Variation in Road-side Vegetation with Reference to Vehicular Pollution

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Abstract

To study the impact of vehicular pollution on the road-side vegetation, four sites in the eastern Uttar Pradesh of India with varying vehicular density were selected. Index of dominance of five plant species, *Ageratum houstonianum* Mill., *Argemone mexicana* Linn., *Rumex dentatus* Linn., *Salvia plebeja* R. Br. and *Solanum nigrum* Linn., were studied at six intervals till 250 m perpendicular to the road at all the four sites. An attempt has been made to correlate the index of dominance of the species with the load of vehicular pollution. Three species, *A. houstonianum*, *S. plebeja* and *S. nigrum*, showed positive correlation with respect to the increasing distance from the road, showing its susceptibility for the pollution whereas *A mexicana* and *R. dentatus* showed positive correlation with the increase in pollution load. However, a comparison between the two species showed that *A. mexicana* was a better bio-indicator of vehicular pollution.

সারসংক্ষেপ

রাস্তার ধারে গাছপালার উপর যান্ত্রিক দূষণের প্রভাব পরীক্ষা করে দেখার জন্য ভারতের উত্তর প্রদেশের পূর্বাংশে চারটি জায়গা চয়ন করা হয় যেখানে যানবাহন চলাচলের ঘনত্ব বিভিন্ন। *Ageratum haustonianum* Mill., *Argemone mexicana* Linn., *Rumex dentatus* Linn., *Salvia plebeja* R. Br. এবং *Solanum nigrum* Linn. এ পাঁচ প্রজাতির গাছের প্রাধান্যকে সূচক হিসাবে গণ্য করে ছয়টি দূরত্বে রাস্তা থেকে ২৫০ মিঃ লম্ব হতে চারটি জায়গায় এ পরীক্ষা করা হয়। এরপর এ পাঁচটি গাছের প্রাধান্য সূচীকে যান্ত্রিক দূষণের সাথে সম্পর্ক স্থাপনের চেষ্টা করা হয়। রাস্তা থেকে ক্রমবর্ধমান দূরত্বে *A. haustonianum*, *S. plebeja* এবং *S. nigrum* প্রজাতিগুলো ধনাত্মক সম্পর্ক দেখিয়েছে যা থেকে এদের দূষণের প্রতি প্রবণতা সম্বন্ধে ধারণা করা যায়। অন্য দিকে দূষণের মাত্রা বৃদ্ধির সঙ্গে *A .mexicana* এবং *R. dentauts* ধনাত্মক সম্পর্ক দেখিয়েছে। যা হোক, এ দুটি প্রজাতির মধ্যে *A. mexicana* কে যান্ত্রিক দূষণের মাত্রা নির্ণয়ে অধিকতর ভাল জীবসূচক হিসেবে গণ্য করা যায়।

Key words : Grand Trunk Road, index of dominance, pollution effect, traffic congestion, vigorousity

Introduction

The various responses of automobile exhaust on the adjacent road-side vegetation have been reported in several studies. In most of the cases the impact of the roads on the environment is negative, but the impact on vegetation is complex. The composition of vehicular exhaust comprises of sulphur oxides. This is absorbed by the plants and interferes in photosynthesis thus affecting its physiology (Darral 1989, Iqbal 1988). The oxides of nitrogen play dual role in plant metabolism, the rate of uptake of nitrate in plants is enhanced at slight higher concentration of nitrogen dioxide in ambient environment thus acting as fertilizer (Jensen and Pelegaard 1993, Qiao and Murray 1998, Rowland *et al.* 1987). But a considerable higher concentration of nitrogen dioxide affects plants adversely (Muller *et al.* 1996, Okano *et al.* 1986). Carbon dioxide acts as fertilizer and enhances the rate of photosynthesis and changes the plant species composition (Bazzaz and Garbutt 1988, Hunt *et al.* 1991). The particulates emitted influence the vegetation by interfering in the gaseous exchange through blocking the stomatal pores (Thompson *et al.* 1984, Tripathi *et al.* 1991). Ethylene is also a constituent of the exhaust, and plants may be highly sensitive to it (Gunderson and Taylor 1988, Taylor *et al.* 1988). Lead, a heavy metal released from the exhaust, causes toxicity in plants and influences the vegetation at a faster rate (Atkins *et al.* 1982). The road-side vegetation is also affected by the run off from the road surface which is rich in organic content, oil and salt (Roberts *et al.* 1980, Rutter and Thompson 1986, Thompson and Rutter 1986).

The persent study is a comparative investigation of gradual change in density of certain selected species of plants along the road-side in response of vehicular pollution. The study is dominance oriented, in which dominance of any plant species away from the road shows its susceptibility and that near the road shows its tolerance to the vehicular pollutants.

Material and method

Study sites

Four study-sites of varying vehicular density were selected. Site-1 was located at Shringarpur on Patrahin to Mehnagar road of Ghazipur in Uttar Pradesh of India, which has a very low traffic load. The remaining three sites were selected on the G. T. Road (Grand Trunk Road) between Allahabad to Mughalsarai of the same state. Site-2 was at Handia which had the load of mostly long route buses and trucks. Site-3 was at Maharajganj and it bears the load of local traffic in addition to the traffic at Site-2. Chandasi was selected as Site-4 on the ground that it is tremendously polluted because of heavy traffic-load and the heavy traffic congestion which is common for the area.

The study-sites were rectangular plots of 50 m x 250 m perpendicular to the road. Sampling was done in the plots along the survey lines parallel to the road at a distance of 20, 50, 100, 150, 200 and 250 m away from the centre of the road.

Plant species composition

Survey of the plant species composition was done during February to April of 1998. Sampling was done at all the sites using 1 m x 1 m quadrat. Ten samples were collected at each sampling belt parallel to the road following the belt transect method. Each and every fifth quadrant on the belt was recorded for further analysis. The collected data were analysed for index of dominance (Simpson 1949) with standard error. The study was oriented towards the plant species which were unevenly distributed at various sites and were unexceptionally common in all the sites irrespective of their densities. In the light of the above, following five plant species were selected for detailed investigation :

(i) *Ageratum houstonianum* Mill.
(ii) *Argemone mexicana* Linn.
(iii) *Rumex dentatus* Linn.
(iv) *Salvia plebeja* R. Br.
(v) *Solanum nigrum* Linn.

In addition to the above five, several other plant species (e. g. *Achyranthes aspera* Linn., *Amaranthus spinosus* Linn., *Calatropis procera* (Ait) R. Br., *Corchorus olitorius* Linn., *Croton bonplandianum* Baill, *Malvestrum tricuspidatum*. A Gray and *Solanum surattense* Burm. f.) were also found. These plants were not considered for the study because of their presence at one or two sites only. Some other plants were also recorded but were not considered for the study because they were uniformly distributed at all the sites i. e. their distribution was unaffected by the vehicular pollution. *Cynodon dactylon* (Linn.) pers., *Cyprus rotundus* Linn. and *Parthenium hysterophorus* Linn. are some of the examples of such plants.

Result and discussion

It is an established fact that the concentration of pollutants will be highest at the edge of the road which gradually decreases as we move away from the road (Tuba and Csintalan 1993). All the studied plant species showed variable result with respect to the pollution load.

The index of dominance of *A. houstonianum* continuously increases at Site-1 as we move away from the source except at 250 m where the value decreases as compared to 200 m (Table 1). At Site-2 and 3 excepting at 150 m the index of dominance continuously rises as we move away from the road (Fig. 1), whereas continuous rise in the index of dominance is seen at Site-4 (Table 4).

The index of dominance of *A. mexicana* shows increasing trend with respect to the pollution load (Fig. 2). As we move away from the road this plant follows decreasing trend. Its maximum value is seen at Site-4 at the distance of 20 m from the road. The value is minimum (i. e. 4.00) at 200 and 250 m at Site-3 (Table 3) and -2 respectively. Thus, this plant shows higher affinity towards the pollution.

The maximum value of the index of dominance in case of *R. dentatus* (9.00) was found at the distance of 50 m at Site-2 (Table 2). The index of dominance decreases as we move away from the road at Site-4. More or less similar observations were recorded at other sites also (Fig. 3). The plants show direct relationship with the increasing load of pollution.

The density of *S. plebeja* was low at all the sites and its index of domiance was minimum (0.01) at Site-4 at the distance of 20 m (Fig. 4). As we move away from the road its value continuously increases showing its maximum value (4.00) at 250 m at Site-1 (Table 1). Execptionally decrease in its value was recorded at 150 m at Site-2 and -3 both (Tables 2 and 3).

S. nigrum showed minimum value of index of dominance (0.09) at Site-4 at the distance of 20 and 50 m both (Table 4), while the maximum was obtained at the distance of 200 m at Site-1 and at other sites at 250 m (Fig. 5). The general trend followed by the plant is of increasing as we move away from the road.

In all the four sites, *A. houstonianum* (Fig. 1), *S. plebeja* (Fig. 4) and *S. nigrum* (Fig. 5) show gradual increase in the index of dominance as we move away from the road. This may be attributed to the effect of higher concentration of sulphur dioxide, which inhibits pollen mitosis, pollen germination and pollen tube growth in selected plant species as reported by Ma and Khan (1976) and Varshney and Varshney (1981). This affects the fertilization and thereby the seed formation. Due to the availability of less number of viable seeds the index of dominance is sure to decrease very near the roads (Banerjee *et al.* 1983). Also sulphur dioxide competes with carbon dioxide in the process of photosynthesis (Ziegler and Happm 1977) thus regarding the growth and development of the plants (Iqbal 1988). Lead is also an important pollutant which hinders physiology and biochemistry of the plants, indirectly affecting its population (Ratcliffe and Beeby 1984, Saxena *et al.* 1991). Among the above plants, greatest variation is seen in the case of *S. plebeja*, which seem to be the most sensitive plant for vehicular pollution.

The index of dominance in the case of *A. mexicana* and *R. dentatus* show positive

Table 1. Index of dominance with respect to distance at Site-1.

Plant species	Distances (m) away from the centre of the road					
	20	50	100	150	200	250
A. houstonianum	4.00[a] ± 0.12[b]	4.41±0.10	5.29±0.15	6.76±0.15	7.84±0.11	7.29±0.13
A. mexicana	6.76±0.11	5.29±0.13	6.67±0.10	5.76±0.12	5.76±0.11	4.84±0.16
R. dentatus	7.84±0.15	6.76±0.13	7.29±0.12	5.76±0.14	4.84±0.16	3.61±0.11
S. plebeja	1.69±0.12	1.44±0.14	1.69±0.11	2.25±0.13	2.56±0.12	4.00±0.12
S. nigrum	1.96±0.13	1.69±0.12	2.56±0.16	3.61±0.13	4.00±0.11	3.61±0.11

Note : a : Index of dominance, b : Standard error

Table 2. Index of dominance with respect to distance at Site-2.

Plant species	Distances (m) away from the centre of the road					
	20	50	100	150	200	250
A. houstonianum	2.56[a]+0.16[b]	4.00±0.12	5.76±0.13	5.29±0.17	6.25±0.11	7.84±0.10
A. mexicana	9.61+0.13	7.84±0.11	6.25±0.12	5.29±0.12	5.29±0.12	4.00±0.14
R. dentatus	7.84±0.16	9.00±0.13	6.76±0.15	6.25±0.15	4.00±0.13	4.41±0.14
S. plebeja	0.36±0.11	0.64±0.10	1.44±0.16	1.21±0.15	1.69±0.09	2.56±0.13
S. nigrum	0.64±0.11	0.49±0.15	1.44±0.13	3.24±0.16	2.56±0.12	4.00±0.13

Note : a : Index of dominance, b : Standard error

Table 3. Index of dominance with respect to distance at Site-3.

Plant species	Distances (m) away from the centre of the road					
	20	50	100	150	200	250
A. houstonianum	1.96[a] ± 0.13[b]	1.96 ± 0.10	4.00 ± 0.12	3.24 ± 0.15	4.84 ± 0.11	8.41 ± 0.11
A. mexicana	10.24 ± 0.16	9.00 ± 0.11	7.84 ± 0.12	4.84 ± 0.11	4.00 ± 0.13	5.29 ± 0.14
R. dentatus	6.76 ± 0.12	6.25 ± 0.15	4.00 ± 0.13	5.29 ± 0.13	4.00 ± 0.14	3.24 ± 0.16
S. plebeja	0.16 ± 0.13	0.25 ± 0.13	1.00 ± 0.11	0.81 ± 0.15	1.44 ± 0.12	2.56 ± 0.14
S. nigrum	0.25 ± 0.11	0.25 ± 0.13	1.00 ± 0.11	1.21 ± 0.16	2.25 ± 0.12	3.24 ± 0.11

Note : a : Index of dominance, b : Standard error

Table 4. Index of dominance with respect to distance at Site-4.

Plant species	Distances (m) away from the centre of the road					
	20	50	100	150	200	250
A. houstonianum	0.64[a]±0.09[b]	1.00±0.10	2.56±0.14	2.89±0.13	4.41±0.11	6.76±0.15
A. mexicana	12.25±0.17	8.41±0.15	6.25±0.10	6.25±0.13	5.29±0.11	5.76±0.12
R. dentatus	7.29±0.11	6.25±0.15	5.29±0.13	4.00±0.16	3.61±0.12	3.24±0.10
S. plebeja	0.01±0.001	0.16±0.07	1.21±0.07	0.64±0.09	1.69±0.09	2.89±0.13
S. nigrum	0.09±0.003	0.09±0.005	0.36±0.13	0.81±0.09	2.89±0.12	3.61±0.14

Note : a : Index of dominance, b : Standard error

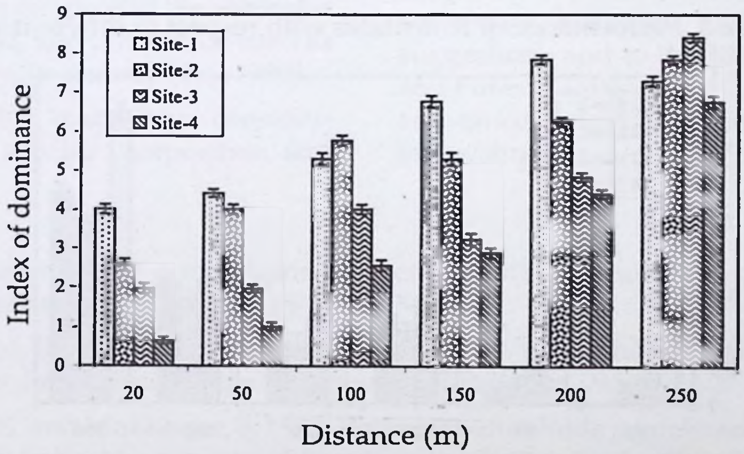

Figure 1. Performance of *A. houstonianum* with respect to different sites.

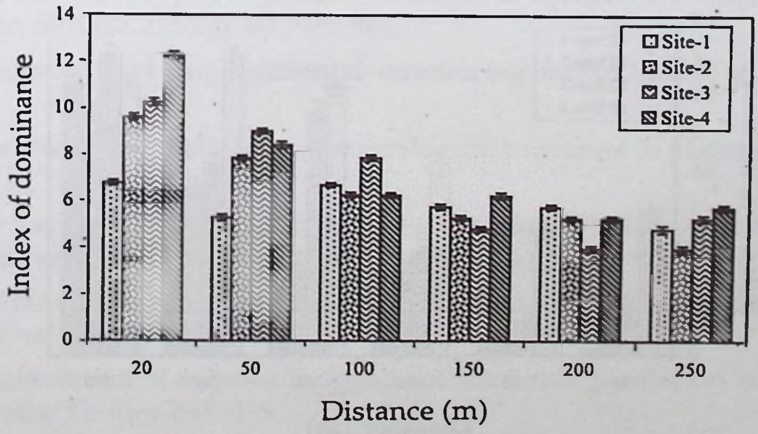

Figure 2. Performance of *A. mexicana* with respect of different sites.

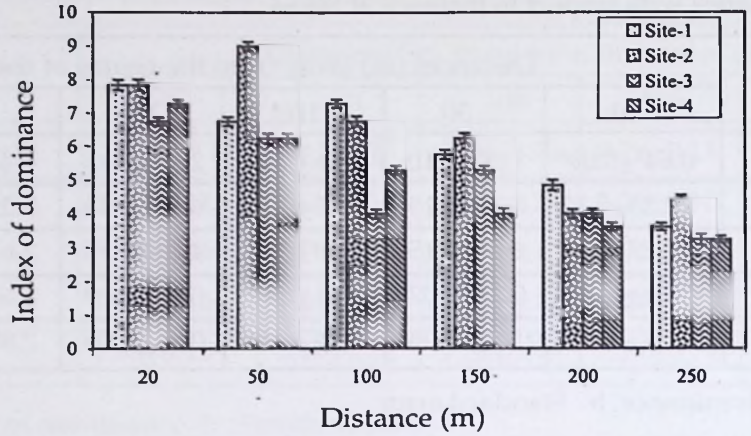

Figure 3. Performance of *R. dentatus* with respect to different sites.

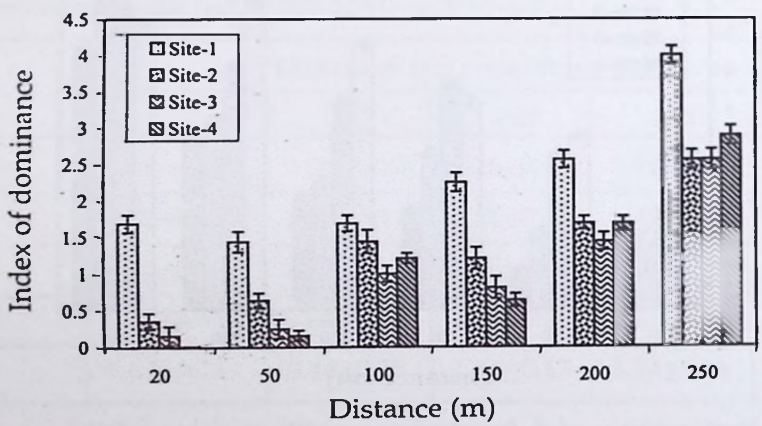

Figure 4. Performance of *S. plebeja* with respect to different sites.

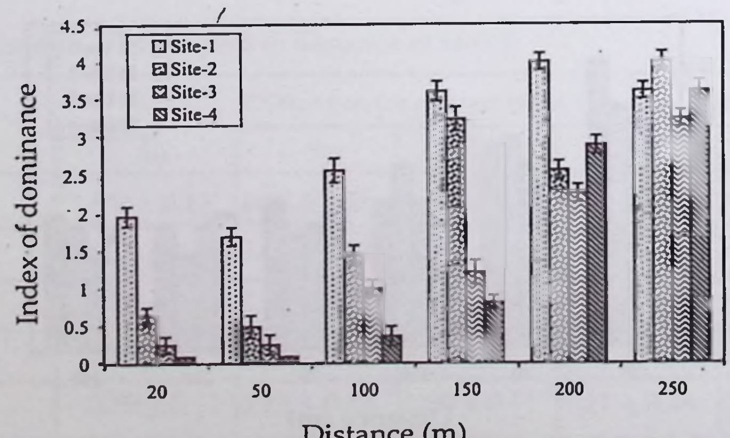

Figure 5. Performance of *S. nigrum* with respect to different sites.

correlation with the pollution load. Their increasing trends towards the source of pollution show their tolerance ability and also the affinity towards the pollutants (Singh *et al.* 1991). We have studied that some of the pollutants act as fertilizer in some plants and increase the vigorousity of the plants (Angold 1997, Atkins *et al.* 1982, Bazzaz and Garbutt 1988, Hunt *et al.* 1991). The same condition seems to be applicable in *A. mexicana* and *R. dentatus*.

A comparison between *A. mexicana* and *R. dentatus* shows that *A. mexicana* has greater affinity for the pollutant as compared to *R. dentatus*. Thus, it can be established that the concentration of *A. mexicana* in an area can prodict the vehicular load of the adjacent road, and can also be used as a bio-indicator of the traffic density (Beg 1980).

Conclusively, the roads have considerable effect on the species composition and performance of vegetation. Near a fast road, changes in the vegetation can be detected till 250 m from the carriage way, while near the slow roads the effect is less far reaching, and positive correlation exists between traffic density and the width of the affected zone.

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