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Assessment of dust capturing capacity of selected ornamentals at southern parts of Andhra Pradesh

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Abstract
Sixteen ornamental species were assessed for their, dust capturing capacity in five different polluted locations. Two seasons sampling was done in pre-monsoon and post-monsoon respectively to study their seasonal variations. According to the Dust capturing capacity values, *Conocarpus erectus, Spathodea campanulata, Rhoeo spathacea, Codiaeum variegatum* were recorded as the plants having the best dust capturing capacity. So these species can be recommended for the heavy traffic, commercial and industrial areas for greenbelt development.

Keywords: Dust capturing capacity, DCC, ornamental plants, air pollution

Introduction
Air pollutants comprising of particulate matter (PM), vehicular exhaust, and industrial emissions cause adverse health effects in humans, disturb plant ecosystem, and impact globally by altering the atmosphere. Foliar surface of plants acts as a sink for deposition of air pollutants in the urban and industrial environment. Plants that are tolerant to air pollutants and particulate matter (PM) are explored and increasingly considered as an eco-sustainable tool for mitigation of air pollution. Trees act as a sink for both particulates and gaseous pollutants. Use of plant canopies to reduce atmospheric particle concentration was reported by Lohr and Pearson-Mims (1996) [12]. Screening and identification of plants that are adaptive to the native environment of polluted sites provide ecological restoration strategies to mitigate the impact of air pollution. Considerable biomonitoring studies have been conducted, in past using several plant species (Baslar *et al.*, 2009, 2005; Yilmaz and Zengin, 2004; Yilmaz *et al.*, 2006; Dogan *et al.*, 2007; Huseyinova *et al.*, 2009; Sánchez-Chardi, 2016) [4, 3, 20, 19, 6, 8, 15]. The use of plants in the purification of atmosphere has been practiced since long. Biomonitoring approach is an economical and reliable alternative to the conventional air monitoring methods used for detecting the presence of pollutants (Durkan *et al.*, 2011; Unver *et al.*, 2015) [7, 17]. Accumulation of dust particles depends on inter nodal distance, petiole length, leaf area, orientation, margin, folding and arrangement, hair density, hair type and length (Yan and Hui, 2008) [18]. Leaves of plants act as an environmental sink as it provides wide surface area for impingement, soaking up and accumulation of air pollutants (Balasubramanian *et al.*, 2018) [2]. Based on the above considerations, in our study to know the sustainability of plants in different polluted areas.

Material and Methods
The present investigation was carried out during the year 2020-2021 at five different locations *viz.*, College of Horticulture, Anantharajupeta (Control site, L_1), Mangampeta (Barytes mining area, L_2), Leela Mahal center to Alipiri area of Tirupathi (city, main road heavy traffic and fly over constructing area including Muncipal park, Tirupati, L_3), Cherlopalle (Tirupati rural, brick kilns area, L_4), Gajulamandyam (Tirupati rural, plastic industrial estate, L_5).

Experimental Sites
1. College of Horticulture, Anantharajupeta (control site L_1)
This is an educational institute which was selected as control site because this college area is covered with a huge number of ornamental trees, climbers, shrubs, herbs, palms, ornamental foliage plants and ground covers. Vehicular, anthropogenic activities, gaseous and air pollutants released in the environment from all sides is comparatively less and minimal at the institute.

2. Mangampeta (Barytes mining area and road traffic area L_2)

It is a massive mining area. The roads of this area bear a very heavy traffic load, including large trucks, loaded trucks, mini trucks, private buses, very high number of cars and public buses. Dust accumulation is more due to mining in this area. Lot of dust pollution occurred at core zone and buffer zone area at mining site along with increased levels of traffic pollution due to vehicle movement.

3. Leela Mahal center to Alipiri area of Tirupathi (city, main road heavy traffic and fly over constructing area including Muncipal park, Tirupati, L_3)

Tirupati city - main road heavy traffic area experienced a highest level of urbanization wherein tourists flow from all over India round the year will be high with increased transportation and other activities in the region. Since, Tirupati is a gateway for all the activities, apart from the all types of vehicles, this has also experiencing high density of heavy vehicles like trucks especially for the different crop produce marketing throughout the year along with heavy crowd movement. The roads at the town area serve as a connecting link with important tourist areas.

4. Cherlopalle (Tirupati rural, brick kilns area, L_4)

The area is located near many brick manufacturing units exists and having high level of pollution.

5. Gajulamandyam (Tirupati rural, plastic industrial estate, L_5)

It has experienced a highest level of pollution from many plastic manufacturing and other industries units in and around this location.

Plant Material

Already growing, existing and commonly occurring multiple ornamental plants at five study sites were selected for investigation. In all five study sites, same ornamental plant species were selected uniformly and tagged randomly as per replication and details of plant species selected are given below.

Details of treatments [Ornamental plant (OP)]

S. No	Common name	Botanical name	Family	Plant type
1	Raintree	*Samanea saman*	Leguminosae	Ornamental tree
2	Neem	*Azadiracta indica*	Meliaceae	Ornamental tree
3	Scarlet Bell tree	*Spathodea campanulata*	Bignoniaceae	Ornamental tree
4	Rosy trumpet tree	*Tabebuia rosea*	Bignoniaceae	Ornamental tree
5	White Frangipani	*Plumeria pudica*	Apocynaceae	Ornamental tree
6	Yellow oleander	*Thevetia peruviana*	Apocynaceae	Ornamental tree
7	Sacred fig	*Ficis religiosa*	Moraceae	Ornamental tree
8	Ficus panda	*Ficus panda/Ficus retusa*	Moraceae	Ornamental shrub
8	Arrowhead plant	*Syngonium podophyllum*	Araceae	Ornamental foliage plant
9	Corn stalk dracaena	*Dracaena fragrans 'Victoria'*	Asparagaceae	Ornamental foliage plant
10	Moses in the cradle	*Rhoeo spathacea*	Commelinaceae	Ornamental foliage plant
11	Garden croton	*Codiaeum variegatum*	Euphorbiaceae	Ornamental foliage plant
12	Desert rose	*Adenium obesum*	Apocynaceae	Ornamental succulent/shrub
13	Crown of thorns	*Euphorbia milii*	Euphorbiaceae	Ornamental succulent
14	Pedilanthus	*Pedilanthus tithymaloides*	Euphorbiaceae	Ornamental succulent
15	Areca palm/butterfly palm	*Areca lutescens*	Arecaceae	Ornamental Palm
16	Golden bamboo	*Phyllostachys aurea*	Poaceae	Ornamental bamboo

Note: OP-Ornamental plant

Collection of Experimental Data

To assess the impact of air, vehicular pollution and dust particles from road side and control site were collected from fully matured leaves during morning hours (Akilan and Nandhakumar, 2016) [1]. The leaf samples were collected in polythene covers and were carried to the laboratory for analysis. Leaf samples were collected during two seasons *i.e.,* Pre- Monsoon season and Post- monsoon season (2020-2021). Leaves facing the roadside were plucked mainly on the same day at all the five locations during each season (Tsega and Deviprasad, 2014; Kaur and Nagpal, 2017) [16, 10].

Dust Capturing capacity (mg cm^{-2})

For calculating the dust capturing capacity (DCC), filter paper was oven dried and weighed to record their initial weight (D_1). The dust deposited on leaf sample was washed using a brush with double distil water. The water containing dust was passed through the pre weighed filter paper, followed by eventual drying (85 °C for 4 h) and weighing. The dried weight of filter paper having washed dust is D_2. The surface area of washed leaves was calculated using graph sheets (S). Calculation of dust capturing capacity was done using the formula below (Manisha and Pal, 2014) [13]:

$$DCC\ (mg/cm^2) = D_2 - D_1\ mg/S\ cm^2$$

Where: D_1 = Initial weight of filter paper; D_2 = Final weight of filter paper with dust; S = Total area of the leaf (cm^2)

Statistical analysis

Seasonal variation of different physiological, biochemical parameters, pattern and their significance level were computed using three-factorial RBD with ornamental plants, different locations and seasons as three factors for analysis. The significance of the analyzed data was tabled at 5 per cent level of significance.

Results and Discussion

Dust capturing capacity (mg cm^{-2})

The data pertaining to (DCC) Dust capturing capacity of the ornamental plants at different locations during different seasons was significantly the data different under different pollution locations was furnished in table 1.

In ornamental plants studied during the year 2020-2021, significant highest dust capturing capacity was recorded in OP_6 (0.52 mg cm^{-2}) which was at par with OP_3 (0.49 mg cm^{-2}), OP_{11} (0.48 mg cm^{-2}), OP_{12} (0.48 mg cm^{-2}) while the lowest was recorded in OP_1 (0.20 mg cm^{-2}). In the seasons studied, Pre-monsoon season S_1 (0.40 mg cm^{-2}) has recorded highest dust capturing capacity. Whereas among the locations studied L_5 (0.47 mg cm^{-2}) has recorded the highest dust capturing capacity which was comparable with L_4 (0.45 mg cm^{-2}) while the lowest was recorded in L_1 (0.16 mg cm^{-2}). Among the interactions of OPXS, significant highest dust capturing capacity was recorded in OP_6S_1 (0.67 mg cm^{-2}) and the lowest was recorded in OP_1S_2 (0.18 mg cm^{-2}). While in the interactions of OPXL, highest DCC (dust capturing capacity) was recorded in OP_6L_5 (0.74 mg cm^{-2}) which stood at a par with OP_3L_2 (0.63 mg cm^{-2}), OP_6L_2 (0.67 mg cm^{-2}), OP_3L_3 (0.66 mg cm^{-2}), $OP_{11}L_3$ (0.70 mg cm^{-2}), $OP_{14}L_5$ (0.67) and $OP_{16}L_5$ (0.64) while the lowest was recorded in OP_7L_1, OP_9L_1 (0.08 mg cm^{-2}). Among the interactions of OPXSXL highest DCC was recorded in $OP_{16}S_1L_5$ (0.87 mg cm^{-2}) which was comparable with $OP_3S_1L_2$ (0.81 mg cm^{-2}), $OP_6S_1L_2$ (0.79 mg cm^{-2}), $OP_8S_1L_2$ (0.70 mg cm^{-2}), $OP_{11}S_1L_2$ (0.75 mg cm^{-2}), $OP_3S_1L_3$ (0.82 mg cm^{-2}), $OP_6S_1L_3$ (0.77 mg cm^{-2}), $OP_{11}S_1L_3$ (0.74 mg cm^{-2}), $OP_4S_1L_4$ (0.70 mg cm^{-2}), $OP_5S_1L_4$ (0.73 mg cm^{-2}), $OP_6S_1L_4$ (0.7 mg cm^{-2}), $OP_{14}S_1L_4$ (0.74 mg cm^{-2}), $OP_{14}S_1L_5$ (0.70 mg cm^{-2}), $OP_4S_2L_3$ (0.70 mg cm^{-2}), $OP_{12}S_2L_4$ (0.73 mg cm^{-2}), $OP_{15}S_2L_5$ (0.71 mg cm^{-2}) and $OP_6S_1L_5$ (0.85 mg cm^{-2}), while the lowest was recorded in $OP_7S_2L_1$ (0.03 mg cm^{-2}).

It was observed that *Conocarpus erectus*, *Spathodea campanulata*, *Rhoeo spathacea*, *Codiaeum variegatum* has recorded the highest dust capturing capacity. This may be due to the dense hairy leaf surface of the leaves which trapped the dust, in spite of high speed winds. Highest dust fall was observed in L5 and L4 compared to all other areas, which might be due to the areas experiencing main road heavy traffic, highest level of urbanization wherein tourists flow from all over India round the year will be high with increased transportation and other activities in the region. Whereas DCC was recorded lowest in L_1 (College of Horticulture, Anantharajupeta). Lot of dust pollution occurred at core zone and buffer zone area at mining site (L_2) along with increased levels of traffic pollution due to vehicle movement. Also pollution from the plastic manufacturing units and industries in and around the locations. It is also observed that pre-monsoon (S_1) has experienced the high dust fall when compared to post-monsoon season (S_2). The higher leaf dust accumulation in the pre monsoon season may be attributed due to higher temperature conditions in the study area as compared to post monsoon months. Further this may be attributed to the road making activities in the study area in pre monsoon season. These results are in corroboration with the findings of Rahul and Jain (2014) [14], (Joshi *et al.*, 2014) [9], Younis *et al*. (2013) [21]

The dust interception ability of plants mainly depends on leaf orientation and its sessile or semi sessile nature. Leaves with larger petioles can be easily be put into motion by minor air movement, and hence hold lesser dust. Dust retention also depends upon the foliar morphology, leaf area and the characteristics of the structure of the leaf like roughness of the surface, shape of the leaves and the trichomes present in the upper and lower epidermis (Chai *et al.* 2005; Liu *et al.* 2012) [5, 11]. The highest dust accumulation at polluted sites might be due to very high traffic density, mining, and lowest dust accumulation at control site was due to minimal vehicular density.

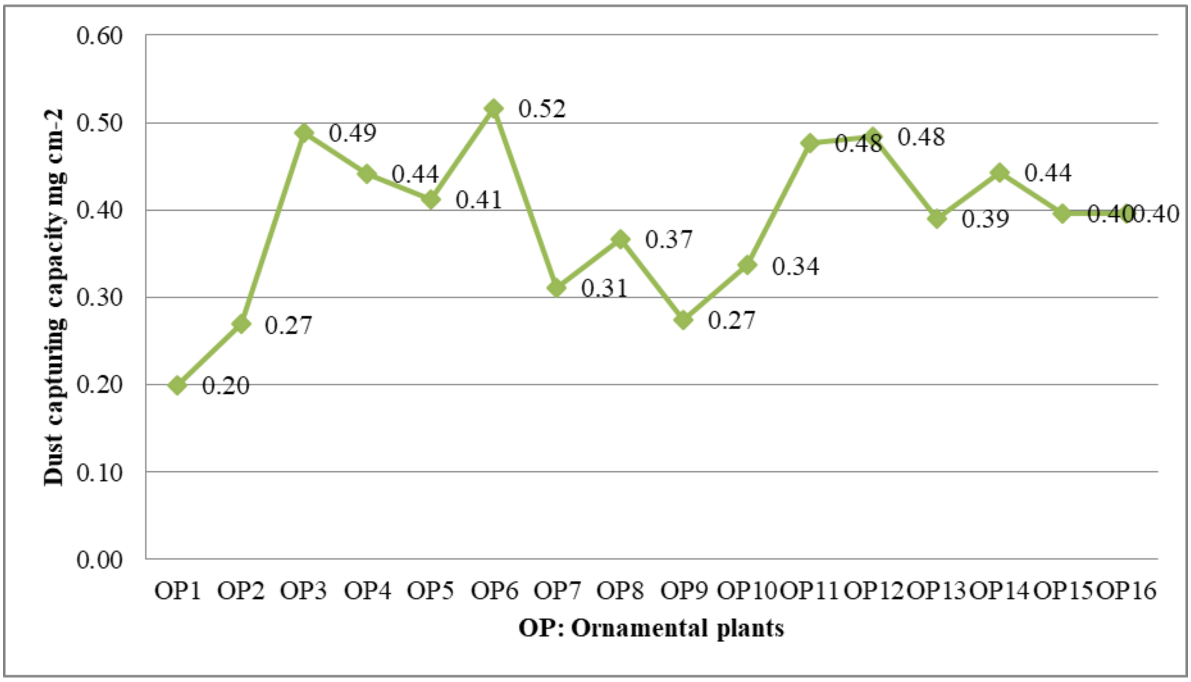

Fig 1: Response of ornamental plants (OP), to various pollutants with respect to Dust capturing capacity (mg cm^{-2}) during 2021-2022

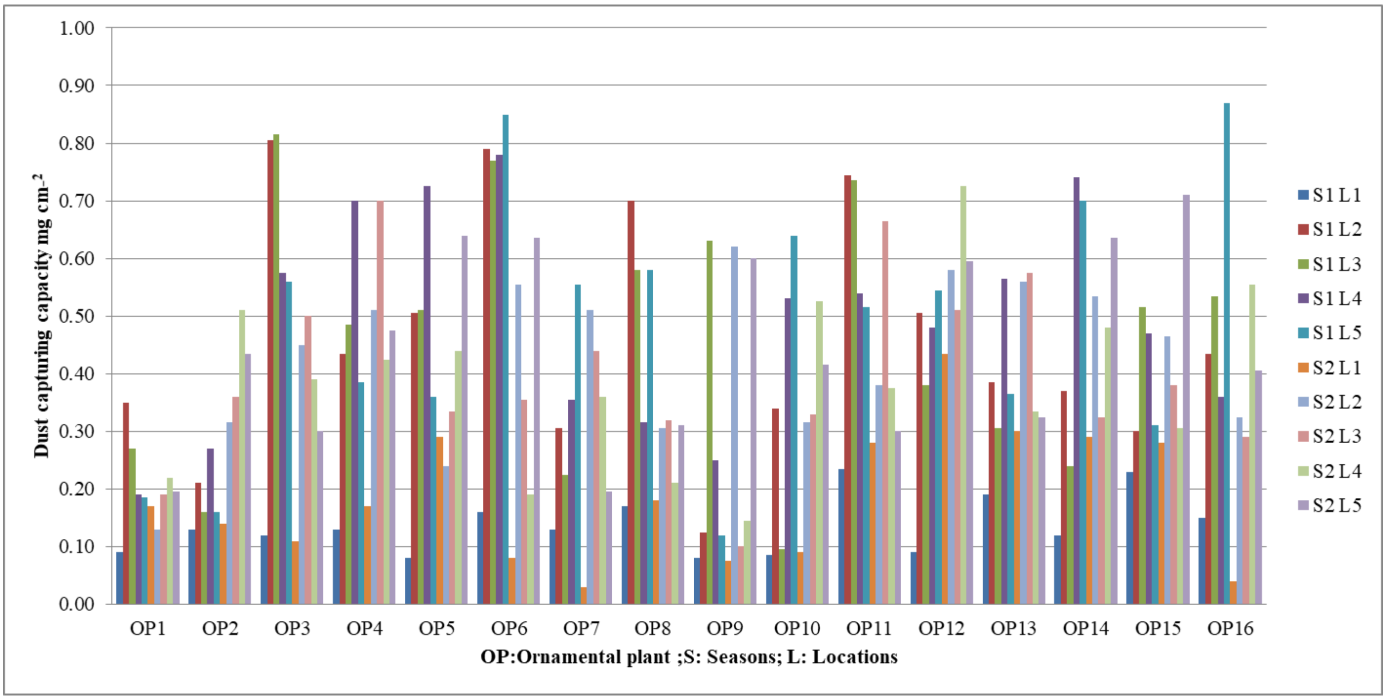

Fig 2: Response of ornamental plants (OP), Seasons (S), Locations (L) and their interaction to various pollutants with respect to Dust capturing Capacity (mg cm^{-2}) during 2020 -2021

Table 1: Response of ornamental plants (OP), Seasons (S), Locations (L) and their interaction to various pollutants with respect to DCC dust capturing capacity (mg cm^{-2}) during 2020 -2021.

Ornamental plants (OP)	Pre-monsoon (s_1)					OPxS	Post-monsoon (s_2)					OPxS	Over all mean					OPxL
	L_1	L_2	L_3	L_4	L_5	Mean	L_1	L_2	L_3	L_4	L5	Mean	L_1	L_2	L_3	L_4	L_5	Mean
OP_1	0.09	0.35	0.27	0.19	0.19	0.22	0.17	0.13	0.19	0.22	0.20	0.18	0.13	0.24	0.23	0.21	0.19	0.20
OP_2	0.13	0.21	0.16	0.27	0.16	0.19	0.14	0.32	0.36	0.51	0.44	0.35	0.14	0.26	0.26	0.39	0.30	0.27
OP_3	0.12	0.81	0.82	0.58	0.56	0.58	0.11	0.45	0.50	0.39	0.30	0.35	0.12	0.63	0.66	0.60	0.44	0.49
OP_4	0.13	0.44	0.49	0.70	0.39	0.43	0.17	0.51	0.70	0.43	0.48	0.46	0.15	0.47	0.59	0.56	0.43	0.44
OP_5	0.08	0.51	0.51	0.73	0.36	0.44	0.29	0.24	0.34	0.44	0.64	0.39	0.19	0.37	0.42	0.58	0.50	0.41
OP_6	0.16	0.79	0.77	0.78	0.85	0.67	0.08	0.56	0.36	0.19	0.64	0.36	0.12	0.67	0.56	0.49	0.74	0.52
OP_7	0.13	0.31	0.23	0.36	0.56	0.31	0.03	0.51	0.44	0.36	0.20	0.31	0.08	0.41	0.33	0.36	0.38	0.31
OP_8	0.17	0.70	0.58	0.32	0.58	0.47	0.18	0.31	0.32	0.21	0.31	0.27	0.18	0.50	0.45	0.26	0.45	0.37
OP_9	0.08	0.13	0.63	0.25	0.12	0.24	0.08	0.62	0.10	0.15	0.60	0.31	0.08	0.37	0.37	0.20	0.36	0.27
OP_{10}	0.09	0.34	0.10	0.53	0.64	0.34	0.09	0.32	0.33	0.53	0.42	0.34	0.09	0.33	0.21	0.53	0.53	0.34
OP_{11}	0.24	0.75	0.74	0.54	0.52	0.55	0.28	0.38	0.67	0.38	0.30	0.40	0.26	0.56	0.70	0.46	0.41	0.48
OP_{12}	0.09	0.51	0.38	0.48	0.55	0.40	0.44	0.58	0.51	0.73	0.60	0.57	0.26	0.54	0.45	0.60	0.57	0.48
OP_{13}	0.19	0.39	0.31	0.57	0.37	0.36	0.30	0.56	0.58	0.34	0.33	0.42	0.25	0.47	0.44	0.45	0.35	0.39
OP_{14}	0.12	0.37	0.24	0.74	0.70	0.43	0.29	0.54	0.33	0.48	0.64	0.45	0.21	0.45	0.28	0.61	0.67	0.44
OP_{15}	0.23	0.30	0.52	0.47	0.31	0.37	0.28	0.47	0.38	0.31	0.71	0.43	0.26	0.38	0.45	0.39	0.51	0.40
OP_{16}	0.15	0.44	0.54	0.36	0.87	0.47	0.04	0.33	0.29	0.56	0.41	0.32	0.10	0.38	0.41	0.46	0.64	0.40
Mean (S X L)	0.14	0.46	0.45	0.49	0.48	0.40	0.19	0.42	0.40	0.39	0.45	0.37	0.16	0.44	0.43	0.45	0.47	0.39
Comparing means of	OP	S	OP X S	L	OP X L	S X L	OP x S x L											
SE(m)	0.02	0.007	0.029	0.011	0.045	0.016	0.064											
C.D	0.057	0.014	0.08	0.02	0.127	NS	0.179											

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