ASIAN JOURNAL
ISSN: 0976-3376

Available Online at http://www.journalajst.com

ASIAN JOURNAL OF SCIENCE AND TECHNOLOGY

Asian Journal of Science and Technology
Vol. 4, Issue, 12, pp. 011-016, December, 2012

RESEARCH ARTICLE

PHYTOMONITORING OF ATMOSPHERIC POLLUTION IN A DRY TROPICAL ENVIRONMENT USING PERENNIAL TREES

[1]Sarala Thambavani, D. and *[2]Maheswari, J.

[1]Department of chemistry, Sri Meenakshi Govt College for Women, Madurai-625002
[2]Department of Chemistry, V. H. N. S. N. College, Virudhunagar-626001

Received 06th September, 2012; Received in Revised from; 29th October, 2012; Accepted 11th November, 2012; Published online 17th December, 2012

ABSTRACT

Air quality is a major environmental problem in many developed and developing countries. Atmospheric pollution is mainly caused by high concentration of particulate matter (PM_{10}, $PM_{2.5}$), Oxides of Sulphur (SO_x) and Oxides of Nitrogen (NO_x) .If their concentration is more than tolerance limit of plants, they adversely affect plants. Variation of plants biochemical parameters like Relative water content (RWC), pH, Ascorbic acid and Total chlorophyll (TCh) content were found to be dependant on air quality. Air Pollution Tolerance Index of fifteen common tree species of Virudhunagar has been evaluated by analyzing these biochemical parameters. And percentage variation of these biochemical parameters with the control (Site 1) and polluted sites were established. *Delonix regia* and *Moringa olifera* showed higher percentage variation of ascorbic acid content variation (>100%) at heavy traffic area(Site 2) and species like *Eugenia jambolana, Ficus religiosa, Ficus benghalensis, Eucalyptus globulus, Ficus benjamina* showed higher percentage variation (>100%) at industrial area (Site 3). Tree species like *Delonix regia, Moringa olifera* showed higher % variation of TCh at site 2(>100%). And species like *Moringa olifera* and *Ficus benghalensis* exhibited higher variation of TCh at site3 (>100%). Leaf pH did not show considerable variation. *Eugenia jambolana* showed 20% variation at Site2. Tamarindus indica, *Mangifera indica, Eugenia jambolana and Tectona grandis* showed 21%, 27%, 23%, 37% variations at site 3..Higher variation of RWC was observed in *Ficus bengamina* at site 2 (79%) and Polyalthia longifolia at site3 (33%) .Thus out of fifteen species of plants studied only 4 species served as indicator of air pollution namely *Ficus benghalensis,Tectona grandis,Eucalyptus globulus and ,Ficus benjamina.Eventhough Delonix regia is a sensitive species it becomes tolerant in industrial area.*

Key words: APTI, Phytomonitoring, Virudhunagar, biochemical parameters, Delonix regia.

INTRODUCTION

Industrial development and greater mobility of goods have brought enormous increase in transportation sector. They have caused severe environmental problems like air, water and noise pollution. In recent past, air pollutants responsible for vegetation injury and crop yield losses are causing increased concern (Joshi and Swami, 2007). Studies on the effects of air pollutants due to automobiles on morphology, physiology and biochemistry of plants have been reported by a number of workers (Treshow, 1985; Kozial and Whately, 1984; Ahmed *et al.*, 1988; Salgere and Nath, 1991; Raina and Agarwal, 2004; Tripathi and Gautam, 2007) in the different parts of the world. In spite of these adverse effect of these pollutants, there are reports on pollution tolerant plants (Nivane *et al.*, 2001).Studies have also shown the impacts of air pollution on relative water content (Rao,1979), leaf extract Ph (Klumpp *et al.*, 2000), Chlorophyll content (Flowers *et al.*, 2007), Ascorbic acid content (Hoque *et al.*, 2007). Categorization of plants as sensitive or tolerant is determined by the level of these parameters in plants, and thus plants show different susceptibility to different pollutants. The selection of plant species which is commonly growing around Virudhunagar in Tamilnadu,differ considerably with reference to their response towards pollutants . Air pollution tolerance index is an index denotes capability of plants to combat against air pollution. In this study changes in parameters such as ascorbic acid, total chlorophyll, relative water content, and pH of leaf extract were used in the degree of tolerance of air pollution by the plant species. Also the work aims to predict the % variation of biochemical parameters for different plant species growing in residential, heavy traffic and industrial area of this town.

***Corresponding author:** maheswarivaseekaran@gmail.com

MATERIALS AND METHODS

Site selection

The present research work was mainly confined in Virudhunagar which is in southern part of Tamil Nadu, India. Virudhunagar is a selection grade Municipality, spread over an area of 6.39 sq.km holding a population of 72,081 as of 2001 (adopting population projection, it is interpolated the population of this town was 77449 in 2009). It is located at 9°35' North latitude, 77o57' East longitude and 101.3m above mean sea level. The climate of the town is hot and dry throughout the year with April and May being the hottest months. The maximum temperature is above 38.5°C, the

minimum temperature is below 34.2°C. The town receives rainfall mostly during Northeast monsoon, and the average rainfall is 780mm per annum. For this study three sampling stations were selected and these stations were Madura coats colony (Site-1), Pavaly (Site 2), Perali (Site 3). The selected locations categorized as Residential area, Heavy traffic area, Industrial area respectively.

Species selection

Fifteen species of evergreen and deciduous dicotyledonous trees, which are common in all the three stations in the study area, were selected for this purpose.

1:*Delonix regia,* 2:*Tarmarindus indica,* 3:*Moringa olifera,* 4*: Azardiracta indica,* 5 *:Mangifera indica,* 6:*Millingtonia hortensis,* 7*:Pongamia glabra,* 8*:Polyalthia longifolia,* 9*:Eugenia jambolana,* 10*:Pithecellobium dulce,* 11*:Ficus religiosa,* 2*:Ficus benghalensis,* 13*:Tectona grandis,* 14*:Eucalyptus globulus,* 15*:Ficus benjamina.*

Sample collection and analysis

Fully matured leaves of plants collected from all side branches of trees, and mixed to get a homogeneous sample. Then plant leaves were kept in polythene bags preserved in refrigerator for further analysis. Estimation of Total chlorophyll content (TCl) was done according to the method described by Arnon (1949).3 g of fresh leaves were blended and then extracted with 10 ml of 80% acetone and left for 15 min. The liquid portion was decanted into another test-tube and centrifuged at 2,500 rpm for 3 min. The supernatant was then collected and the absorbance was then taken at 645 nm and 663 nm using a spectrophotometer. Calculations were made using the formula given below:

Chlorophyll a = 12.7DX663 – 2.69DX645 x V/1000W mg/g

Chlorophyll b = 22.9DX645 – 4.68DX663 x V/1000W mg/g

TCh = chlorophyll, a + b mg/g,
Dx = Absorbance of the extract at the Wavelength Xnm,
V = total volume of the chlorophyll solution (ml).

Ascorbic acid is determined by Agarwal (1985). 10 gm of the leaf samples were transferred into a glass pestle mortar and macerated well with 4% oxalic acid. The contents were transferred to a 100ml volumetric flask by filtering through a muslin cloth. And repeated the extractions with 4% oxalic acid. Titrated against 0.02% of a selective reagent 2, 6 dichlorophenol indophenol dye solution taken in the burette, a permanent pale pink color is obtained. RWC is determined by using the method described by Barrs and Weatherly (1962). Each sample is placed in a pre-weighed airtight vial. Leaf sample should be placed in a vial slightly longer than the sample, with its basal part to the bottom. Samples should reach the lab as soon as possible. In the Lab vials are weighed to obtain leaf sample weight (W), after which the sample is immediately hydrated to full turgidity for 3-4h under normal room light and temperature. After hydration the samples are taken out of water and are well dried of any surface moisture quickly and lightly with filter/tissue paper and immediately weighed to obtain fully turgid weight (TW). Samples are then oven dried at 80°C for 24h and weighed (after being cooled down in a desiccator) to determine dry weight (DW).

Calculation

RWC (%) = [(W-DW) / (TW-DW)] x 100,

Where,
W – Sample fresh weight
TW – Sample turgid weight
DW – Sample dry weight.

For the measurement of leaf extract pH, 2g of the sample was homogenized with 20 ml of deionised water and the pH of the suspension was measured with a digital pH meter with a glass combined electrode.

Computation of APTI

The air pollution tolerance index was commuted by the method suggested by Singh and Rao (1983) using the equation.

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

Where

A = Ascorbic acid content (mg/g),
T = total chlorophyll (mg/g),
P = pH of leaf extract, and
R = relative water content of leaf (%).

The period of study ranges from May2009 to May 2011. Results were statistically analyzed and interpreted for drawing conclusions using SPSS and MAT-LAB soft wares.

RESULTS AND DISCUSSION

The values obtained for the monthly analysis (May 2009-May 2011) of selected bio chemical parameters of plants were analyzed statistically. All the bio chemical parameters exhibited significant variation from species to species and station to station were shown in table 1 at 0.08% ($p<0.05$). Selected plant species showed considerable variation of biochemical parameters in their response to air pollutants. However plants maintained a balance between the injury caused by the pollutants and the homeostatic process governing repair. Analysis of four parameters such as Ascorbic acid content, total chlorophyll content, and leaf extracts pH and Relative Water Content which are considered as bio indicators of pollutants. The air pollutants from various sources include Oxides of Nitrogen, Oxides of Sulphur and particulates. Oxides of Nitrogen damages the leaves of plants, retard the photosynthetic activity. Sulphur dioxide causes bleaching of leaf pigments due to conversion of chlorophyll pigment-a in to phycophyllin–a, reducing the plant productivity. Particulate pollutants emitted from the sources deposited on the leaves blocks the stomata and thus inhibiting the rate of transpiration and also restrict the absorption of carbon dioxide, there by reducing the rate of photosynthesis. (D. Sarala thambavani and C. Kamala, 2010).

Change in ascorbic acid content

Ascorbate reduced glutathione and peroxidase are important superoxide scavengers in the chloroplast .The significance of each of these scavengers is dependent on their concentration and rate constant for the conversion of superoxide

Table .1: Analyzed biochemical parameters values of selected plants along the three selected sampling location in study area

Plant species	Site 1(control area)				Site 2 (heavy traffic area)				Site 3(industrial area)			
	R%	pH	Tmg/g	Amg/g	R%	pH	Tmg/g	Amg/g	R%	pH	Tmg/g	Amg/g
D. regia	64.42	6.11	2.30	1.03	44.50	5.99	3.64	2.39	70.73	6.00	17.70	1.11
T. indica	44.73	4.41	3.47	1.35	54.46	3.58	4.44	1.66	53.69	3.48	4.64	0.82
M.olifera	85.42	5.77	2.75	0.80	74.03	5.72	14.57	1.76	62.54	5.86	10.22	0.27
A*.indica*	58.11	6.12	13.96	2.68	58.23	5.72	11.00	2.23	63.75	6.19	13.26	2.64
M*.indica*	73.19	5.30	11.71	2.25	74.49	5.34	12.48	2.75	58.13	6.75	16.69	1.21
M*.hortensis*	37.18	6.26	4.09	0.80	35.97	6.28	4.62	1.10	41.48	6.13	8.21	0.88
P*.glabra*	56.58	6.32	5.07	0.57	57.16	5.89	5.59	0.40	55.11	5.78	3.60	0.72
P*.longifolia*	46.92	5.86	5.86	0.71	62.54	5.99	6.58	0.60	69.24	6.08	7.73	0.47
E.jambolana	63.35	6.07	11.59	0.85	74.01	4.85	12.21	1.44	60.18	4.67	13.47	2.91
P*.dulce*	39.42	5.89	11.73	1.59	40.80	6.21	11.29	1.90	46.99	5.71	4.23	2.23
F*.religiosa*	62.08	7.05	8.44	0.27	54.68	7.47	9.04	0.41	60.76	6.40	15.37	1.52
F*.bengalensis*	58.85	7.47	3.54	0.36	63.49	7.65	4.29	0.40	70.27	7.68	9.67	1.24
T*.grandis*	54.92	4.98	4.42	1.20	50.90	5.50	5.18	1.54	59.28	6.85	5.32	0.73
E*.globulus*	62.03	5.22	10.27	0.24	69.34	5.73	10.76	0.26	70.32	5.73	14.96	0.68
F*.benjamina*	38.67	6.91	8.96	0.12	50.71	6.95	10.25	0.12	69.26	6.96	12.47	1.21

(R: Relative water content (RWC); A: Ascorbic acid content; pH; leaf extract pH, T: Total chlorophyll Data represent mean of 24 replicates. Results are significant at 0.08% ($p<0.05$)

Table 2: Variation of Bio chemical parameters with control area

Plant species	Sampling Site	Ascorbic acid		Total chlorophyll		Leaf extract pH		Relative water content	
		V	%V	V	%V	V	%V	**V**	**%V**
D. regia	S_2	√	>100	√	57			√	30
	S_3			√	>100				
T.indica	S_2			√	28			√	21
	S_3	√	40	√	33	√	21	√	20
M. olifera	S_2	√	>100	√	>100				
	S_3	√	60	√	>100			√	26
A. indica	S_2			√	21				
	S_3								
M.indica	S_2								
	S_3	√	46	√	42	√	27	√	20
M. hortensis	S_2	√	37						
	S_3			√	100				
P. glabra	S_2	√	28						
	S_3	√	26	√	28				
P.longifolia	S_2							√	33
	S_3	√	33	√	31			√	47
E.jambolana	S_2	√	68			√	20		
	S_3	√	>100			√	23		
P. dulce	S_2								
	S_3	√	40	√	63				
F.religiosa	S_2	√	50						
	S_3	√	>100	√	82				
F.benghalensis	S_2			√	21				
	S_3	√	>100	√	>100				
T.grandis	S_2	√	28						
	S_3	√	39	√	20	√	37		
E. globulus	S_2								
	S_3	√	>100	√	45				
F. benjamina	S_2							√	31
	S_3	√	>100	√	39			√	79

√- presence variation of biochemical parameter with control station (site 1)

Table 3. Mean APTI value of the leaf samples of selected plant species

Plant species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Site 1	4.17	12.92	14.87	17.60	10.54	4.92	13.70	12.75	14.93	14.60	13.31	3.66	4.10	4.12	2.73
Site 2	6.92	16.53	20.52	19.64	21.73	8.80	16.18	17.04	19.87	17.41	16.14	6.82	6.75	7.37	5.29
Site 3	18.77	16.04	16.70	21.67	18.66	14.80	16.16	17.56	21.44	17.04	19.67	9.14	6.74	8.41	9.39

1:*Delonix regia,* 2:*Tarmarindus indica,* 3:*Moringa olifera,* 4*: Azardiracta indica,* 5:*Mangifera indica,* 6:*Millingtonia hortensis,* 7:*Pongamia glabra,* 8:*Polyalthia longifolia,* 9:*Eugenia jambolana,* 10:*Pithecellobium dulce,* 11:*Ficus religiosa,* 12:*Ficus benghalensis,* 13:*Tectona grandis,* 14:*Eucalyptus globulus,* 15:*Ficus benjamina.*

Table 4. Categarization of plants according to its APTI values

Index value	*category*
<10	Sensitive
>10<16	Intermediate
>17	Tolerant

Table 5.Categorization of selected plant species in Virudhunagar town

Plant species	Categorization of plant species		
	Residential	Heavy traffic	Industrial
D. regia	Sensitive	Sensitive	Tolerant
T.indica	Intermediate	Tolerant	Tolerant
M. olifera	Intermediate	Tolerant	Tolerant
A. indica	Tolerant	Tolerant	Tolerant
M.indica	Intermediate	Tolerant	Tolerant
M. hortensis	Sensitive	Intermediate	Intermediate
P. glabra	Intermediate	Tolerant	Tolerant
P.longifolia	Intermediate	Tolerant	Tolerant
E.jambolana	Intermediate	Tolerant	Tolerant
P. dulce	Intermediate	Tolerant	Tolerant
F.religiosa	Intermediate	Tolerant	Tolerant
F.benghalensis	Sensitive	Sensitive	Sensitive
T.grandis	Sensitive	Sensitive	Sensitive
E. globulus	Sensitive	Sensitive	Sensitive
F. benjamina	Sensitive	Sensitive	Sensitive

(Table1). Varshney and Varshney (1984) of the opinion that higher ascorbic acid content of the plant is a sign of its tolerance against sulphur dioxide pollution. In the control station highest value is observed in *A.indica* (2.68 mgg^{-1}) followed by *M.indica* (2.25 mgg^{-1}). In site 1 and 2 the lowest base value is observed in Ficus benjamina (0.12 mgg^{-1}). At site 2 species like *D.regia, M.olifera* shows higher percentage variation (>100%) and at site 3 species like *E.jambolana, F.religiosa, F.benghalensis, E.globulus, F.benjamina* shows higher variation (>100%) (Table 2). Pollution load dependant increase of ascorbic acid content of plant species may be due to the increased rate of production of reactive oxygen species (ROS) during photo oxidation of SO_2 to SO_3 where sulphites are generated from SO_2 absorbed (S. Jissy jyothi and D. S. Daya, 2010).

Change in total chlorophyll content

One of the most common impacts of air pollution is the gradual disappearance of chlorophyll. The decrease in chlorophyll content was depending upon the increasing pollution load in high traffic areas. The level of toxicity may be responsible for lowering the levels of total chlorophyll (Joshi and Swami 2007). On contrary several researchers have exhibited increase in chlorophyll content under air pollution, such as Tripathi and Gautam reported that *Mangifera indica* leaves subjected to air pollution showed an increase 12.8% in chlorophyll content (Tripathi and Gautam, 2007). In a study by pandey and Agarwal (1994) the chlorophyll concentration into tomato plants increased initially but declined after longer period of exposure of SO_2 and NO_2. Agbaire and Esienfarienrhe in a study have demonstrated the plants from experimental site contain more chlorophyll compared with those from the control site (Agbaire and Esienfarienrhe, 2009). The highest base value of chlorophyll content is observed in *A.indica* (13.96 mgg^{-1}) at Site1, *M.olifera* (14.57 mgg^{-1}) at site2 and *D.regia* (17.70 mgg^{-1}) at site 3. Higher level of chlorophyll content observed may be its tolerant nature. And the lowest value was observed in *D.regia* (2.30 mgg^{-1}) at site1, *D.regia* (3.64 mgg^{-1}) at site2 and *P.glabra* (3.60 mgg^{-1}) at site3 respectively. Degradation of photosynthetic pigment has been widely used as an indicator of air pollution (Ninave *et al.,* 2001). The total chlorophyll ranged between (3.64 $mgg^{-1}$to 14.67 mgg^{-1}) in site2 and (3.60 mgg^{-1} to 28.70 mgg^{-1}) in site 3.Species like *D.regia, M.olifera* shows higher % variation at site 2 (>100%) (Table 2). Tree species like *M. olifera* and *F. benhalensis* shows higher variation at site3 (>100%).

Change in leaf extract pH

The high pH may increase the efficiency of the conversion from hexose sugar to ascorbic acid (Escobedo *et al.,* 2008) while low leaf pH extract showed good correlation with sensitivity to air pollution and also reduces photosynthesis in plants. The photosynthetic efficiency strongly dependant on leaf pH (Yan-ju liu and Hui ding , 2008) the photosynthesis was reduced in plants with low pH (Turk and Wirth, 1975). The leaf extract pH in plants increased due to basic pollutants present at the polluted site. The leaf extract Ph value ranges between 4.41 to 7.47 at site1, 3.58 to 7.65 at site 2 and 3.48 to 7.68 at site3. Leaf ph does not show more variation. *E.jambolana* shows 20% variation at site2 . At site 3 *T.indica, M.indica, E.jambolana* and *Tectona grandis* show 21%, 27%, 23%, 37% variations respectively (Table 2).

Change in leaf's Relative Water Content

The relative water content (RWC) of leaves is an indicator of the plants water status with respect to physiological consequences of cellular water. RWC is a useful indicator of the state of the water balance of the plant. The large quantity of water in plant body helps in maintaining its physiological balance under stress conditions (Gonalez and Gonalez vilar, 2001) the value ranges from 85.42% to 37.18% at site 1, 74.49% to 35.97% at site2 and 70.73% to 41.48 % at site 3. The higher value observed in *M.olifera*, and the lower value shown by *M.hortensis* at site 2. And *M.indica*, *M.hortensis* showed the maximum and minimum values at site3.Higher variation of RWC is observed in *F.bengamina* at site 3(79%) and *P.longifolia* at site3 (33%) (Table 2)

Air Pollution Tolerance Index

The plants with high and low APTI values serve as tolerant and sensitive species respectively. Also the sensitivity levels of pollution differ for different plants(Singh and Rao,1983). APTI of 15 plant species at residential, heavy traffic and industrial sites of the study area are given in table-3. Plants are categorized in to three categories according to the calculated APTI values (Table-4). Thus on the basis of the above study 15 common growing trees are categorized into tolerant, intermediate and sensitive (Table-5). Out of 15 species studied 4 species served as indicators of air pollution namely *Ficus benghalensis, Tectona grandis, Eucalyptus globulus, Ficus benjamina. Eventhough D.regia is a sensitive species it becomes tolerant in industrial area.*

Conclusion

Phytomonitoring is an important tool to evaluate the impact of air pollution on vegetation. Plants provide an enormous leaf area for impingement, absorption and accumulation of air pollutants to reduce the pollutant level in the air environment, with the various extents for different species (Liu and Ding, 2008). The use of plants as monitors of air pollution has long been established as plants are the initial acceptors of air pollution. They act as scavengers for many air borne particulates in the atmosphere (Joshi and Swami, 2009). Plant adaptation to changing environmental factors involves both short term physiological responses and long term physiological responses, structural and morphological modifications. These changes help plants minimize stress and maximize use of internal and external resources (Dineva, 2004). In general, in all these studies indicate that tolerant species have assimilated the emitted pollutants .Research needs to be expanded to encompass a greater variety of plant response to air pollutants in Virudhunagar. And this study is useful for the better understanding and management of air quality as well as in selection of suitable plant species with high APTI.

Acknowledgement

The authors gratefully acknowledge the Secretary, the director of VHNSN College managing board. Authors wish to acknowledge C. R. Chandrasekaran Head, department of chemistry. Also, the authors would like to thank Dr. G. Ramanathan, Assistant professor, Department of Microbiology.

REFERENCES

Agbaire, P. O. and Esiefarienrhe, E. 2009. Air pollution tolerance indices of some plants around Otorogun Gas Plant in Delta State, Nigeria. *J.Appl.Sci.Environ.Manage.*,13 (1): 11-14.

Agarwal, M.1985. Plants factors as indicators of SO2 and O3 pollutants . Symp on Bio-Monitoring State environment. New Delhi. Proceedings, pp.225-231.

Agrawal, S.B. and Agrawal, M. 1994.Effect of Sulphur dioxide exposure on chlorophyll content and nitrogenase activity of Victa fabaL., *"Bull. Environ. Contam. Toxicol.,"* 47:770-774.

Ahmed, Y., Bhargava, R. and Parida, M. 2002. Transport generated air pollution on national highways in Haridwar District. *J IAEU*, 31:225-229.

Arnon, D. I. 1949. Copper enzymes in isolated chloroplasts. *Plant Physiol*., 24: 1-15.

Barrs, H. D and Weatherly, P. T. 1962. A re-examination of the relative turgidity technique for estimating water deficits in leaves. *Australian journal of Biological Sciences*, 15: 413-428.

Dineva, S. B. 2004. Comparitive studies of the leaf morphology and structure of white ash *Fraxinus americana* L. and London plane tree Platanus acerfolia wild growing in polluted area. *Dendrobiology.*, 52:3-8.

Escobedo, F. J. Wagner, J. E and Nowak, D. J. 2008. Analyzing the cost effectiveness of Santiago, Chile's policy of using urban forests to improve air quality. *Jounal of Environmental management*.86:148-157.

Flowers, M. D., Fiscus, E. L and Burkley, K. O. 2007. Photosynthesis, Chlorophyll fluorescence and yield on snap bean (Phaseolus Vulgaris.L.,) genotype differing in sensitivity to ozone.*Environ.Exp.Bot.*, 61:190-198.

Freebairn, H. T. and Taylor, O. C. 1960. Prevention of plant damage from air-borne oxidizing agents. *Proc.Am.Soc.Hort.Sci*.76:693-96.

Gonalez, L. Gonalez-Vilar M and Reigosa, M. J. 2001. Determination of relative water contentHandbook of plant ecophysiology Techniques Kluwer Academic Publishers. *Dordrecht*, The Netherlands.207-212.

Hoque, M, A., Banu, M. N. A and Okum, K. 2007. Exogenous proline and glycine betaine increase NaCl- induced ascorbate –glutathione cycle enzymes activities and proline improves salt tolerance more than glycine betaine in tobacco bright yellow -2 suspension clustered cells .*J.plant physiol.*, 164:1457-1468.

Joshi, P. C and Swami, 2007. Physiological responses of some tree species under roadside automobile pollution stress around city of Haridwar, India.*Environmentalist*, 27:365-374.

Jyothi, J. S. and Daya, D. S, 2010. Evaluation of air pollution tolerance index of selected plant species along road sides in Thiruvananthapuram, Kerala. *J.Environ.Biol.* ,31**:** 379-386.

Klump, G., Furlan, C. M., Domingos, D. and Klumpp, A. 2000. Response of stress indicators and growth parameters of Tibouchina pulchra logn.Exposed to air and soil pollution near the industrial complex of cubato, Brazil.*Sci.total Environ.*, 246:79-91.

Kozial, M. J and Whately, F. R. 1984. In: Gaseous pollutants and plant metabolism, Butterwort, London.

Liu, Y. J. and Ding, H. 2008. Variation in air pollution tolerance index of plants near a steel factory: implication for landscape-plant species selection for industrial areas. *Wseas Transactions on Environment and Development.,* 4: 24-32.

Mondal, D., Gupta S., and Datta, J. K. 2011.Anticipateer performance index of some tree Species considered for green belt, development in an urban area. *Int.Res.J.Plant Science.*, 2(4**):** 99 – 106.

Nivane, S. Y, Chaudhari, P. R., Gajghate, D. G. and Tarar, J. L .2001. Foliar biochemical features of plants as indicators of air pollution. *Bull.Environ. Contam.Toxicol.* 67:138-140.

Raina, A. K. and Agarwal, B. 2004. Effect of Vehicular exhaust on some trees in jammu-11.*J.Ind pollut.control.*, 20:229-232.

Raja Subramanian, D., Sundaramoorthy P., Baskaran L., Sankar Ganesh K., Chidambaram A. L. A. and Jegannathan M. 2011. Effect of Cement dust pollution on germination and growth of groundnut. (Arachis hypogrea l). *Interenat. Multidispl. Res.J.,* 1(1): 25-30.

Rao, D. N. 1979. Plants as a pollution monitoring device. *Fertilizer News.* 24:26-28.

Salgare, S. A and P. Nath. 1991. Effect of auto exhaust pollution at Bandar (East) on the growth performance of some plants-1(Monsoon collection).*New agriculturalist .*, 2:43-48.

Saralathambavani, D. and Kamala, C. 2010. Air Pollution Tolerance Index (APTI) of Some Tree Species Growing Near Rail Roads of Madurai, TamilNadu (India). *J.Environ. Science&Engg.*, 52(4):285-290.

Sarath, K., Guthikunda, Agarwal, R. 2009. Contribution of vehicular Activity to Air Pollution in Hyderabad, India: Measurements, Chemistry and Analysis. *Indian journal of Air pollution control.*, 9(2):37 – 40.

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

Seyyadnejad, S. M., Koochak, H., 2011. A study on Air pollution - Induced Biochemical Alternations in Eucalyptus Camaldulensis S. *Aust. J. Basic & Appl.Scie.*,5(3) 601 -606.

Singh, S. K and Rao D. N.1983. Evaluation of plants for their tolerance to air pollution. In: proceedings of symposium on air pollution control. Indian association for air pollution control. New Delhi: 218-224.

Treshow, M. 1985. In: Air pollution and plant life, Jhon wiley and sons, New York.

Freebairn, H. T. and Taylor, O. C. 1960. The prevention of plant damage from air-borne oxidizing agents. *Proc.Am.Soc.Hort.Sci*.76:693-96.

Tripathi, A. K and Mukesh Gautam. 2007. Biochemical parameters of plants as indicators of air pollution. *J.Environ.Biol*. 28:1127-1132.

Turk, R. and Wirth, V. 1975. The pH dependence of SO2 damage to lichens . *Oecologia.*, 19:285-295.

Varshney, S. R. K. and Varshney, C. K. 1984. Effects of Sulphur dioxide on ascorbic acid in crop plants. *Environ. Pollut.*, 35:285-291.

Yan-ju and Hui ding. 2008. Variation in air pollution index of plants near a steel factory: Implications for landscape plant species selection for industrial areas. WSEAS Transactions on environment and development. 4 (1):24-32.

****