EFFECT OF AUTOMOBILE EXHAUST ON SOME TREE SPECIES LINING THE LAHORE MALL: A CASE STUDY

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SUMMARY

The choking atmosphere created at the site specifically chosen for the study is due to emissions of vehicle exhaust which resulted in abnormal growth of trees lining the road. Six species, namely *Alstonia scholaris, Heterophragma adenophyllm, Mimusops elengi, Ficus religiosa, Ficus bengalensis* and *Ficus infectoria* growing along both sides of the road were compared with the same species of trees in a relatively cleaner atmosphere. Tree species growing along the Mall reveal departure in their morphological, reproductive and phenological pattern. The amount of lead absorbed by the trees along the road is greater than those growing in the garden but the effect is more pronounced on some than others. The three *Ficus* species are better adapted to survive dehydration stresses compared to other species which are more susceptible and are therefore more prone to pollution injuries. The chemical and physical forms of the pollutants, effects of exposure dosage on the plants, alongwith plant physiology and the energy and chemical balance in the plant microenvironment created on the road determine to what extent pollutants can be absorbed or emitted by these trees.

INTRODUCTION

The biggest problem that today's large cities face is air pollution and its major source is the enormous quantity of vehicles frequenting the highways and roads of cities. The Shahrah-e-Quaid Azam (the Mall), in metropolis Lahore, is one of the busiest roads in the city. This tree-lined avenue was at one time, a beautiful sight but today, it presents quite a different picture. The steady increase in the number of vehicles has resulted in a parallel increase in exhaust emissions causing steady deterioration of the surrounding air quality, especially during the daytime from 8.00a.m. to 7.00p.m. Carbon monoxide standard level is 9 ppm and it reaches to 40 ppm during the rush hours (Hayat, 1990). This level indicates that there must have been equally higher concentration of other main components of automobile exhaust such as Nitrous oxides, unsaturated hydrocarbons and their photochemical products, soot, Lead compounds and Sulphur dioxide. The aim of this work was to find the extent of the impact of atmospheric phytotoxicants on the departure from the normal pattern of growth and the degree of susceptibility of various species growing there. This objective was achieved through the comparison of trees growing immediately along the road with trees growing about 100 meters away from the road in Jinnah gardens. It was hoped that this comparison would indirectly reflect the effect of microenvironmental complex on the trees of the two habitats. Damage is registered and assessed, by taking into consideration effects on vegetative and reproductive morphological structures, reproduction, phenology and depreciation due to necroses. In view of the limited availability of facilities only the amount of lead in the leaves of the trees was quantified for diagnostic purposes.

The stretch of road from the Punjab University to the Charing cross is the busiest portion of the Mall, with the worst traffic jams and busy intersections. It is estimated that about

70,000 automobiles traverse this stretch each day. The distance of the survey area was about 2 km, and the observations were made on trees situated on both sides of road.

This stretch has about 64 *Alstonia scholaris* R.Br., 22 *Mimusops elengi* L., 6 *Heterophragma adenophyllum* seem, 140 *Ficus religiosa* L., 6 *Ficus infectoria* Roxb. and 4 *Ficus bengalensis* L. trees. All these species are popular for roadside plantations.

METHOD

The observation period lasted from January 1991 to January 1992. The observations and comparisons were made on the spot for both situations, i.e. the road side and Jinnah gardens. In addition a branch of 1 meter length was cut and brought to the laboratory for detailed observations. This method was repeated at monthly interval throughout the year. The following characteristics were noted:

Growth pattern and general appearance

- Senescence: timings of leaf abscission in the deciduous species. Any peculiarity observed in pattern of senescence was noted.
- Permanent damage and effect on canopy: Most trees along the roadside posses a considerable number of leafless branches as compared to trees away from the roadside. These branches represent the extent of mortality present in the tree.
- Flowering and fruiting: Timing, extent, number and condition of flowers and fruits produced per branch.
- Effect on leaves: the following observation were made:

i. Leaf Size: In case of *M. elengi* and three *Ficus* species an average sized mature leaf was selected as representative of most of the leaves of that plant and its length was measured. In case of *A.scholaris* and *H.adenophyllum*, lower leaflets were selected and its length (excluding the petiole) measured.

ii. Damage in the form of necrosis, chlorosis, and other symptoms were observed round the year.

iii. Amount of dust: leaves of each species were selected at random from the two situation. The samples were collected in June and December. Dust was removed collectively from three leaves or leaflets of each species with a brush on a pre-weighed slip of paper.

- Shoot condition: condition of apical buds, suppleness of shoots, leafiness, exudation of latex were noted.

Accumulation of lead

Amount of lead in the washed leaves was determined by aspirating directly the ashed sample solution into an air-acetylene flame. The determinations were carried out on an Atomic Absorption Spectrophotometer equipped with a lead hollow cathode lamp.

RESULTS AND DISCUSSION

I. Growth pattern and general appearance

Senescence

The three *Ficus* species are deciduous in nature. Difference in timing of senescence could be due to definite genetic variation. Generally it was observed that *F.religiosa* senescence starts from February and extends uptil May with maximum leaf fall in March. On the Mall road, senescence starts in November and extends till May. It was also observed that younger trees were more prone to shed leaves in November as compared to the older trees. A second senescence was observed on the Mall in some trees of *F.religiosa* during the month of June. In *F.bengalensis* leaf abscission (June) behaviour was observed at both locations on same dates. There are two varieties of *F.infectoria* which are deciduous, one variety sheds leaves in March and the other in May and this pattern is persistent and similar in the two varieties at both the locations. *M.elengi* is not deciduous and senescence is more pronounced during winter on Mall road, otherwise not very obvious. *H.adnophyllum* is strictly deciduous, it sheds leaves in May in the garden, on the Mall, leaf shedding occurs in April. *A.scholaris* is not deciduous but 70% of trees show from partial to total leaf fall on the road in December. However, senescence was not observed in the garden.

Permanent damage and effect on canopy

Leaf-less branches were observed in all the trees lining this stretch of road. In F.bengalensis it ranges from 10 to 30 percent and in *F.religiosa* it ranges from 10 to 60%. In *F.infectoria* the damage seems to be 5 to 10%. In *F.religiosa*, since all ages of trees are represented, it appears that in older trees (girth greater than 1.5 meter), mortality is more prominent on branches extending over the road, medium sized trees (girth less than 1.5 meter). have higher mortality and stunted appearance and still younger trees (less than 0.5 meter) showed less damage. In most trees branches covering the road and the top branches which are more exposed to the pollutants are mortified and it has given the tree crowns very uncharacteristic asymmetrical form. The tree avenues which are less polluted (upper Mall) show a complete canopy over the road. *F.infectoria* which is comparatively shorter and more compactly branched does not lose its original shape.

In *H.adenophyllum* the percentage of leaf-less branches is 15-25% and in *M.elengi* branch mortality is 20-40%, and is prominent on the branches facing the road. In *A.scholaris* percentage of leaf-less branches is 35-50% and the pattern of branch mortality is the same as observed in *M.elengi. A.scholaris* is more or less cone shaped in the gardens but on the road verges it has rather stunted growth with a very small crown. It is probable that uncharacteristic loss of leaf in winter is responsible for this retarded growth. The canopy of *H.adenophyllum* is elongated vertically with a less lateral spread and is generally less robust. *M.elengi* which has a round canopy in the garden assumes a very asymmetrical shape with almost leafless branches projecting on the road.

Timing and extent of flowering and fruiting

In the three *Ficus* species flowering and fruiting in some cases was premature. This effect was more prominent in *F.religiosa* and *F.bengalensis* compared to *F.infectoria*. The fruits of all roadside *Ficus* species were usually softer, smaller in size (30% reduction) and less robust than fruits of garden trees. Reduction in number of fruits per branch ranged from 20% in *F.infectoria* and 45% in the other two species. The road side *M.elengi* trees showed from very scattered to complete absence of flowering and fruiting (85% reduction). Trees in less polluted areas showed both profuse flower and fruit development. *H.adenophyllum* showed scattered flower buds (60% reduction) but few of the buds facing the road developed into flower and still fewer into fruits (90% reduction). Whereas trees in less polluted areas showed profuse flower and fruit development. *A.scholaris* growing on the roadside exhibited no flowering, even in the garden flowering and consequent fruiting is not very frequent.

Effect on leaves

(i) Leaf size: observation of leaves from roadside showed reduction in size. In *A.scholaris*, *M.elengi*, and *H.adenophyllum* average size was: 400 cm^2, 200 cm^2, 1200 cm^2 in garden, whereas on the road side it was 180 cm^2, 130 cm^2, 760 cm^2 respectively. Similarly, mean surface area of leaves of all *Ficus* species was greatly reduced on road side samples. In *F.religiosa* and *F.bengalensis* the average mature leaf on the road has 739 cm^2 surface area compared to the garden samples leaf size of 1100cm^2, and 977 cm^2 respectively. In *F.infectoria* there is less difference in the size of the leaf at the two sites (140 cm^2 to 190 cm^2).

(ii) Leaf colour and damage: Road side trees were plaer, which was due to the reduced production of pigments (Siddique, 1990; Naz, 1990) compared to the garden trees. Leaves of roadside trees were spotted i.e. with chlorotic and necrotic patches and epinasty. The typical symptoms on the leaves were as follows: The leaves of *M.elengi* had burnt margins and scattered necrosis. *A.scholaris* has burnt margins and chlorosis on tips. *H.adenophyllum* had burnt margins with white spot and bleaching. *F.religiosa* had necrotic patches and bronzing. In *F.bengalensis*, leaves had curved margins with yellow colour. Whereas in *F.infectoria* leaves had burnt tips. Furthermore, the leaves brought from the road side trees showed symptoms of dehydration and wilting when brought to the lab compared to garden samples which remained fresh for considerable period of time, an indication that the road side trees are suffering from water stress. Furthermore, very few insects (spiders, milibugs) were observed on the roadside trees compared to the garden trees

iii. Dust deposition: The study of the quantity of dust deposited on leaves shows a clear trend of greater amount of dirt deposited on the roadside samples compared to the garden samples (Table 2). The colour of dust on roadside samples was sooty black while the garden leaves had lighter colour. On brushing the under surface, garden leaves become very clean whereas the sooty spots on the roadside leaves can not be removed, particularly in the angles between veins on the undersurface of leaflets. The leaves of *F.bengalensis* had hairy surface and thus the dust deposited on leaves was not easily removed. *Ficus* species showed higher amount of dust on the roadside trees. The dust caught on *H.adenophyllum* leaflets is slightly greater because of their pubescent under surface which easily traps particulate matter. Leaves of *M.elengi* and *A.scholaris* are relatively smooth and have comparatively less deposition of dust.

Table 1. Comparison of quantity of lead (ppm) on dry weight base

	Lead (ppm)	
	Road	Garden
H.adenophyllum	670	210
M.elengi	425	205
A.scholaris	800	225
F.religiosa	860	305
F.bengalensis	642	165
F.infectoria	365	175

Shoot growth: The pattern of shoot growth in all the trees is the same. This pattern follows two peaks one in March and the other in September. Both peaks are more prominent in garden samples as compared to the road side trees. Monthly observations pointed out clearly the following sharp differences in the general condition of the shoot: a) Apical buds of garden plants were relatively hard and robust whereas those of roadside plants were tender and more easily broken off. ii) Generally it was noticed that the roadside shoots were brittle and not as supple as shoots of garden plants. Roadside shoots were often easily snapped whereas garden shoots were bent but not easily broken. It was also observed that in *F.bengalensis* the ends of rootlets become very brittle. iii) In the latex containing plant (*A.scholaris* and the three *Ficus* species) it was noticed that in garden samples breakage of shoot resulted in rapid exudation of latex but in roadside shoots latex did not ooze out as readily.

II. Accumulation of Lead

The accumulation of lead in the samples revealed that the same amount of lead did not accumulate in each species. There were definite similarities and trends of low accumulation of lead in the garden samples as compared to the roadside trees where the accumulation was more varied and much higher (Table 1). Variations in lead accumulation in different species may be due to sinks and larger surface area of some tree species. The concentration of lead is proven to be a function of the distance of the sample from the source of the lead (road traffic) and it falls off with the distance from busy roads (Ward, *et al.*, 1977). The levels of lead accumulated in the trees on the Mall is much higher than the levels generally considered toxic for the plants (300 ppm).

Table 2. Comparison of the quantity of dust deposited (mg) on the leaves during the two seasons

Species	Months	Dust (mg)	
		Road	Garden
H.adenophyllum	June	1.47	0.48
	Dec	1.29	0.36
M.elengi	June	1.51	0.41
	Dec	1.33	0.47
A.scholaris	June	1.16	0.68
	Dec	1.86	0.94
F.religiosa	June	2.56	1.30
	Dec	2.15	1.39
F.bengalensis	June	3.84	1.13
	Dec	2.82	1.28
F.infectoria	June	1.74	0.76
	Dec	3.36	1.22

CONCLUSION

Plant leaves are specialized structures which efficiently remove phytotoxic air pollutants and filter particulates from the air, and can act as persistent sorbers of pollutants when exposed to sufficiently low dosages. This is because plants are self renewing, they undergo growth and metabolic regenerative processes, and periodically shed replaceable leaves and other tissues. But this action of vegetation is not very effective in areas where plants are exposed to higher levels of pollutants.

Each plant, being a product of the condition under which it grows and is therefore a measure of its local environment. Measured amount of lead in the leaves gives a rough correlation between lead accumulation and the observed departure from the normal behaviour. However different species respond differently to these conditions. The three *Ficus* species, in spite of having greater amount of lead, show lesser departure from the pattern of fruiting and senescence compared to the other species. This makes the *Ficus* species more resistant compared to the other three species. This resistance could be partly due to deciduous nature which help them to shed the overburdened leaves but mainly due to the possession of efficient root systems: especially adapted to growing in the crevices. In this way they overcome the elevated temperature by depressing the dehydration which ameliorate pollutant injuries. Among *Ficus* species it can be said with certainty that newly planted *F.religiosa* will never assume the stature of those plants that were planted fifty years ago, forming extensive canopies. Younger trees are responding to the pollutants by showing mortality resulting in stunted growth compared to the older trees which attained considerable height and root spread before the road has reached the present level of phytotoxic pollutants. Long petioles, more height and spread of branches of *F.religiosa* probably make them more prone to accumulation of lead as well as other pollutants. *F.bengalensis* also seems equally susceptible, probably more because of presence of aerial rootless which provide an effective sink for the pollutants. *F.infectoria* shows less accumulation of lead and has similar growth behaviour as its garden counterpart, this is probably because of short bole height and dense crown which make them more resistant to the pollutant intake.

The other three species have root systems which are adapted to grow on deep soils in moist situations and have narrower ecological adaptability than the three *Ficus* species. These inherent characteristics have made them more prone to dehydration and pollution stresses along the busy road verges. Among them *A.scholaris* is the most susceptible, the morphological features such as presence of green shoots with lenticels probably expose greater sink to pollutants, and leaves in whorls trap more aerosol and make them more prone to injuries, to which it interact by acquiring deciduous nature and shading the leaves during winter. This behaviour results in its very stunted stature. *H.adenophyllum* having large and hairy leaves, provide effective fall out sinks as expressed by partial and complete absence of flowering and fruiting. *M.elengi* although accumulates lesser amount of lead but shows decline in reproductive capacity.

This survey clearly indicates that there are many other features that may determine the susceptibility of the species to pollutant injuries. It includes position of the leaves within a canopy, shape, size and texture of the leaf, length of leaf petiole, size of stomata and presence of lenticulas on the shoots and the orientation of the leaf angle, height and lateral spread of branches. It is also obvious that the pollutants, as moisture, dusts, and sprays react on other vegetation surfaces-the barks, aerial roots or reproductive structures-flowers and fruits, which are acting as potential absorbants.

The trees growing on the cross roads and bus stops and trees growing singly are more badly affected than the trees which are away from busy intersections. Greater mortality in the upper canopy and branches facing the road is due to the fact that light exposure affect plant physiology; since net photosynthesis occurs in the upper canopies where light intensities, ventilation, and temperatures are greatest, and the stomata are probably most open causing an increase in the intake of pollutant. Over this stretch of Mall road which was surveyed, a stable atmospheric layer persists in which the temperature increases with height. Chain of buildings on both sides suppresses convective turbulence and mixing, making this enclosed area protected from the wind, and giving more opportunity for aerosol deposition to occur. The line of trees towards the highcourts shows lesser symptoms possibly because the lawns in front of the highcourts provide conditions favouring some ventilation making plant exposure dosages less as compared to the opposite lane, where condition limits dispersion and subject to local buildup of air pollution.

More predictable interactions can be explained by knowledge of other prevalent pollutants, their chemical properties and probable plant reaction sites. The deformed trees observed on the Mall road can also be spotted on other busy roads showing similar symptoms, whereas trees growing on the less polluted roads do not show any such symptoms. The levels on lead in the leaves on the Mall road are very close to the levels of lead in plants growing at a distance of 1.5 km from a lead smelter (Ragaini *et al.*, 1977). With continuous increase of vehicles and with no control on defective fuel and engines it is probable that this road in future would lead to the environmental conditions prevailing in the immediate vicinity of a smelter, resulting in a more deformed tree lined avenue-a tell tale story of level of automobile exhaust.

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