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RESEARCH ARTICLE

Importance of Common Roadside Plants as Dust Collectors in Tarapur Industrial area

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ABSTRACT

Plants are reliable indicators of dust pollution. Dust fall on leaf surfaces was estimated on four plant species namely, Calotropis gigantea (L.), Hyptis suaveolens (L.), Lantana camara (L.) and Ricinus communis (L.), to ascertain the highest dust capturing potential of common roadside plants at three major road sites in Tarapur industrial area. Dust was collected from leaves in the dry seasons i.e. October –May and expressed in gm/m^2. January and February were identified as the most polluted months as maximum dust deposited in these months amounted to 113 gm/m^2 and 83gm/m^2 respectively. Amongst the different species studied, Hyptis suaveolens (L.) hs the maximum ability to accumulate dust (88gm/m^2 1 way ANOVA, F = 3.75, P = 0.013) followed by Lantana camara (L.)73gm/m^2,Ricinus communis (L.), 65gm/m^2 and Calotropis gigantea (L.),35gm/m^2. The use of Hyptis suaveolens to monitor dust pollution is recommended and hence should be planted on roadside hedges and other public places to reduce atmospheric dust pollution.

KEY WORDS: - Industrial area, foliar dust fall, seasonal SPM (suspended particulate matter), Hyptis suaveolens(L.), dust monitor.

INTRODUCTION

Air pollution is one of the most severe environmental concerns faced globally. Anthropogenic activities including urbanization, industrialization and transporta- tion, contribute to amplified pollutant levels in the air due to the increase in harmful gases like sulfur dioxide (SO_2), nitrogen dioxide(NO_2), carbon monoxide (CO) and Suspended particulate matter (SPM) (Joshi and Chauhan, 2008). Dust pollution itself comprises 40% of total air pollution problems in India (Lone *et al.*, 2005). In urban environment, pollutants commonly found in dust on the roads can be potentially harmful to roadside vegetation, wildlife and the neighboring human settlements (Bhattacharya *et al* 2011). Thus the use of vegetation to filter out dust, soot and particulates from the atmosphere has been extensively used as a common practice in developed countries (Yunus *et al.*, 1985). Plants can be effectively used for monitoring air pollutants as different plant species respond to different types of air pollutants (Joshi, 1990). Plant leaves has been regarded as bio-filters as they absorb large quantities of particles from the environment (CPCB 2007). The dust interception capacity of a plant depends on its surface geometry, phyllotaxy and external characteristics of its leaf such as hairs, cuticle, length of petioles, height /canopy of trees and the prevailing weather conditions with direction and speed of the wind (Prajapati and Tripathi, 2008). Plants have the potential to serve as an excellent quantitative and qualitative tool to evaluate the impact of air pollution (Wagh *et al*., 2006).

Central Pollution Control Board (CPCB) has selected 24 areas in India designated as 'Critically Polluted Areas' (CPA) with respect to air and water pollution (CPCB 2003). Tarapur is an industrial town situated in the Thane district of Maharashtra, India (Fig 1.A) located at 17°42′N 75°28′E , 17.7°N 75.47°E. MIDC Tarapur one among the 24 specified areas was selected for the current study. It was established in 1972 by the Government of Maharashtra and is one of the largest chemical industrial belts of the state. It is 100 km away from Mumbai and is located at a distance of 45 km North of Virar on the Western railway line of the Mumbai Suburban Railway and around 20 km off the National highway NH-8. Boisar is the nearest Railway station to MIDC Tarapur. The total area available for industries here is 852.74 hectares (MPCB 2010). There is continuous movement of heavy transportation vehicles in and around this industrial area. Also public transport like State transport buses and auto-rickshaws ply in M.I.D.C. throughout the day. Due to heavy vehicular traffic there is circulation of suspended particulate matter in the ambient surrounding which accumulates on roadside plants. The roadside plants that grow in this area include shrubs, trees and seasonal flora. Since this area experiences rainfall from May to October, the study was performed by collecting plant samples only in the dry seasons, which is October to May.

Maharashtra Pollution Control Board (MPCB) has only one air monitoring station in Tarapur, thus limited data on air quality of Tarapur is available. The commonly found plant species that exist on the roadsides and street dividers were used in this study to monitor gravitational dust fall on the plants. The study was conducted in three ideally located areas, which were selected and monitored for dust fall, on a monthly basis.

MATERIALS AND METHODS

Study area: - The important roads connecting Tarapur M.I.D.C. are:-

1) Boisar- Tarapur road (Site A):- Road passing through commercial complexes and residential colonies, comprises of regular traffic with state transport buses and private vehicles.

2) Navapur road (Site B):- Road passing through the centre of Tarapur M.I.D.C. and has heavy vehicular traffic comprising of trucks, auto-rickshaws and buses.

3) MIDC road (Site C):-Road passing through the outskirts of Tarapur M.I.D.C. and is interconnected with Navapur road. Heavy moving traffic is seen as it is also connected to the state highway (Fig 1B).

Fig. 1A: Location of Boisar (Tarapur MIDC) with reference to Mumbai.

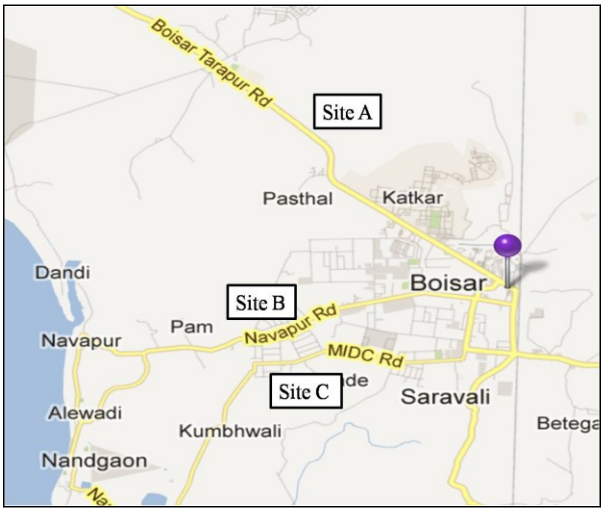

Fig. 1 B: Location of study sites: - Boisar- Tarapur road (Site A), Navapur road (Site B) and MIDC road (Site C).

Sampling : Plant samples were collected from both sides of the main roads identified. Since the dust experiment was carried out in the dry season i.e. from October– May, 4 common plant species namely, *Calotropis gigantea* (L.), *Hyptis suaveolens* (L.), *Lantana camara* (L.) and *Ricinus communis* (L.) were available at all sites for uniform comparison. Leaves from these roadside plants were collected in separate zipper pouches, in triplicate, every month and were then brought to the laboratory. Dust from the leaves of each plant sample was washed with water using spray bottles and was carefully collected on pre-weighed Whatman's filter paper (pore size 110mm). The filter paper was then oven dried and later weighed to calculate the dust fall. Washed leaves were blotted dry and then traced on graph paper which gave the total leaf area in cm^2 and dust fall was calculated in gms/m^2 (Chaphekar *et al*. 1980).

Statistical analysis: - Box and whisker plots were used for exploratory data analysis. The data was tested for normality using K-S test and Analysis of Variance (Zar, 2009) was applied to determine significant differences between the plant species. Statistical analysis was carried out using SPSS software version 11.

RESULTS AND DISCUSSIONS

The dust fall quantified, on the leaf surfaces of *Calotropis gigantea* (L.), *Hyptis suaveolens* (L.), *Lantana camara* (L.) and *Ricinus communis* (L.) present at the three study sites are represented in the Table 1.0. The readings were taken in the post monsoon months from October (2011) – May (2012).

It was observed that Boisar-Tarapur road (**Site A)** showed comparatively less dust fall as compared to Navapur road (**Site B)** and MIDC road (**Site C)**. Site A is located in a residential area where heavy movement of vehicles is not observed. Site B on the other hand showed very high dust fall followed by Site C. This is because Site B is located in the Centre of Tarapur M.I.D.C. where there is continuous heavy vehicular movement and high emission of particulates from nearby industries. Site C also showed good dust fall, due to it being linked with main roads and interconnected with M.I.D.C. It is also harbored by traffic and industrial emission but lesser than Site B (Fig 2.0).

One Way ANOVA results show that between all three sites, Site B had significantly more dust deposited than other two sites i.e. Site A and Site C. (ANOVA $F=9.11$, $P<0.001$). Multiple range tests (Duncans MRT) suggest that all three sites differ significantly in their quantity of deposition ($P<0.05$).

Amongst the different species studied, *Hyptis* has the maximum ability to accumulate dust (1 way ANOVA, $F = 3.75$, $P = 0.013$). The box and whisker plot (Fig.3.0) gives the details of different plant species using Duncan's Multiple range tests reveals that the order of dust accumulation is as follows: *Hyptis*, *Lantana*, *Ricinus*, *Calotropis*, with *Calotropis* being significantly less ($P<0.05$) than *Hyptis* and *Lantana*. From statistical analysis it is clear that amongst all the four plants, the dust capturing potential is ordered as *Hyptis suaveolens* (L.)>*Lantana camara* (L.)>*Ricinus communis* (L.)>*Calotropis gigantea* (L.). Amongst the different species studied *Hyptis suaveolens* (L.) has the maximum ability to accumulate dust with 88gm/m^2 followed by *Lantana camara* (L.)73gm/m^2, *Ricinus communis* (L.), 65 gm/$m^2$and *Calotropis gigantea* (L.),35gm/m^2. *Hyptis* and *Lantana* have trichomes on leaf surfaces, hence captured more dust (Fig.4.0).

Table1.0 Monthly Dust fall in gm/m^2on Roadside plants in Tarapur Industrial area:-

Plant name	Site No.	Dust fall in gm/m^2							
		Oct	Nov	Dec	Jan	Feb	March	April	May
***Calotropis gigantea* (L.)**	**A**	9.41	11.25	21.42	24.6	3.33	15.15	14.44	11.90
	B	21.42	29.67	38.09	42.66	155	96.42	26.47	16.3
	C	20.21	24.6	26.47	50	89.65	15.15	56.86	15.15
***Hyptis suaveolens* (L.)**	**A**	16.66	26.47	33.33	55.55	80	100	56.25	50
	B	80	94.44	100	133.33	100	133.33	60	300
	C	50	55.55	56.25	57.14	175	66.66	42.30	183.33
***Lantana camara* (L.)**	**A**	29.67	33.33	38.09	46.66	25	52.72	48.38	33.96
	B	48.38	71.25	84.21	278.57	171.42	84.21	29.67	46.80
	C	60	90.62	100	220	6.33	90.62	46.80	33.33
***Ricinus communis* (L.)**	**A**	25	32.92	37.32	52.72	62.74	50	37.2	33.03
	B	61.90	72.72	92.18	330	33.23	66.66	92.18	41.37
	C	32.92	51.61	61.90	74.54	95.16	59.18	42.66	32.92

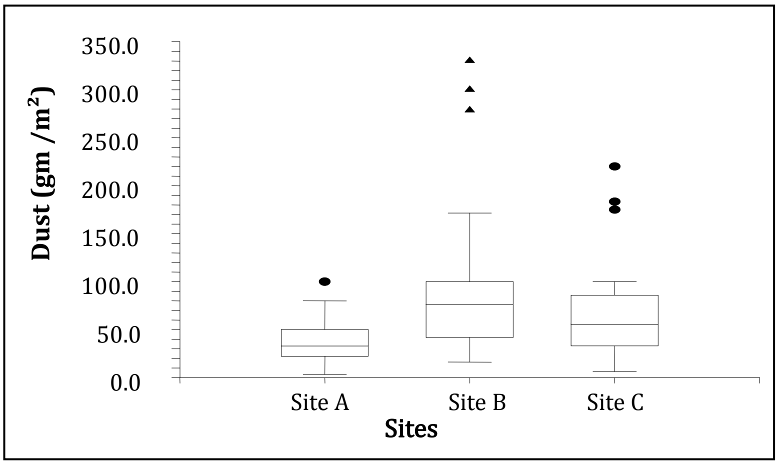

Fig. 2 : The three sampled site A (Boisar), Site B (Navapur road) and Site C (MIDC road) differed in their dust pollution as depicted by dust accumulation on leaf surfaces (ANOVA F=9.11, P < 0.001).

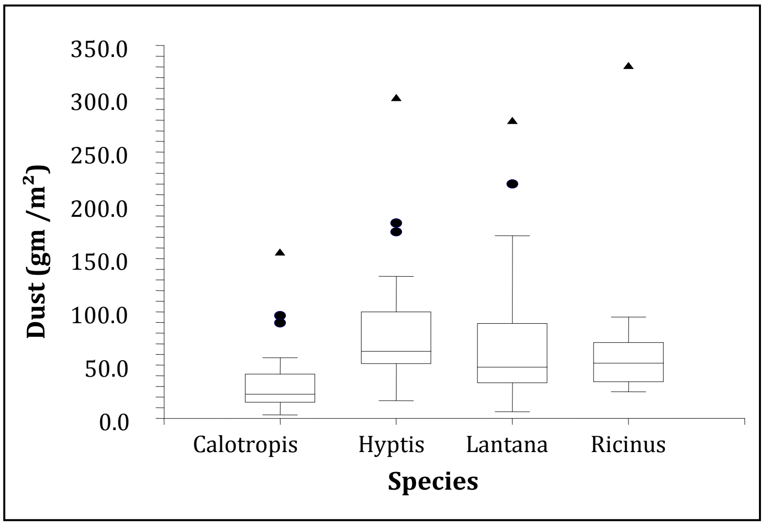

Fig. 3 : *Hyptis suaveolens* (L.) had the highest Dust accumulating capacity followed by *Lantana camara* (L.)(ANOVA, F =3.75; P =0.013).

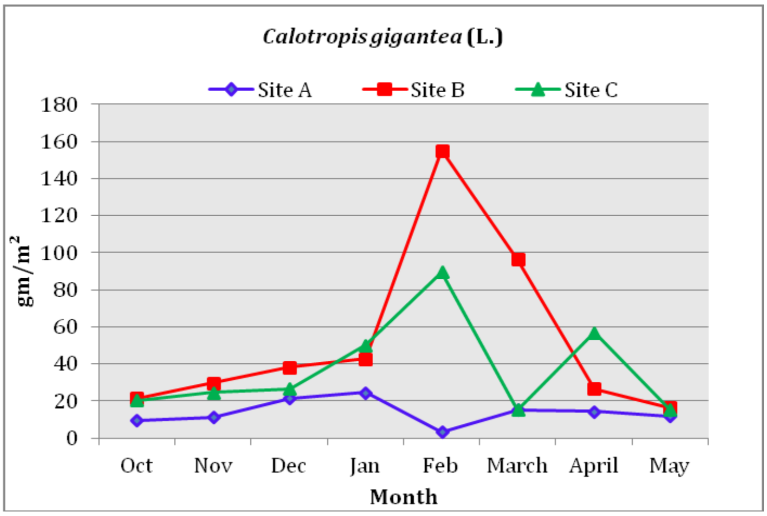

Fig.4: Monthly gravitational Dust fall on *Calotropis gigantea* (L.) at different sites.

It was observed that the maximum dust fall from the different species of plants varied in different months of study. *Calotropis gigantea* (L.) showed the highest dust fall in the month of February with 155 gm/m² and 89.65 gm/m² of dust at Site B and Site C respectively, followed by March with 96.42 gm/m² at Site B (Fig. 4.0). Dust fall for *Hyptis suaveolens* (L.)(Fig. 5.0) was highest in the month of March with 100 gm/m² at Site A and 133.33 gm/m² at Site B. In the month of May the dust fall for *Hyptis suaveolens* (L.) was 300 gm/m² at Site B and 183.33 gm/m² at Site C, while in January it was 133.33 gm/m² at Site B and in February with 175 gm/m² at Site C. *Lantana camara* (L.)(Fig. 6.0) showed highest dust fall in January with 278.57 gm/m² at Site B and 220gm/m² at Site C, followed by February, with 171.42 gm/m² at Site B and in December with 100 gm/m² at Site C. Dust fall for *Ricinus communis* (L.)(Fig.7.0) was observed to be highest in the month of January with 330 gm/m² at Site B and February with 95.16 gm/m² at Site C.

All the four plants in the study i.e. *Calotropis gigantea* (L.), *Lantana camara* (L.), *Hyptis suaveolens* (L.) and *Ricinus communis* (L.) showed the highest dust fall in January, February and December (Fig.8.0,Fig.9.0 and Fig.10.0). Wind speed is generally high in summer and Monsoons but calm during the winter season. Also due to high humidity dust storms are a regular feature during the pre- monsoon period. During the winter temperature at night is lower than the temperature in the day. Therefore air near the ground cools faster at night and emissions from the warmer surroundings sink to ground level. Upward motion of the pollutant is restricted and hence high SPM level is seen during the winter season (CPCB 2007). SPM concentration is mainly affected by moving vehicles and during winter, calm winds are experienced which result in little dispersion of pollutants causing higher levels of SPM (Chauhan and Pawar, 2010). *Hyptis suaveolens* (L.), in addition, also showed the highest dust fall in May.

This may be due to the dense hairy leaf surface of *Hyptis* which trapped the dust, in spite of high speed winds. Construction activity of road dividers at Site B and Site C contributed to excessive road dust. From the above study, it can be concluded that roadside

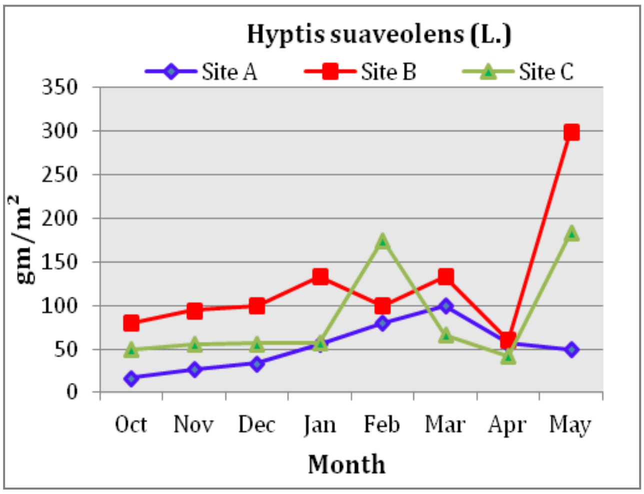

Fig. 5: Monthly gravitational Dust fall on *Hyptis suaveolens* (L.) at different sites.

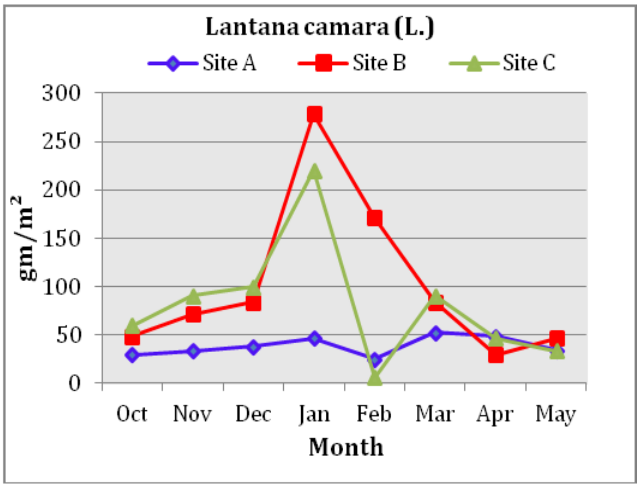

Fig. 6: Monthly gravitational Dust fall on *Lantana camara* (L.) at different sites.

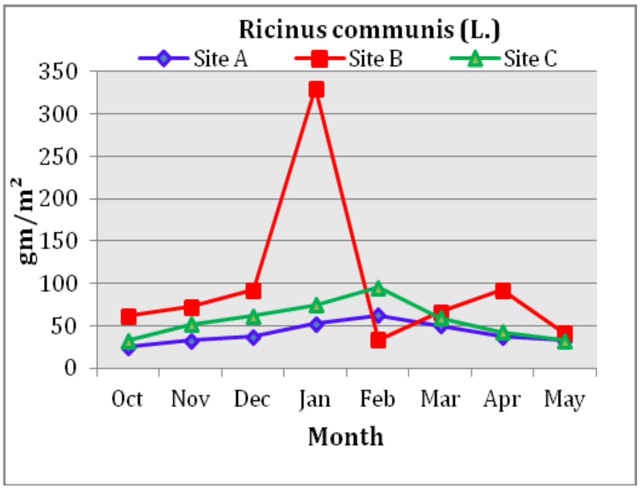

Fig. 7: Monthly gravitational Dust fall on *Ricinus communis* (L.) at different sites.

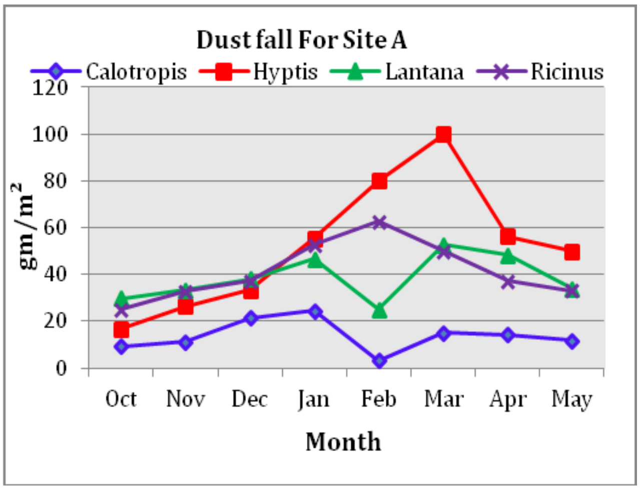

Fig. 8 : Monthly variations in Dust fall in gm/m^2 at Site A as depicted by various plant species in the study.

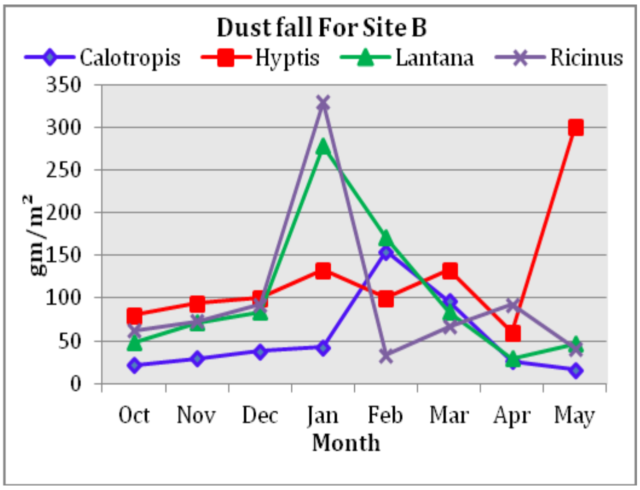

Fig. 9 : Monthly variations in Dust fall in gm/m^2 at Site B as depicted by various plant species in the study.

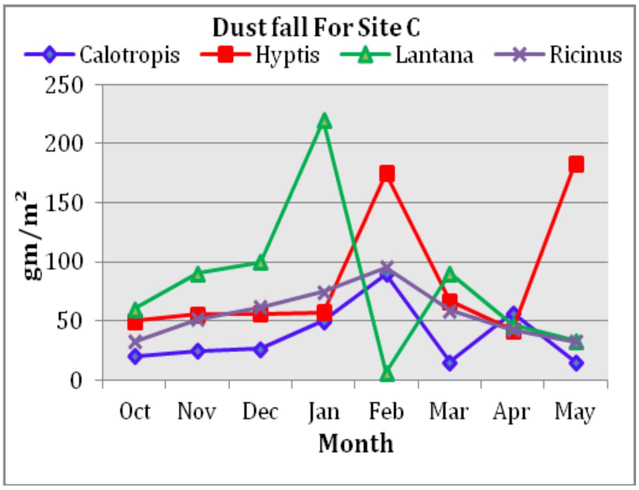

Fig. 10: Monthly variations in Dust fall in gm/m^2 at Site C as depicted by various plant species in the study.

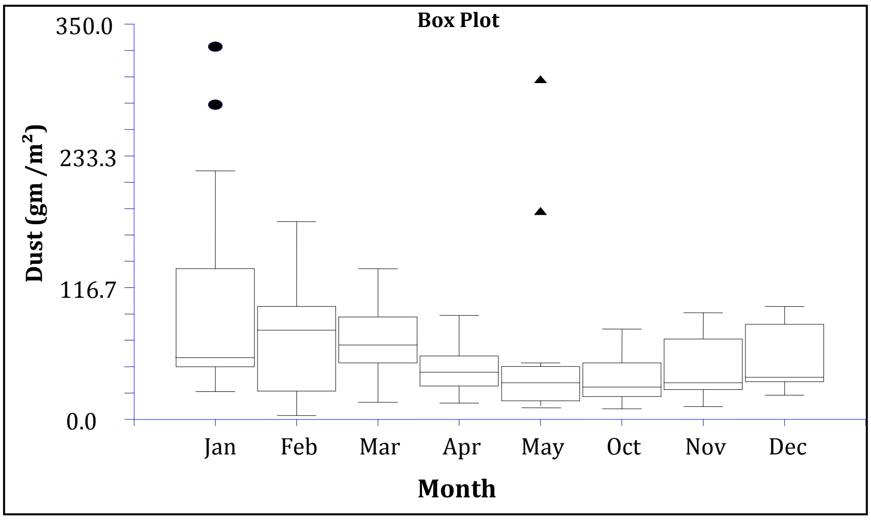

Fig 11: Box and Whisker plots showing Dust accumulation during different months

plants serve well to study the suspend- ed particulate matter in the surround- ding atmosphere and can prove an effective sink for air pollutants. Site A showed less dust on *Hyptis suaveolens* (L.) in all the months and sites in comparison with Site B and Site C.

CONCLUSIONS

Different plants have different dust capturing capacities. The dust fall depends on local and regional climatic as well as microclimatic conditions. December, January and February show a high proportion of dust fall (fig 11). January and February were the most polluted months as the maximum dust deposited amounted to 113 gm/m^2 and 83gm/m^2 respectively (fig11.0). These months are the winter months with slower wind speeds. High values of dust are seen in some months largely due to construction or road making activities at the sites where readings were taken.

This study concludes that plants like *Hyptis suaveolens* (L.) and *Lantana camara* (L.) can effectively be used as active monitors for dust fall. Plants can either be placed or locally grown to monitor dust accumulation and fall. Using plants as monitors of dust has advantage over more sophisticated and costly energy instruments. Thus use of plants can be a cost-effective substituent and can be placed at specific sites and also do not risk pilferage

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