Effect of Traffic Pollution on Plant Photosynthesis

G. F. DURRANI*, M HASSAN, M. K. BALOCH AND G. HAMEED
Department of Chemistry, Gomal University
Dera Ismail Khan (N.W.F.P), Pakistan.

(Received 13th October, 2003, revised 12th March, 2004)

Summary: Vehicular exhaust is considered as one of the worst forms of environmental pollution. To assess the effect of traffic pollution on photosynthesis, leaf samples of four different types of plants at different distances from G.T Road at Wah Cantt were collected. The samples consisted of sunny, shady and semi shady leaves of Orange, Guava, Apricot and Eucalyptus trees. The leaves were washed, dried and homogenized before undertaking analysis for different parameters like total chlorophyll, chlorophyll a, chlorophyll b and carotene content. Results showed that average values of total chlorophyll varied in the range of 22.6-36.0, chlorophyll a, 12.6-20.0 and chlorophyll b, 16-18.60 and carotene content in the range of 12-34mg/gm of the sample taken depending upon the type of the plant and the distance from the busy road. These values were in order of sunny > semi-shady >shady leaves. The concentration of all the pigments increased as the distance from the busy road increased. Soil and the air samples in the vicinity of the trees under study were also analyzed for the concentration of lead, CO, SO_2 and NO_2 and particulates and found to be comparatively high in the dense traffic areas and their concentrations tend to decrease as we move away from the road. It is concluded that vehicular emission had significant effect on the photosynthesis of plants.

Introduction

Trees and plants play a vital role in creating healthy environments for people beginning with the release of the life giving oxygen we breathe [1-2] in. However, their own life is at jeopardy as their growth rate is very much effected by the air pollution. The photosynthetic activity and the plant pigment formation is suffered due to traffic and industrial pollution. With the increase in volume of road traffic, the NOx, VOCs and the particulates deposition increases causing uncertain effects on roadside plants [3-5]. Exposure to these pollutants in combination may be more harmful to plants than individual ones [6]. The taller plants are the sites of deposition of a variety of air borne biological materials and atmospheric pollutants [7]. Gaseous pollutants enter the plant through stomata in the leaves, over the cuticle or epicuticular wax covering and damage them. The particulates, from vehicular exhaust may abrade these epicuticular waxes, and hence reduce cuticular resistance to gas diffusion [8] and affect stomatal responses. A single pollutant, such as SO_2 has been observed to promote and inhibit stomatal closure depending at its concentrations and environmental conditions [9]. These responses are further tensified by the presence of other chemicals in the gaseous environment [10]. These stomatal responses will vary the uptake of the pollutants, and hence the sensitivity of the plants. The pollutants may also change the morphology, physiology and biochemistry of sensitive plants. Chronic exposure of SO_2 to plants causes bleaching of leaf pigments due to conversion of chlorophyll a to phacophytin, reducing plant productivity [11]. High concentration of NO_2 damages the leaves, retards photosynthetic activity and causes chlorosis [4,10]. Photochemical oxidants inhibit photosynthesis, causing silvering of leaves. Drying of leaves occurs more quickly in plants at the roadside, suggesting some loss of drought tolerance in these plants. Heavy metals leach to earth surface by rainwater which are absorbed by the plants through roots and ultimately reach to the leaves of the plants through routine transpiration. within the plant body. Heavy metals may also be absorbed directly from the air [12]. A decrease in total chlorophyll contents with metal toxicity has been observed in plants. Heavy metals block the synthesis of activity of enzyme aminolevulinic acid dehydratase (ALAD) responsible for chlorophyll biogenesis. It has been noted that Cd is present in tires up to the concentration of 20-90 ppm. This Cd is thrown into the air and absorbed by the plants which decreases the leaf chlorophyll [13]. Since effect of pollutants on plants is manifested on their leaves, leaf of the plants can be considered as index of photosynthetic biomass as well as index of pollution effect

*To whom all correspondence should be addressed.

[9]. The present study was therefore, carried out to investigate the effect of toxic compo-nents emitted by motor vehicles on pigments for-mation and photo-synthesis process of plants and to correlate them with the extent of pollution in that area.

Results and Discussion

The leaves after homogenization were analyzed for various parameters and the data is presented in tables 1-4. It can be seen that mean values of total chlorophyll, the chlorophyll a, chloro-phyll b and carotene contents in each case increase as the distance from the road increases. Individual values of all the pigments are higher for the sunny leaves than the semi shady and the shady leaves of each tree. It is evident from the data given in the Table 1-4 that these values decrease in the order of sunny, semi shady and shady leaves indicating the importance of light for the pigment formation.

The roadside soil of the same locations from which the plant samples were collected, has been analyzed and the results are compiled in Table 5. The results show that the samples collected away from the road side contain less amount of lead as compared to the one near the road side (See Table1-4). The reason for such trend may be attributed to the fact of the

Table-1: Analysis of Photosynthetic Pigments in Sunny, Semishady and Shady leaves of Orange trees at various distances from busy road.

Distance from the Road	*Leaves	Total **Chl (mg/g)	Mean	Chl--a (mg/g)	Mean	Chl-b (mg/g)	Mean	Carotene (mg/g)	Mean
20m	Sunny	24		14		12		20	
	Semishady	22	22.6	12	12.6	10	10.6	18	16.6
	Shady	22		12		10		12	
150m	Sunny	28		16		14		24	
	Semishady	24	25.3	14	14	12	12	20	20
	Shady	24		12		10		16	
300m	Sunny	30		18		16		30	
	Semishady	26	27.3	16	16.6	16	15.3	24	24
	Shady	26		16		14		18	

Key: *Leaves of Orange trees, **Chl: Chlorrophyll

Table:-2:Analysis of Photosynthetic Pigments in Sunny, Semi shady and Shady leaves of Apricot trees at various distances from busy road.

Distance from the Road	*Leaves	Total **Chl (mg/g)	Mean	Chl-a (mg/g)	Mean	Chl-b (mg/g)	Mean	Carotene (mg/g)	Mean
200m	Sunny	32		18		18		26	
	Semishady	30	30	16	16.6	16	16	22	22
	Shady	28		16		14		18	
500m	Sunny	36		18		20		34	
	Semishady	32	33.3	18	18.0	18	18	26	22.66
	Shady	32		18		16		20	
700m	Sunny	38		20		20		30	
	Semishady	36	35.3	18	18.6	20	19.3	28	28
	Shady	32		18		18		26	

Key: *Leaves of Apricot trees, **Chl: Chlorrophyll

Table-3:Analysis of Photosynthetic Pigments in Sunny, Semishady and Shady leaves of Guava trees at various distances from busy road.

Distance from The Road	*Leaves	Total **Chl (mg/g)	Mean	Chl-a (mg/g)	Mean	Chl-b (mg/g)	Mean	Carotene (mg/g)	Mean
	Sunny	12		06		06		38	34
20m	Semishady	10	10	04	4.66	04	4.66	34	
	Shady	08		04		04		30	
	Sunny	14		08		08		40	36.6
200m	Semishady	12	11.3	06	06	06	06	36	
	Shady	08		04		04		34	
	Sunny	20		10		12		45	42.6
400m	Semishady	20	19.3	08	08	10	10.6	43	
	Shady	18		06		10		40	

Key: *Leaves of Guava tree, **Chl: Chlorrophyll

Table-4:Analysis of Photosynthetic Pigments in Sunny, Semi shady and Shady leaves of Eucalyptus trees at various distances from busy road.

Distance from the Road	Leaves*	Total **Chl (mg/g)	Mean	Chl-a (mg/g)	Mean	Chl-b (mg/g)	Mean	Carotene (mg/g)	Mean
10m	Sunny	28		16		16		16	14
	Semishady	26	26	14	14	14	14	14	
	Shady	24		12		12		12	
100m	Sunny	36		20		18		18	16
	Semishady	34	34	18	18.66	18	17.3	16	
	Shady	32		18		16		14	
500m	Sunny	38		20		20	18.6	24	21.3
	Semishady	36	36	20	20	18		22	
	Shady	34		20		18		18	

Key: *Leaves of Eucalyptus, **Chl: Chlorrophyll

Table-5:Lead Contamination of Roadside soil and plants

Distance from G.T Road (meters)	Lead in washed leaf sample (μg/g)	Lead in soil Sample (μg/g)
10	565	613
50	450	505
100	307	390
200	283	300
500	155	187

Table-6:Air pollutants at various distances from G.T. Road.

Location	Particulates (mg/m^3)	NO_2 (mg/m^3)	SO_2 (mg/m^3)	CO (mg/m^3)
At 10m from G.T. Road	0.51	0.22	2.01	19.4
At 50m from G.T. Road	0.37	0.17	1.46	18.7
At 100m from G.T. road	0.15	0.12	0.89	16.9
At 200m from G.T. road	0.09	0.08	0.75	12.2
At 500m from G.T. road	0.05	0.05	0.50	8.4
At 700 m from G.T. road	0.03	0.03	0.22	5.6

Table-7: National Air quality standards (NAQS) for gaseous pollutants

Pollutants	Time Span	U.S. Standards	W.H.O. Standards
SO_2	1 hr	365μg/m^3	350μg/m^3
	24 hr		
NO_2	24 hr	100μg/m^3	150μg/m^3
	Annual		
CO	1 hr	40mg/m^3	30 mg/m^3
	8 hr	10mg/m^3	10 mg/m^3

high traffic density in that area, which is major cause of the pollution.

The air samples of the roadsides and around the trees under study were collected and analyzed to deduce the effect of traffic pollution over the environment. The air analysis show that the concentration of lead, CO, SO_2 and NO_2 were comparatively high in the dense traffic areas and decreases as we move away from the busy roads [14,15] (Table 7). These findings are in agreement with the work reported earlier [16-20]. Based on the soil and air quality analysis it seems that vehicular pollution has a great negative impact over the photosynthesis of plants.

Experimental

Reagents

All the chemicals were of A.R quality and obtained from either B.D.H England or E. Merck Germany. All the solvents were distilled before use. Double distilled water was used for preparation of solutions.

Instruments

The Instruments used were Spectronic-21 (Bausch & Lomb Japan), Atomic absorption spectrophotometer (AA-202,Brukar USA),High volume dust apparatus (NILFISK, TYPE GS 80, Finland) and General-purpose gas analyzer (Foxboro, USA).

Sample Collection

Samples of leaves from different trees of Wah Cantt. were collected. The trees were selected in such a way that they were at 10 to 700 meters from the main G.T road .The samples, after plucking, were stored in air container and labeled before bringing them to the laboratory. The samples collected were not specific to one kind of tree; instead available trees were selected on the basis of assuming them active air pollutant absorbing sites.

Procedure

All the leave samples were well washed with water till the removal of dust and smoke from the surface and dried at 110 C up to constant weight. One-gram of dried sample of the leaves in each case was homogenized in 5 ml double distilled water in a blender. The final volume was made up to 100 ml with same water. An aliquot of 0.5 ml was taken and mixed with 4.5 ml of 80 % acetone. The mixture was centrifuged and the supernatant was used for determination of total chlorophyll, chlorophyll a, b and the carotene content by measuring optical density at their respective wavelengths [11].

Analysis

One-gram of washed leaves in each case were burnt to ash at 650 C. The ash was dissolved in 5 ml of mixture of HCl and HNO_3, (5:1). The slurry was filtered and the residue ash was washed till free of acids. The washings and filtrate were combined and evaporated to a constant volume of 50 ml and used for lead analysis by atomic absorption spectrophotometer. The soil samples were also treated in the same way and all analyses were performed in triplicate.

Air samples were collected at various distances from the road near the investigating trees using high volume Dust Apparatus (NILFISK, Type GS 80, Finland). CO, SO_2 and NO_2 in the air samples were analyzed using general-purpose gas analyzer (Foxboro, USA). All the experimental results were compared with the U.S and W.H.O standards [21].

Conclusions

The studies show that pollutants have harmful effect upon photosynthesis of plants. The presence of high amounts of toxic pollutants in air and soil near high traffic G.T road give us a signal to take some precautionary measures to reduce the release of pollutants into the environment. Leaf surfaces of plants are not passive receptors but are in a dynamic relationship with the atmosphere. Wet and dry deposition of atmospheric contaminants may alter a plant's response to parasitic microorganisms in a variety of ways, depending on the sensitivity of the plants. Any exposure to pollutants, which result an increase tissue injury enhancing the potential for invasion by pathogens. When two or more pollutants for example SO_2, ozone and NO_2 interact, increased tissue injury occurs. Raining in the area can minimize the contaminants. However, an artificial water spray would be very much helpful for combating air pollution. Since trees are the first rank pollution fighters, an extensive plantation will reduce air pollution.

References

1. Environmental Health Science Center, The role of plants in environmental pollution. Environ. Health Sci. Ctr. Oregon State University, Corvallis Oregon, 34 pp (1975).
2. W.H.Smith, Air pollution and Forests Springer-Verlog, Berlin and New York (1981)
3. K.P. Beckett, P.H. Freer-Smith, and G. Taylor, *Environmental Pollution*, **99**, 347 (1998).
4. H. Kammerbaur, H. Selinger, R. Römmelt, A. Ziegler-Jöns, D. Knoppik, and B. Hock, *Environmental Pollution* **48**, 235 (1987).
5. S. Bell, T.W. Ashenden, and C.R. Rafarel, *Environmental Pollution*, **76**, 11 (1992).
6. K.E. Percy, (ed.) Air Pollutants and the Leaf Cuticle - NATO ASI Series, Vol. G36, Springer-Verlag, Berlin (1994).
7. P.C. Moonen, J. Binnie, J.N. Cape and T.W. Ashenden, Impacts of vehicle emissions on vegetation: Feasibility Study (URGENT 2) GST/02/2084 (1999).
8. K.A. Sunil Babu, Effect of Atmospheric Pollution On Soils. Recent trends in Biotechnology. Proceedings of the Ninth National Convention of Chemical Engineers and International Symposium, June 5-7, Viskhapatnam, India (1993)
9. A.H.Chappelka and P.H.Freer-Smith, *Environmental Pollution*, **87**, 105 (1995).
10. E. -L. Viskari, S. Kössi, and J.K. Holopainen, *Environmental Pollution*, **107**, 305 (2000).
11. Sharma Environmental Chemistry, Krishna Prakashan Media (P) ltd,Meerut-1, India. (2000)
12. M. Ishaq, A. Khan, I. Ahmad, A. Bahader, and M.Ibrahim. *J Sci & Tech. Univ. Pesh*, **26**, 55 (2002).
13. R.K. Trivedy, Advances in environmental science & technology, Ashish Publishing House, New Dehli. 1:227 (1995).
14. Environmental Protection Agency, Pakistan. The Gazette of Pakistan, notification (1995).
15. The daily "News", Islamabad April 13, NO_2 concentration reported by EPA, Peshawer (1996).
16. S.O. Tumi, N.S. Kumar, and A.K. Hinshery, *Libya. Bull. Environ. Contam. Toxicoal.*, **45**; 718 (1990).
17. S.D. Sithole, N. Moyo, M. Machelea, *Environ. Anal. Chem.*, **53**(1), 1 (1993).
18. H. Arsalan, *JTMT*, **19**, 439 (2001).
19. D. Muhammad, I. Khatoon, and I. Ahmad, Lead pollution in Islamabad. Proc. NSMTCC 97 on environmental pollution, Islamabad, Pakistan. (1997).
20. S. Tokalioglu, and S. Kartal, *J. Trace metal and microp. Techniq*, **20**(1), 127 (2002).
21. C. Baired, Environmental Chemistry, W.H. Freeman and Co. Newyark 2^{nd} Ed. 124, (1999).