (RWC)

The relative water content of each species is based on the values of fresh weight, turgid weight and dry weight. High water content within a plant body helps maintain its physiological balance under stressful conditions, such as exposure to air pollution (Lakshmi, Sravanti & Srinivas, 2009).Relative water content in the plant is associated with protoplasmic permeability in cells which causes loss of water and dissolved nutrients, resulting in early senescence of leaves(Agrawal S & Tiwari,1997). Therefore, the plants with high relative water content under polluted conditions may be tolerant to pollutants. (Jyothi & Jaya, 2010). The highest and lowest values were obtained from *Pongamia pinnata* and *Artocarpus heterophyllus* respectively (Table 3). Decrease of RWC in urban site may be due to the dust deposited on the leaves which affects the process of transpiration due to the closure of the stomata and the absorption of water from the tissues of the leaf. and the correlation coefficient showed a weak negative correlation ($r = - 0.241$; $p<0.05$) between the RWC and Air pollution Tolerance Index of the plants (Table 7).

Total chlorophyll content

Photosynthetic pigment degradation has been widely considered asan indication of air pollution(Ninave et.al, 2001) so that total chlorophyll is used frequently to evaluate the impact of air pollutants on the rate of photosynthesis in plant leaves((Bharti et al, 2017) the total chlorophyll content in 10 plant species were from 0.21 to 15.7 mg/g. at rural site and 0.15 to 10.8 at urban site (Table 4). Total chlorophyll was found maximum in *Muntingia calabura* whereas the lowest in *Pongamia pinnata*.The results of the present study showed thatthe total chlorophyll content in all plants varies with the state of pollution in the area .The reduction of chlorophyll tends towards the rural and urban sites. The decrease in total chlorophyllcontent may be due to the accumulation of dust on the plant leaf that prevents the gaseous exchange process or the intensity of light that affect photosynthesis and metabolism. Rate of photosynthesis and availability of nutrients are two factors on which chlorophyll content of leaves are dependent. The value of chlorophyll content is high in rainy season followed by summer and least in winter as the accumulation of dust in winter season is high, it obstructs the light for photosynthesis and also chunk the stomata pores for dissipation of air, thus effects the natural metabolism of plants (Keller & Lamprecht, 1995).

Ascorbic acid content

The results showed a significant increase in the content of ascorbic acid in the urban site compared to rural site (Table 5) Ascorbic acid ranges in the selected plant species were from 47.36 to 0.55 in rural site and 10.6 to 0.34 in urban site. The highest and lowest values were obtained from *Pongamia pinnata* and *Ficus benghalensis* respectively. (Chaudhary & Rao,1977), (Varshney & Varshney, 1984) . The higher ascorbic acid content of the plant is a sign of its tolerance against sulphur dioxide pollution. Ascorbic acid plays important role in cell division, defense and cell wall synthesis (Varshney& Varshney, 1984). It is a natural detoxicant, which may prevent the effects of air pollutants in the plant tissues (Conklin,2001). Pollution load dependent increase in ascorbic acid content of all the plant species may be due to the increased rate of production of reactive oxygen species (ROS) during photo- oxidation of SO2 to SO3 where sulfites are generated from SO2 absorbed (Jyothi & Jaya,2010). The results of the study are well matched by previous reports that plants that keep ascorbic acid high under pollutant conditions are tolerant to air pollution (Begum & Harikrishna, 2010)

Air pollution tolerance index (APTI)

The results of Air pollution tolerance index(APTI) calculated for each plant species studied at different sites is mentioned in the above (Table 6). The APTI values exhibited at rural - *Plumeria obtuse* > *Pongamia pinnata* > *Polyalthia longifolia* > *Azadirachta indica*> *Muntingia calabura*> *Mangifera indica*> *Spathodea campanulata*> *Psidium guajava* > *Ficus benghalensis* >*Artocarpus*

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ISSN: 2278-0181
Vol. 11 Issue 09, September 2022

heterophyllus and urban sites - *Pongamia pinnata* > *Plumeria obtuse* > *Polyalthia longifolia* > *Azadirachta indica* > *Muntingia calabura* > *Spathodea campanulata* > *Mangifera indica* > *Psidium guajava* > *Ficus benghalensis* > *Artocarpus heterophyllus* respectively. Determining the tolerant and susceptible species is essential for the reduction of pollution in rural and urban sites (Gholami, Mojiri & Amini, 2016). A high positive correlation was found between APTI and ascorbic acid ($r= 0.883$; $p<0.05$) and moderate positive correlation exists between pH of leaf extract ($r = 0.664$; $p<0.05$) While a weak positive correlation was found between chlorophyll and APTI ($r = 0.447$;$p<0.05$) (Table 7). Some previous studies have also indicated a similar correlation between biochemical parameters and APTI (Madan & Verma, 2015), (Bharti et al, 2017). It indicates that, as the pollution load increases ascorbic acid content in plant leaf also increases to combat the stressed condition. Increased ascorbic acid content maintains cell division and cell membrane stability in plants by scavenging free radicals and reactive oxygen species during photo-oxidation of SO2 to SO3(Palit, et.al, 2013).

CONCLUSION

The APTI determination provides a reliable method for screening large number of plants with respect to their susceptibility to air pollutants. It is an easy and inexpensive way to bio-monitor urban air pollution for adoption under field conditions without the use of expensive tools or devices. From this study we have analysed that the nature of plants varies from place to place. It depends upon many factors like climatic conditions, daily traffic, surrounding areas like residential, industrial and commercial etc. As we can see same species have high relative water content at one site and low relative water content at another site. Very few species possess same value of parameters at both sites. Plants in urban areas are continuously exposed to air pollutants, ensuring accumulation of pollutants and their integration into their system, resulting in changing the nature of leaf and its tolerance and sensitivity. This sensitivity is measured through various biochemical parameters and finally through APTI. Thus, APTI is a very helpful and practical index to analyse the tolerance limit of every plant species. Individually these bio-chemical parameters do not signify anything but collectively it helps in building a greenery environment. The plant that shows higher index value is tolerant to air pollution and can be used as a sink to control pollution. The plants with lower index value seemed to be sensitive and used as bio-indicator to recognize levels of air pollution. thus, trees can utilize as tolerant or sensitive towards air pollution.

Air pollution in the urban region is on the rise and augmented significantly due to increased vehicular pollution, urbanization and fast increase in small scale industries. Existing quantity of air quality improvement due to pollution removal from urban trees is although in significant, it can improve by improving urban tree. Like we do service to balance our basic need of life simultaneously we all should plant at least one tree to balance our oxygen need then it would contribute to a balance environment too.

ACKNOWLEDGEMENTS

The author is grateful to Karnataka Science and Technology Academy (KSTA) for funding the projetct and Dr. Sr. Lalitha Thomas, Prinicpal, Jyoti Nivas Colilege Autonomous , Bengaluru for providing facilities and support.

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International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 11 Issue 09, September 2022

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