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Research paper

Cumulative effects of roadside fugitive emissions and cement industrial dust on three common greenbelt tree species.

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Abstract: The fugitive emissions contribute a considerable amount of load on ambient air in the industrial sector. Heavy vehicle movements in and around the industry for transportation of raw and final products generate a huge amount of road dust fugitive emissions that contribute to the adjoining area pollution load along with the industrial emissions. In the present study an evaluation of cumulative effect of fugitive dust load and a cement industry load on adjoining tree species growing in the greenbelt around it was made. Three tree species namely Neem (*Azadirachta indica* L.), Karanj (*Millettia pinnata*) and Peela Gulmohar (*Peltophorum pterocarpum*) were evaluated for their response in the stressed ambient air. Trees at Sites (I and III) near the national highway were affected most. Among the three test trees *P. Pterocarpum* was most tolerant followed by *A. indica* and *M. Pinnata*. Photosynthetic pigments and leaf dry matter production decreased significantly at Sites close to NH-8. Leaf wash pH and Leaf extract pH both were highly alkaline in nature as compared to respective control suggesting the alkaline nature of the dust. A serious effort should be made to minimize the fugitive emission load around the industries. Emphasis on Pakka roads in and around industries for transportation, regular dust collection from roads/pavements and water sprinkling, if given, can certainly put a check on fugitive emissions that contribute a lot to the ambient air load.

Keywords: Fugitive emission, Green belt, Cumulative load

INTRODUCTION

Air pollution has been a major concern in developing countries like India. Due to rapid industrialization, increase in infrastructure and construction projects, including mining and crushing activities along with transportation of raw materials, the scenario around various industries and urban sectors is getting worse each day. It is an established fact that the fugitive dust around industrial units, due to poor condition of roads, increased automobile and heavy vehicle moments results in deterioration of air quality. According to Frazer, (2003) vehicle travelling one kilometre of unpaved roadway once a day, every day for a year, one ton of dust may deposit along a passage spreading 500 feet on either side of the road.

The airborne particles thus generated are referred as road side fugitive dust. More The road traffic, more is the fugitive dust generated (Sheridan *et. al*., 2006). The amount of dust emissions that a road produces is also dependent on the"dirtiness" of the unpaved road surface. The road surface aggregate's resistance to abrasion and amount of fine materials, contribute to the amount of road dust generated (Addo *et. al*., 2012). Air pollution can directly affect plants via leaves or indirectly via soil acidification (Steubing *et. al*., 1989). Cement manufacturing sector is one of the major sources of air pollution due to heavy vehicle moments and raw material transfer from limestone mines to cement plant and fugitive emissions generated during limestone blasting, transportation from limestone mines to crusher and crushed material transfer to cement plant, raw material loading and unloading during these activities heavy vehicle moments by haul road as well as final product transported by road. fugitive emissions are generated in all these mentioned activities.

Air pollutants, are responsible for vegetation injury and crop yield losses. It is very difficult to the estimate air pollution effects on vegetation, since various factors like weather conditions, wind speed, temperature and other uncontrolled variables govern them. Even the morphology, anatomy and physiology varies in different plant species (Leghari and Zaidi, 2013).

Air pollution has become a major threat to the survival of plants in the industrial areas (Gupta and Mishra,1994). Damages caused by air pollutants to plant include chlorosis, necrosis and epinasty (Katiyar and Dubey 2001).The leaf are good indicator of air pollutants, plant absorb pollutants through the leaves that can cause a reduction in the concentration of photosynthetic pigments viz., chlorophyll, which directly affect to the plant productivity. The Green belt around various industries plays a major role in mitigating the effects of these air pollutants. They act as shields and check the dispersal of pollutants to long distances, but in doing so are affected by these pollutants.

Chlorophyll is the principal photoreceptor in photosynthesis process. The carotenoids are a class of natural fat-soluble pigments found in plants, algae and photosynthetic bacteria, where they play a critical role in the photosynthetic process (Ong and Tee, 1992) and also protect chlorophyll from photo oxidative destruction (Siefermann-Harms, 1987). A number of recent studies observed that PM_{10} and $PM_{2.5}$ particulate matter generated due to traffic related pollutants and other combination process. Hence, plants can be used as bio indicators in various field of research.

The present study was carried out to study the cumulative effect of road side fugitive dust and the prevailing raw material dust, on physiology of three common green-belt tree species viz., Neem (*Azadirachta indica* L.), Karanj (*Millettia pinnata*) and Peela Gulmohar (*Peltophorum pterocarpum*).

MATERIALS AND METHODS

STUDY SITES

The research site was near to Mohanpura, Kotputli tehsil of Jaipur District (Rajasthan) and is located between two capitals (Delhi and Jaipur) on NH- 08 (Delhi – Jaipur Nation highway near to NCR Delhi area). It is a heavy traffic highway around 8000 to 10000 vehicles passing every day on the highway (data collected from toll tax booth –Mahanpura -Rajasthan). Mohanpura is located at coordinates 270 39′ 36″ N to 270 40′ 28″ N and 760 07′ 33″ E to 760 08′ 36" E, at an elevation of about 355-m above sea level (MSL). The entire area falls in Survey of India topo sheet no.54 A/2. The site is located at about 1.75 km (edge to edge) off

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the National Highway No. 8 and 110 km away from Jaipur-Rajasthan in NE direction.

Ambient air pollution has increased at study site due to the poor road conditions around the industrial complex. Plants growing along with roads in heavy trafficular area are thus exposed to variety of pollutants such as air born particulate matter PM10, $PM_{2.5}$ TSMP, NO_X and SO_2 etc. Six different sites were marked in all directions of the industrial unit for collection plant samples Table-1and Figure 1). Site VI was taken as Reference site about 2.0 KM away from the industry at village Kansli.

Table 1. Ambient Air Quality sampling locations (Sites)

S. No.	Sites	Distance (m) from Cement Plant	Coordinate of sites
01	Site-I	900*	Latitude 27°39'57.8"N longitude 76°07'30.0"E
02	Site- II	700	Latitude 27^{0}40’04.1" N longitude 76^0 07’32.8" E
03	Site-III	600	Latitude 27^{0}40’ 22.4" N longitude 76^0 07'39.1" E
04	Site -IV	800	Latitude 27°.39' 50" N longitude 76$'^0$8,32"
05	Site- V	950	Latitude 27^{0}40’12.4" N longitude 76^0 08’13.4’ E
06	Site-VI (Control site)	2000**	Latitude 27^{0}41’26.1" N longitude 76^0 08’14.6" E

Near National and State highway,*Reference site

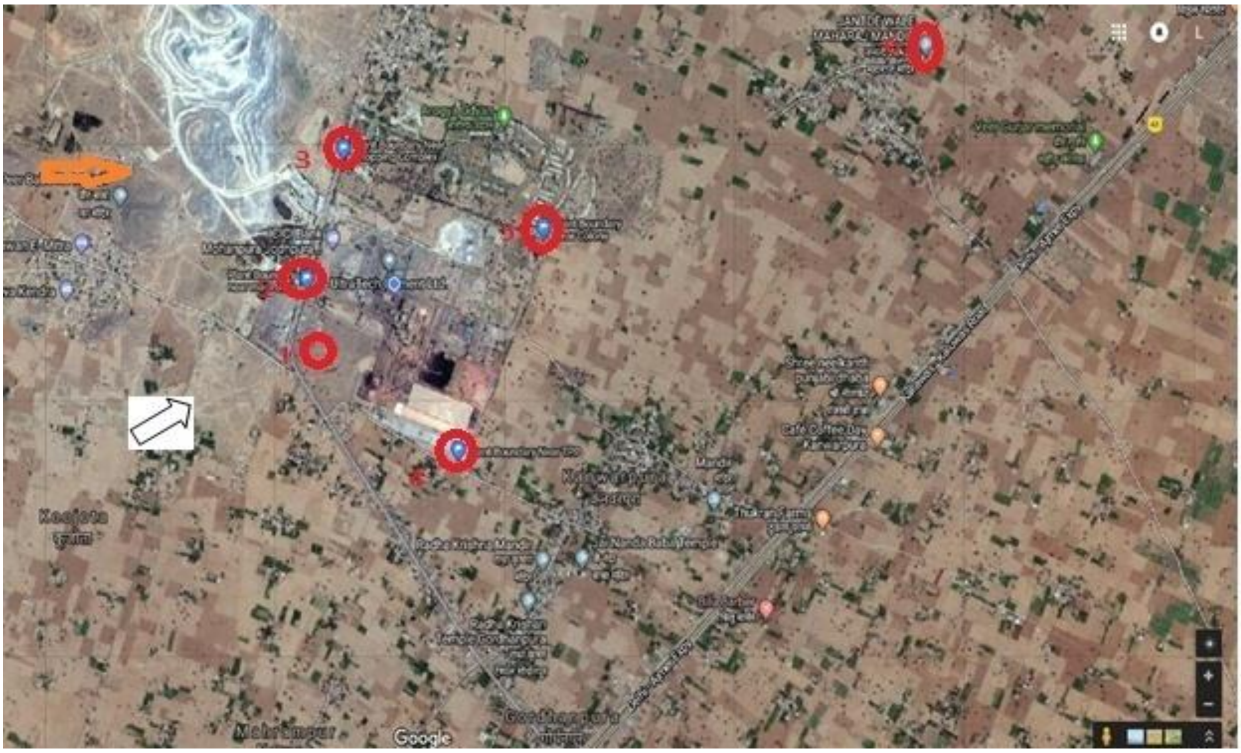

Figure 1. Map Showing Study Sites (Source: Google Earth)

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SAMPLE COLLECTION and ANALYSIS

The tree species common to all the selected sites and of approximately equal apparent growth and health were selected for further study. The three tree species selected for the study were Neem (*Azadirachta indica* L.), Karanj (*Millettia pinnata*) and Peela Gulmohar (*Peltophorum pterocarpum*). Leaf samples from all the test species were collected during winter season (Nov.- Feb.) from a height of 7-8 feet. The whole leaves from different tree species were collected with care in polythene bags and were taken to lab for further analysis. A random grab of 30-50 leaves of various tree species from all canopy strata i.e., upper, middle and lower and from luff and lee wards, were collected. The total chlorophyll content (including Chlorophyll-a and Chlorophyll-b) was estimated following Arnon, (1949) while pH of leaf surface wash and leaf extract was estimated by Systronics digital pH meter and fresh and dry weight of leaves was estimated using digital electronic balance. For dry weight leaves were oven dried at 80° C for 48 hours.

RESULTS AND DISCUSSION

The biochemical and physiological parameters that were evaluated in the present study,reveal that in general, site-I is most affected followed by site-II, IV,III, and V. Site-V is least affected as compared to control. The leaf wash pH study (Table -2), suggests that pH has increased at all the sites over control suggesting a shift towards alkalinity. It can be inferred form this that the dust or particulates that are accumulating over the tree foliage is of alkaline nature. Since Site –V is showing least increase in pH suggests that it has less deposition of the particulates and possibly is in less ambient stress. The Leaf wash pH increase is more comparatively in *Millettia pinnata* followed by *Peltophorum pterocarpum* and *Azadirachta indica*, which suggests the morphological difference of the leaf of different tree species. Probably leaves of *M. Pinnata* holds more particulate dust on its surface as compared to *P. Pterocarpum* and *A. Indica*. The leaf extract pH also reveals a similar trend as that of leaf wash (Table-2). The pH increased at all sites in all the tree species as compared to control site. The pH increase was least at Site-V, while it was maximum at Site-I. The trend of leaf extract pH increase was *P. Pterocarpum* ≡*A. Indica* followed by *M. Pinnata*. It suggests that probably the dust particles that are alkaline in nature as revealed by leaf wash pH might be entering the leaf through stomata and are making the extract pH alkaline. This alkalinity in the system may lead to altered metabolic processes of the plant and may hamper its normal physiology.

Table-3, reveals the effect of particulates on photosynthetic pigments of different test species. Total chlorophyll content decreased more in *A. Indica* and *M. Pinnata* followed by *P. Pterocarpum.* Interestingly chlprophyll 'b' decreased more in *M. pinnata* and *P. pterocarpum* while in *A. Indica*, it was pigment chlorophyll 'a' that decreased more as compared to chlorophyll 'b'.

The overall effect of metabolic alteration due to any stress is reflected on the dry matter (biomass) production of a plant. In the present study (Table-4) reveals the fresh and dry weight alteration with exposure to ambient air pollution at study sites. The fresh and dry weight decreased at all the sites as compared to respective control. However the decrease in dry weight was maximum at site-I followed by site-II, IV, III and V. The decrease comparatively was more in *M. Pinnata* foliowed by *A. Indica and P. Pterocarpum.* It clearly suggests that *M. Pinnata* is comparatively more affected and is less tolerant than the other two tree species studied. *P. Pterocarpum* appears to be most tolerant and is better adapted to such dusty conditions. Secondly the leaflets

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of *P. Pterocarpum* are much smaller than *A. Indica* and probably the size difference provides an edge over other species.
The results shows that concentration of pollutants was maximum at site-I followed by site –IV, II, III and V. Site-VI was the control site and was having least ambient load. Selected plant leaves were exposed to particulate matter (aerosols) and gases generated from heavy traffic movements to light and lighter traffic moments as compared to control sites VI. The fugitive dust load depended on distance of the site from the National highway, Site-I closest to NH-8 and state highway.
The results of this study indicated a decreased physiological performance of all the test tree species not only due to cement industry but also due to road side fugitive emissions. A cumulative impact of industry and bad conditions of haul roads, vehicles at national highway and other stray fugitive emissions of the cement plant, is imposed on the study area and plants are exposed to a collective ambient pollution load.
At this juncture of the study it is clear that the ambient pollution load can be minimised to a great extent by having well maintained pakka roads in and around the industries. Proper and regular cleaning of the roads may add to the purpose. The Green belt development be scientific with proper plantation of tolerant plants having better adaptations for different pollutants. A detail inventory of the traffic pollution load be prepared and monitored regularly along with seasonal variations. An integrated and co-assertive approach from the local and regional levels is required.

Table 2. Cumulative ambient load effect on Leaf wash and Leaf extract pH of three test tree species

Name of plant species	site- I	site- II	site- III	site- IV	site- V	site- VI
Azhadirachta indica						
pH leaf wash	9.21± 0.03 (1.59 ↑)	9.19± 0.24 (1.57 ↑)	9.12 ± 0.03 (1.50 ↑)	9.2 ± 0.032 (1.58 ↑)	8.72 ± 0.23 (1.10 ↑)	7.62 ± 0.276
pH of leaf extract	7.63 ±0.06 (1.48 ↑)	7.61 ±0.07 (1.46 ↑)	7.14 ± 0.05 (0.99 ↑)	7.45±0.054 (1.30 ↑)	6.53 ± 0.24 (0.38 ↑)	6.15± 0.266
Millettia pinnata						
pH leaf wash	9.55± 0.03 (2.40 ↑)	9.12± 0.23 (1.97 ↑)	9.09 ± 0.03 (1.94 ↑)	9.18 ± 0.04(2.03 ↑)	8.22 ± 0.13 (1.07 ↑)	7.15 ± 0.281
pH of leaf extract	7.43 ± .06 (1.33 ↑)	7.39± 0.07 (1.29 ↑)	7.11 ± 0.05 (1.01 ↑)	7.41±0.051 (1.31 ↑)	6.31 ± 0.09 (0.21 ↑)	6.10± 0.169
Peltophorum pterocarpum						
pH leaf wash	9.29± .029 (2.07 ↑)	9.21± .231 (1.99 ↑)	9.12 ±0.03 (1.90 ↑)	9.18± 0.035 (1.96 ↑)	8.52 ± 0.23 (1.30 ↑)	7.22 ± 0.279
pH of leaf extract	7.62 ± 0.060 (1.50 ↑)	7.58± 0.064 (1.46 ↑)	7.13 ± 0.059 (1.01 ↑)	7.47±0.050 (1.35 ↑)	6.51 ± 0.231 (0.39 ↑)	6.12± 0.263

Values in parentheses indicate percent decrease (↓) or increase (↑) over Respective control value ± Standard Deviation,

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Table 3. Cumulative ambient load effect of Photosynthetic pigments of three test trees

Name of plant species	site- I	site- II	site- III	site- IV	site- V	site- VI
			Azhadirachta indica			
Chlorophyll 'a'	1.08± 0.11 (44.62↓)*	1.17± 0.13 (40.00↓)*	1.21 ± 0.23 (37.95↓)*	1.41± 0.31 (27.69↓)	1.72± 0.38 (11.79↓)	1.95± 0.52
Chlorophyll 'b'	0.69±0.011 (30.30↓)*	0.73±0.02 (26.26↓)	0.82 ± 0.02 (17.17↓)	0.88±0.017 (11.11↓)	0.96 ±0.03 (3.03↓)	0.99± 0.06
Total chlorophyll	**1.77± 0.12 (39.79↓)***	**1.90± 0.14 (35.37↓)***	**2.03± 0.24 (30.95↓)**	**2.29± 0.33 (22.11↓)**	**2.68± 0.40 (8.84↓)**	**2.94± 0.78**
			Millettia pinnata			
Chlorophyll 'a'	1.02± 0.19 (39.64↓)*	1.14± 0.21 (32.54↓)*	1.27 ± 0.27 (24.85↓)	1.38± 0.31 (18.34↓)	1.42± 0.38 (15.98↓)	1.69± 0.49
Chlorophyll 'b'	0.67±0.10 (40.18↓)*	0.69± 0.13 (38.39↓)*	0.72 ± 0.14 (35.71↓)	0.79±0.19 (29.46↓)	0.82 ±0.21 (26.79↓)	1.12± 0.25
Total chlorophyll	**1.69± 0.29 (39.86↓)***	**1.83± 0.34 (34.88↓)***	**1.99± 0.41 (29.18↓)**	**2.17± 0.50 (22.78↓)**	**2.24± 0.59 (20.28↓)**	**2.81± 0.74**
			Peltophorum pterocarpum			
Chlorophyll 'a'	1.28± 0.21 (27.27↓)	1.31± 0.24 (25.57↓)	1.47 ± 0.28 (16.48↓)	1.56± 0.31 (11.36↓)	1.69± 0.38 (3.98↓)	1.76± 0.41
Chlorophyll 'b'	0.69±0.076 (29.59↓)	0.72± 0.09 (26.53↓)	0.87 ± 0.11 (11.22↓)	0.89±0.14 (9.18↓)	0.91 ±0.17 (7.14↓)	0.98± 0.21
Total chlorophyll	**1.97± 0.29 (28.10↓)**	**2.03± 0.33 (25.91↓)**	**2.34± 0.39 (14.60↓)**	**2.45± 0.45 (10.58↓)**	**2.60± 0.55 (5.11↓)**	**2.74± 0.62**

Values in parentheses indicate percent decrease (↓) or increase (↑) over Respective control value
± Standard Deviation, *Mean values significant at ($p \leq 0.05$)

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Table 4. Cumulative ambient load effect on Fresh and Dry weight (mg/g) of three test tree species

Name of plant species	site- I	site- II	site- III	site- IV	site- V	site- VI
Azhadirachta indica						
Fresh Weight of leaves	115± 45 **(16.06↓)**	120 ± 39 **(14.60↓)**	125± 29 **(10.95↓)**	121± 36 **(13.87↓)**	125 ± 41 **(8.76↓)**	137± 39
Dry Weight	8.25± 6.1 **(31.25↓)***	8.29 ±4.9 **(27.92↓)**	9.58 ± 3.7 **(19.67↓)**	8.97±5.2 **(20.25↓)**	11.05± 5.2 **(7.92↓)**	12.00 ± 5.97
Millettia pinnata						
Fresh Weight of leaves	82.23± 32 **(28.58↓)**	85.29 ± 21 **(15.55↓)**	89.57± 18 **(11.32↓)**	86.19± 24 **(14.66↓)**	91.78 ± 16 **(9.13↓)**	101.00± 12
Dry Weight	6.89± 4.10 **(34.10↓)***	7.12 ±3.92 **(28.80↓)**	8.02 ± 3.12 **(19.80↓)**	7.95±4.01 **(20.50↓)**	9.15 ± 5.10 **(8.50↓)**	10.00 ± 5.23
Peltophorum pterocarpum						
Fresh Weight of leaves	28.59± 12 **(15.28↓)**	29.01 ± 11 **(13.73↓)**	31.26± 12 **(10.03↓)**	29.95± 14 **(12.63↓)**	35.46 ± 12 **(8.93↓)**	40.00± 11
Dry Weight	5.98± 2.03 **(29.00↓)**	6.92 ±3.12 **(23.11)**	7.28 ± 2.14 **(19.11↓)**	7.12±3.15 **(19.78↓)**	8.19 ± 2.10 **(7.89↓)**	9.00 ± 2.05

Values in parentheses indicate percent decrease (↓) or increase (↑) over Respective control value
± Standard Deviation, * Mean values significant at ($p \leq 0.05$)

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