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Air Pollution Tolerance Index: A Comparative Study

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Abstract—*Vehicular emissions, rapid industrialization, fuel combustion and some other sources lead to the formation of unhealthy atmospheric conditions. As plants are immobile they are prime suspect to air pollution. The main aim of this study is to see the impact of air pollution on plant species exposed to road sides of town and also to find the sensitivity of plant species. In the present study 5 different plant species i.e. Ficus Religiosa, Delonix regia, Polyalthia Longifolia, Plumeria Sp. And Azadirachta indica were considered from traffic road side of Noida and Greater Noida. For evaluation of its tolerant limit four physiological and bio-chemical parameters namely relative water content, leaf extract pH, ascorbic acid, chlorophyll content and carotenoid were analyzed. And on these parameters APTI i.e. air pollution tolerance index has been framed. The result signifies that all the above species comes under sensitive zone at both sites.*

1. INTRODUCTION

As we know air pollution is becoming a serious threat to environment due to increasing urbanization and industrialization [1]. Continuous impact of air pollutants on plant species around us is one of major environmental issue.

Plants expertise a good array of symptoms once exposed to pollutants throughout chemical process, respiration, catalyst reactions, membrane disruption, stomata behavior and ultimately death. 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 [2].

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 [3-4].

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 [5]. 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 [6].Urban forests is 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 [7] .A plant's tolerance to air pollutants varies with these parameters.

2. MATERIAL AND METHOD

2.1 Study region

The present study was performed in the city of Noida (Gold mine of Uttar Pradesh) and Greater Noida. Noida (P1) and Greater Noida (P2) both are located in Gautam Buddh Nagar district of Uttar Pradesh state. Noida is about 20 kilometers northwest of Greater Noida. Common trees that grow naturally in Noida are Neem, peepal, banyan, sheesham and teek. Greater Noida is one the most planned city in India. My area of study is mainly on viewing the effect of air pollution due to industrial growth coupled with vehicular emissions. Noida sector 78 is a recently developed area for habitation. Many townships have been constructed and projects are still on. And Greater Noida is a famous for its well planned and organized colonies, roads, bus stand and commercial complexes.

2.2 Sample collection

Fresh leaves were collected during November 2016 from road side of Noida, sector 78 (residential area) and greater Noida (bus stand near LG chowk) in early morning. The sample was kept in air tight polythene bag to avoid deterioration of leaves and brought to laboratory for experimental work. The chlorophyll test for all 10 samples was done on same day. And rest test were performed on consecutive days.

2.3 Biochemical Measurements

Ascorbic acid contents in (mg/g of fresh weight), total chlorophyll (mg/g fresh weight), pH of leaf extract and relative water content are the parameters that are essential for determination of APTI, an associated index to evaluate the impedance and susceptibleness of plant species to pollution.

Chlorophyll content decreases owing to production of Reactive oxygen Species (ROS) within the plastid beneath water stress [9]. Presence of upper ascorbic acid content in leaves may well be a technique to shield thylakoid membranes from aerophilic injury beneath such water stress conditions[10], as ascorbic acid is concerned within the defenses against ROS created by the photosynthetic equipment [11-12]. Ascorbic acid also helps in cell growth. Whereas pH helps in balancing the nutrient demand of plant. Relative water content signifies the moisture holding capacity of plants when exposed to different climatic condition.

2.3.1. Relative water content

Fresh weight (FW) was received by means of weighing the fresh leaves. The samples have been then hydrated to full turgidity underneath normal room temperature overnight. After hydration the samples had been taken out of water and were properly dried fast and lightly with tissue paper and straight away weighed to achieve absolutely turgid weight (TW). Samples had been then oven dried at 80 ^{0}C for 24h and weighed (after being cooled down in a desiccator) to decide dry weight (DW) [14].

$$Relative\ water\ content\ (RWC) = [(FW - DW)/(TW - DW)] \times 100$$

Where:

FW = fresh weight,

DW= dry weight, and

TW= turgid weight.

2.3.2 Leaf Extract pH

1 gram of washed leaves was homogenized in10 ml de-ionized water and centrifuged at 2,500 rpm for 3 mins. The pH of filtered leaf extract was measured with the help of digital pH-meter with a glass electrode dip in homogenized solution of leaf filtrate. The glass electrode was calibrated using the buffer solutions of pH4 and pH 9 [7].

2.3.3. Total Chlorophyll Content (Photosynthetic Pigment)

According to Arnon (1949) [15] chlorophyll concentration was calculated.1 gram of fresh leaves were taken and cut into small pieces (about 1 mm wide) with scissors, leaves were grinded in 20 ml of 80 % acetone. After grinding the sample was transferred to another test tube and centrifuged at 2,500 rpm for 3 minutes.

Measure the optical density (absorbance) of the extract with the help of spectrophotometer. Measure optical density at 480 nm, 510 nm, 645 nm and 663 nm. These are positions in the spectrum where maximum absorption by chlorophyll *a* and *b* occur. The concentration of chlorophyll *a* and *b*, in mg/g of tissue, and carotenoids in mg/g is calculated by the following formula as given by Mac Kinney (1941) :

$$Chlorophyll\ a(\frac{mg}{g}) = \frac{12.7 \times O.D645 - 2.69 \times O.D663}{1000 \times W} \times V$$

$$Chlorophyll\ b(\frac{mg}{g}) = \frac{22.9 \times O.D645 - 4.68 \times O.D663}{1000 \times W} \times V$$

$$Carotenoids\ (\frac{mg}{g}) = \frac{7.6 \times O.D480 - 1.49 \times O.D510}{1000 \times W} \times V$$

Total chlorophyll content (Tch) = Chlorophyll a + Chlorophyll b (mg/g)

V = Total volume of the chlorophyll solution (ml)

W = Weight of the tissue extracted (g)

O.D=Optical density

2.3.4. Ascorbic Acid

Take 5 ml of working standard in 100 ml of conical flask and add 10 ml of 4% oxalic acid. Titrate against the dye and note the point in appearance of pink color, which persists for a few minutes (V_1 ml). Extract 1 gm. of sample in 10 ml of 40% oxalic acid and filter, collect the filtrate and make the volume up to 100 ml by adding 4% oxalic acid. Pipette out 5 ml of the extract, add 10 ml of 4% oxalic acid and titrate against dye, by (Sadasivam and Manikam, 1991).[16]

$$Ascorbic\ acid\ mg/100\ gm\ sample = (0.5mg \times V1ml) \times (V2ml/5ml) \times (100ml/wt.of\ sample) \times 100$$

Where:

V_1= Reading with standard

V_2= Reading with extract

3. AIR POLLUTION TOLERANCE INDEX

APTI of tree species has been calculated by the following formula proposed by Singh and Rao (1983) [7-17].

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

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 (%)

Based on the APTI values the plants were conveniently grouped into categories as mentioned in the following (Kalyani and Singaracharya, 1995) [18]:

APTI values Response are -

30 to100= Tolerant

29 to17= Intermediate

16 to 1 =Sensitive

<1 =Very sensitive

4. RESULT ANALYSIS

After performing and analyzing all bio-chemical parameters of samples (plants leaves) and resultant APTI, following result has been concluded.

4.1 Relative water content

The relative water content of each species is based on the values of fresh weight, turgid weight and dry weight. As per the result Polyalthia longifolia has lowest relative water content at both points, but still there is last difference between the values of both sites. And Delonix regia has highest relative water content at both sites, and there is very slight difference between values of both sites **(refer Table 1 and graph 1**).

GRAPH 1: RELATIVE WATER CONTENT OF BOTH SITE

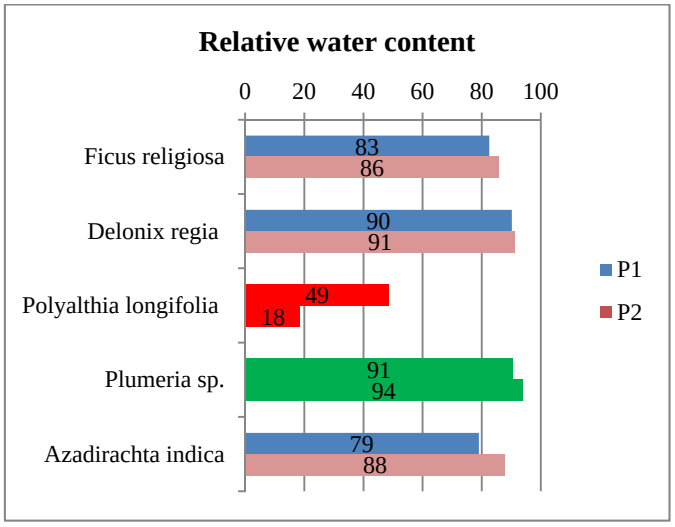


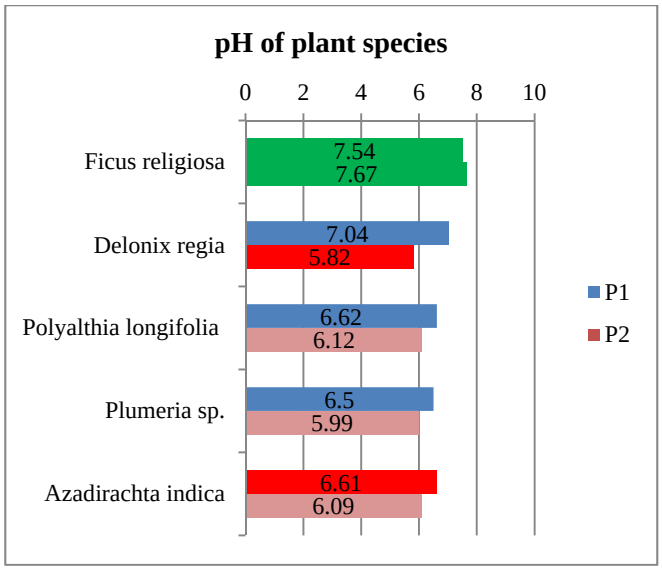
Table 1: Relative water content of both site

S No.	Name of species	NOIDA SECTOR 78 (P1)			
		FW	TW	DW	RWC
1	Ficus Religiosa	3.83	4.34	1.42	83
2	Delonix regia	0.56	0.61	0.1	90
3	Polyalthia longifolia	0.86	1.25	0.49	49
4	Plumeria sp.	6.15	6.64	1.44	91
5	Azadirachta indica	1.41	1.67	0.43	79
		GREATER NOIDA (P2)			
1	Ficus Religiosa	2.47	2.78	0.6	86
2	Delonix regia	1.2	1.3	0.16	91
3	Polyalthia longifolia	1.42	2.88	1.09	18
4	Plumeria sp.	7.7	8.14	1.18	94
5	Azadirachta indica	0.69	0.76	0.18	88

4.2 pH:- Nutrient deficient plants are result of and imbalanced soil pH. Change in the colour of plant leaves is observed which may be due to many reasons like lack of water, imbalanced pH of soil etc. As pH scale is logarithmic, thus even slight change in pH greatly affect the plants. As per the result pH content of Ficus Religiosa is highest at both sites and Azadirachta indica ha lowest at P1 and Delonix regia at P2 (**refer Table 2 and graph 2**).

Table 2 : pH of both site

S No.	Name of species	NOIDA SECTOR 78 (P1)		GREATER NOIDA (P2)	
		pH	Temp	pH	Temp
1	Ficus Religiosa	7.54	23.2	7.67	20.9
2	Delonix regia	7.04	23.1	5.82	18
3	Polyalthia longifolia	6.62	23	6.12	20.3
4	Plumeria sp.	6.5	24.4	5.99	19.2
5	Azadirachta indica	6.61	22.5	6.09	19



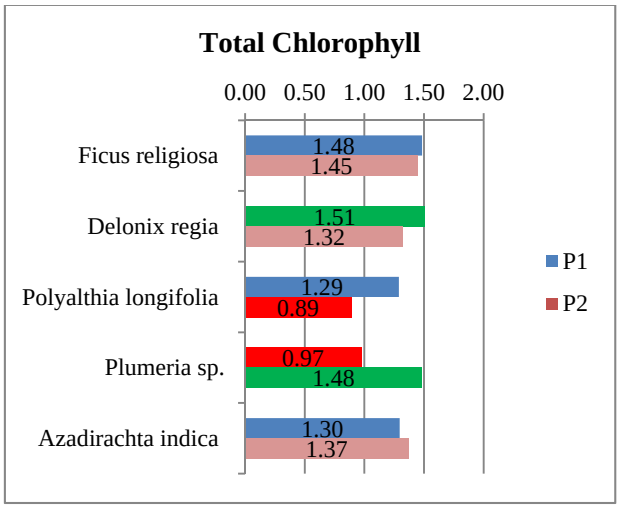
GRAPH 2: PH OF PLANT SPECIES AT BOTH SITES

4.3 Total chlorophyll content and carotenoid:- Rate of photosynthesis and availability of nutrients are two factors on which chlorophyll content of leaves are dependent.

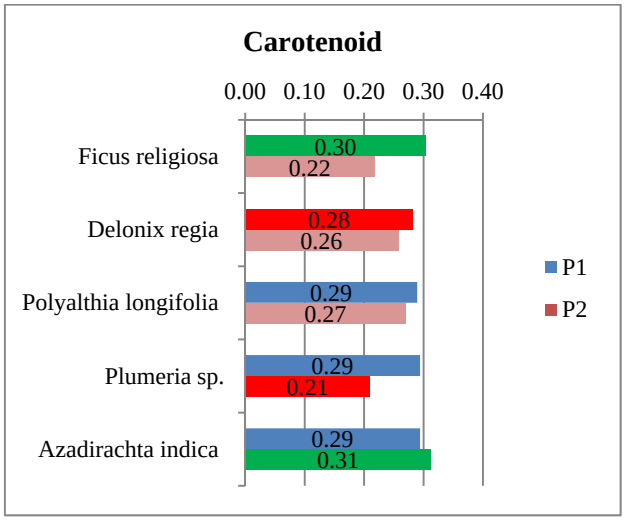
The value of chlorophyll content is high in rainy season followed by summer and least in winter.AS the accumulation of dust in winter season is high, it obstruct the light for photosynthesis and also chunk the stomata pores for dissipation of air, thus effects the natural metabolism of plants[19-21].

As per the result the chlorophyll content of Plumeria sp. Is lowest and P1 and Polyalthia longifolia at P2.and the highest of Delonix regia at P1 and Plumeria sp. At P2.

And the carotenoid content is highest of Ficus Religiosa is at P1 and Azadirachta indica at P2, and lowest of Polyalthia longifolia at P1 and Plumeria sp. At P2 (**refer Table 3 and Graph 3 & 4**).



GRAPH 3: TOTAL CHLOROPHYLL CONTENT AT BOTH SITES



GRAPH 4: CAROTENOID CONTENT OF BOTH SITES

Table 3: Total chlorophyll and carotenoid content of both sites

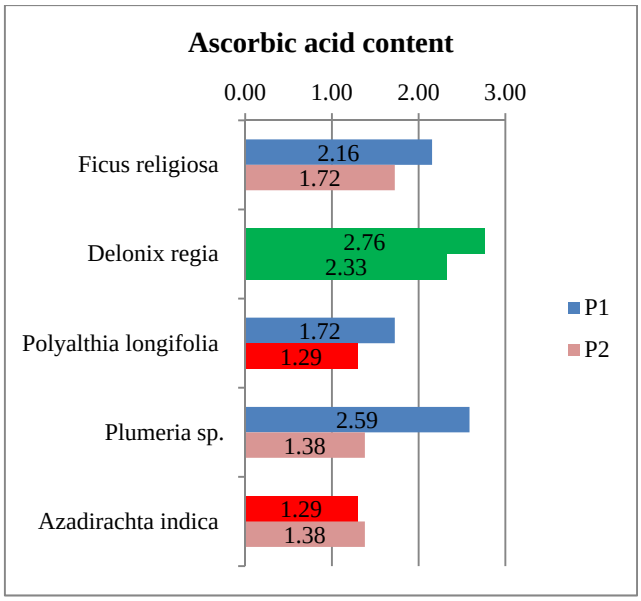
S No.	Name of species	NOIDA SECTOR 78 (P1)			
		Chlorophyll a	Chlorophyll b	T. Chlorophyll	Carotenoid
1	Ficus Religiosa	0.49	1.00	1.48	0.30
2	Delonix regia	0.52	0.98	1.51	0.28
3	Polyalthia longifolia	0.48	0.81	1.29	0.29
4	Plumeria sp.	0.48	0.49	0.97	0.29
5	Azadirachta indica	0.43	0.86	1.30	0.29
		GREATER NOIDA (P2)			
1	Ficus Religiosa	0.48	0.97	1.45	0.22
2	Delonix regia	0.49	0.83	1.32	0.26
3	Polyalthia longifolia	0.21	0.68	0.89	0.27
4	Plumeria sp.	0.47	1.02	1.48	0.21
5	Azadirachta indica	0.47	0.90	1.37	0.31

4.4 Ascorbic acid content: - Ascorbic acid plays important role in cell wall synthesis, and cell division and act as a shield to air pollutants [22-23].

As per the result Delonix regia has highest ascorbic acid content at both sites but Azadirachta indica has low ascorbic acid content at P1 and Polyalthia longifolia (**refer table 4 and graph 5**).

Table 4: Ascorbic acid content of plant species at both sites

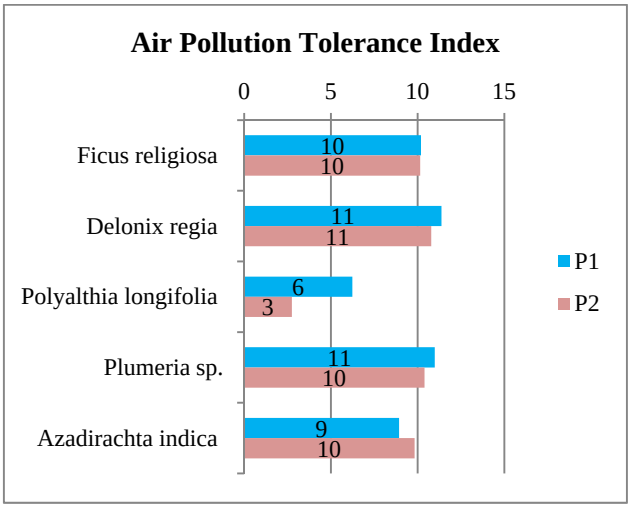
S No.	Name of species	NOIDA SECTOR 78 (P1)		GREATER NOIDA (P2)	
		volume of extract(V2)	Ascorbic acid	volume of extract(V2)	Ascorbic acid
1	Ficus Religiosa	2.5	2.16	2	1.72
2	Delonix regia	3.2	2.76	2.7	2.33
3	Polyalthia longifolia	2	1.72	1.5	1.29
4	Plumeria sp.	3	2.59	1.6	1.38
5	Azadirachta indica	1.5	1.29	1.6	1.38



GRAPH 5: ASCORBIC ACID CONTENT OF BOTH SITES

5. APTI

The air pollution tolerance index of 5 species of both sites has been analyzed below.The result shows that all the species at both sites falls under sensitive zone,some being more sensitive and some less sensitive to air pollutants **(refer Table 5 and Graph 6 below).**



GRAPH 6: AIR POLLUTION TOLERANCE INDEX OF BOTH SITES

Table 5: APTI response of plant species of both sites

NOIDA SECTOR 78 (P1)							
S No.	**Name of species**	**RWC**	**pH**	**Ascorbic acid**	**Total Chlorophyll**	**APTI**	**response**
1	Ficus Religiosa (PIPAL)		7.54	2.16	1.48	10	S
2	Delonix regia (GULMOHAR)	90	7.04	2.76	1.51	11	S
3	Polyalthia longifolia (ASHOKA)	49	6.62	1.72	1.29	6	S
4	Plumeria sp. (CHAMPA)	91	6.5	2.59	0.97	11	S
5	Azadirachta indica (NEEM)	79	6.61	1.29	1.30	9	S
GREATER NOIDA (P2)							
1	Ficus Religiosa (PIPAL)	86	7.67	1.72	1.45	10	S
2	Delonix regia (GULMOHAR)	91	5.82	2.33	1.32	11	S
3	Polyalthia longifolia (ASHOKA)	18	6.12	1.29	0.89	3	S
4	Plumeria sp. (CHAMPA)	94	5.99	1.38	1.48	10	S
5	Azadirachta indica (NEEM)	88	6.09	1.38	1.37	10	S

6. CONCLUSIONS

From this study I have analysed that the nature of plants vary 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 other site. Very few species possess same value of parameters at both sites. 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. In future I would like to study on same and more species at more sites of National capital region and some more factors affecting the tolerance limit of plant. 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.

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REFERENCES

[1] Rajput, M. And M. Agarwal. 2004. Physiological and yield responses of pea plants to ambient air pollution. Indian J. Plant Physiology.9 (1): 9-14

[2] Datta JK, Banerjee A, Dirghangi A, Mondal NK, Gupta S. Studies on the evaluation of air pollution tolerance index (APTI) of some crop plants in old alluvial and lateritic zone of Burdwan

District, West Bengal, India. Asian J Microbial Biotechnology Environ Sci 2009;11(2):423-6.

[3] Sung, C. Y. (2013). Mitigating surface urban heat island by a tree protection policy: A case study of The Woodland, Texas, USA. Urban Forestry & Urban Greening,12(4), 474–480. *Http://dx.doi.org/10.1016/j.ufug.2013.05.009*

[4] Wong, N. H., Kwang Tan, A. Y., Chen, Y., Sekar, K., Tan, P. Y., Chan, D., et al. (2010).Thermal evaluation of vertical greenery systems for building walls. Building and Environment, 45(3), 663–672. Http://dx.doi.org/10.1016/j.buildenv.2009.08.005

[5] Wong, N.H., et al., 2010. Thermal evaluation of vertical greenery systems for building walls. Build. Environ. 45, 663–672, http://dx.doi.org/10.1016/j.buildenv.2009.08.005.

[6] Kanakidou, M., et al., 2011. Megacities as hot spots of air pollution in the East Mediterranean. Atmos. Environ. 45, 1223–1235, http://dx.doi.org/10.1016/j.atmosenv.2010.11.048.

[7] Singh, S. K., & Rao, D. N. (1983). Evaluation of plants for their tolerance to air pollution. In Paper presented at the Proceedings Symposium on Air Pollution Control. New Delhi, India.

[8] Prajapati, S., Tripathi, B. D., & Pathak, V. (2009). Distribution of vehicular pollutants in street canyons of Varanasi, India: A different case. Environmental Monitoring and Assessment, 148(1–4), 167–172. Http://dx.doi.org/10.1007/s10661-007-0148-7

[9] Prajapati, S. K., & Tripathi, B. D. (2008). Anticipated Performance Index of some tree species considered for green belt development in and around an urban area: A case study of Varanasi city, India. Journal of Environmental Management, 88(4), 1343–1349. Http://dx.doi.org/10.1016/j.jenvman.2007.07.002

[10] Tambussi, E. A., Bartoli, C. G., Beltrano, J., Guiamet, J. J., & Araus, J. L. (2000).Oxidative damage to thylakoid proteins in water-stressed leaves of wheat (Triticum aestivum). Physiologial Plantarum, 108(4), 398–404. Http://dx.doi.org/10.1034/j.1399-3054.2000.t01-1-100409.

[11] Mittler, R. (2002). Oxidative stress, antioxidants and stress tolerance. Trends in Plant Science, 7(9), 405–410.

[12] Sharma, P., Jha, A. B., Dubey, R. S., & Pessarakli, M. (2012). Reactive oxygen species, oxidative damage, and anti-oxidative defense mechanism in plants under stressful conditions. Journal of Botany, 2012.

[13]Smirnoff, N. (1996). Botanical briefing: The function and metabolism of ascorbic acid in plants. Annals of Botany, 78(6), 661–669.

[14]H. D. Barrs, and P. E. Weatherley, A re-examination of the relative turgidity technique for estimating water deficits in leaves, Aust.(J. Biol. Sci,. 15, 1962, 413-428).

[15]]Arnon DI.(1949) Copper enzymes in isolated chloroplasts polyphenol oxidase in Beta Vulgaris. Plant Physiol; 24:1-15.

[16]Sadasivam S, Theymdli Balasubraminan. In: Practical Manual in Biochemistry Tamil Nadu Agricultural University, 1987; 14: Coimbatore.

[17]S. K. Singh, and D. N. Rao, Evaluation of plants for their tolerance to air pollution. In Proc. Symp. On Air pollution control, IIT, Delhi, 1983, 218-224

[18]Y. Kalyani, and M. A. Singaracharya, Bio monitoring of air pollution in Warangal city, Andhra Pradesh, Acta Botanica indica, 23(1), 1995, 21-24.

[19]Keller, Th. And H. Schwager. 1977. Air pollution and ascorbic. European J. For-estpathology.7: 338-350.

[20]Hope, A.S., et al. 1991.Tussock tundra albedos on the north slope of Alaska: Effects of illumination, vegetation composition and dust depositin.J.Appl. Meteorol 30: 1200-1206.

[21]Keller, J. And R. Lamprecht.1995.Road dust as an indicator for air pollution transport and deposition: An application of SPOT imagery .Remote Sens. Env., 54: 1-12.

[22]Anthony, P.2001. Dust from walking tracks: Impacts on rainforest leaves and epiphylls. Cooperative Research Centre for tropical Rainforest Ecology and Management, Australia.

[23]Conklin, PL.2001. Recent advances in the role and biosynthesis of ascorbic acid in plants. Plant cell Env, 24:383-394.