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Research Article

Dust Accumulation by Roadside Trees of Bangalore

Sumangala H P [1*] , Madhurya L [1] , Anusha L [1] , Aswath C [1] , Laxman R H [2]

[1]Division of Floriculture and Medicinal crops, Indian Institute of Horticultural Science, Hesarghatta lake post, Bangalore-89

[2]Division of Physiology, Indian Institute of Horticultural Science, Hesarghatta lake post, Bangalore-89

*Corresponding Author E-mail: sumangala.hp@icar.gov.in

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ABSTRACT

Air pollution is a major environmental treat that concerns public health. It has been proposed that reduction in air pollution levels may lessen the global burden of disease. Particulate matter is one of the major air pollutants. One of the sources of particulate matter is dust. Particulate matter associated with heavy metal is dangerous to human health. Trees are known for their ability to purify air by releasing oxygen and also for absorbing air pollutants such as sulphur dioxide, nitrogenoxides, carbon-dioxide as well as suspended particle matter. Thus trees naturally cleanse air and capture dust. Various morphological features of plants attribute to their ability to trap/accumulate particulate matter such as roughness of leaf surface; epidermal cell arrangement; frequency, length, size and density of trichomes ; Phyllotaxy; wax deposition, distribution of stomata and petiole length. In this study the ability of roadside trees to accumulate dust on their leaves is evaluated. Species-wise analysis of dust accumulation shows that Broussonetia papyrifera is the highest accumulator of dust at 3.2492 g/m^2. Ficus elastica was found to be least efficient in dust accumulation at 0.3722 g/m^2

Keywords: *Particulate matter, air pollution, roadside trees, dust accumulation.*

INTRODUCTION

Air pollution is a major environmental treat that concerns public health. It has been proposed that reduction in air pollution levels may lessen the global burden of disease. Particulate matter is one of the major air pollutants. One of the sources of particulate matter is dust (Ram et al., 2015). Dust can arise from either anthropogenic or natural means (Ram et al., 2015). Atmospheric reaction of chemicals (SO_2, NO_2 and organic compounds) may produce particulates (Cromar et al., 2004), while re-suspended dust, ash, sea salt, pollen, soil, industrial processes, agricultural activities (Leys et al., 1998), combustion of wood (Chowdhury et al., 2007), biomass combustion (Pant & Harrison, 2013), cement dust from construction sites (Central Pollution Control Board 2010) and vehicular exhaust (Bhaskar et al., 2008) is also a source of particulate matter (Fisher et al., 2007).

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On the highways/roadsides, resuspension of dust by vehicular movement may make up to 33-40% of air pollution (Rahul et al., 2016). Atmospheric dust particles gets settled on the above ground surfaces of roadside tree (such as leaves, bark and other exposed parts (Samal & Santra, 2002) either due to gravity or wind impaction. Elemental composition of dust particles depends on their sources (Ram et al., 2015). Particulate matter associated with heavy metals, organic pollutants and other genotoxic chemicals, is alleged to cause damage to human health (Beelen et al., 2008). Trees are known for their ability to purify air by releasing oxygen and also for absorbing air pollutants such as sulphur dioxide, nitrogenoxides, carbon-dioxide as well as suspended particle matter (Subramani et al.,). Thus trees naturally cleanse air and capture dust.

Air pollution levels, in Indian cities, is found to be the highest during winter, followed by summer and rainy season (Karar & Gupta, 2006), (Nagendra et al., 2010), (Deshmukh et al., 2013a). This variation in air pollution level is due to factors like relative humidity and temperature. Relative humidity is negatively correlated to the concentration of particulate matter as higher relative humidity may cause in settling down or washing of particulate matter by precipitation (Deshmukh et al., 2013a), (Hien et al., 2002).

Foliar features that favours dust absorption

Many morphological features help trees in capturing dust particles.Morphological features such asroughness of leaf surface; epidermal cell arrangement; frequency, length, size and density of trichomes; Phyllotaxy (compound leaves capture more dust); wax deposition and distribution of stomata all attribute to the plant's ability to capture dust (Khan et al., 1989), (Meusel et al., 1999), (Harrison & Yin, 2000), (Beckett et al., 2000), (Prusty et al., 2005). Leaves with long petiole in comparison with shorter petiolated leaves capture lesser amount dust as they are easily set into motion by slightest movement of air. (Harrison n yin) Thicker green belts is less efficient in filtering air for dust in contrast to thinner green belt (Chakre, 2006) . Deposition of atmospheric pollutants on canopy surfaces occur vertically and laterally by sedimentation, impaction and precipitation (Lohr & Pearson-Mims, 1996). Other than morphological features of tree, size and shape of particulates also matter in deposition of particulate matter.

Trees/vegetation cover act as sinks not just for gaseous pollutants but for particulate matters as well (Nowak et al., 2006). Plants are indispensable part of ecosystems and their sensitivity to air pollution is more considerable than standards of air pollution (Thomas, 1991). Urban vegetation such as roadside trees, vertical gardens, roof gardens etc., help in decreasing particulate concentration (McPherson et al., 1994).

Effect of Air Pollution on Roadside trees

Air pollution has become a serious environmental stress to plants due to increasing industrialization and urbanization during the last few decades (Prajapati & Tripathi, 2008). Immotile nature of trees has in fact become a curse to trees, especially roadside trees in urban region. Air pollutants emitted by vehicles are the major stress inducers. Synthesis of photosynthetic pigments decrease with increase in air pollutants concentration (Irwe et al., 2017). Other factors such as water and nutrient availability, light, relative humidity and ambient temperature may influence the plant response to air pollutants (Prajapati & Tripathi, 2008). Physical and chemical nature of air pollutants determines the overall growth and development of trees (Pandey et al., 1999). Soil mineral dust at relatively high surface level and low surface level of cement dust could cause damage to trees (Grantz et al., 2003), (Thomas, 1991). Damage caused by air pollutants include chlorosis, necrosis and epinasty . Air

pollutants at a very high concentration interfere with physiological and biochemical processes by inhibiting certain enzymatic activities which ultimately leads to yield losses (Calatayud & Barreno, 2004), (Heath, 2008).

MATERIALS AND METHODS

Study Area

Data for estimating carbon sequestered by roadside trees was collected from 16 locations in and around Bengaluru, where Karnataka State Pollution Control Board monitors the air quality. Once renowned as India's "Garden City" (Nagendra et al., 2010), Bengaluru is the fifth largest metropolis in India with a population of about 8.4 million (Census, 2011) (Ramachandra et al., 2014), located 920m above mean sea level, has salubrious climate throughout the year with an annual rainfall of about 850-950mm. Due to rapid and unplanned urbanization, the spatial extent of Bengaluru has increased from 69sq.km (1949) to 741sq.km (2010) while water bodies have decreased to 98 (2010) from 265 (1962) (Ramachandra et al., 2014). Bengaluru's road network is estimated to cover approximately 3500 km (Nagendra et al., 2010) as a result numerous trees were cut for road network extension and widening purposes. Estimated crown cover of the city is about 100.02 sq.km (14.08%), about 14,78,412 trees. This amounts one tree for every 7 persons (Ramachandra et al., 2014).

Climate: Bengaluru has a tropical savannah climate with distinct wet and dry seasons. Due to its high elevation, Bengaluru usually enjoys a more moderate climate throughout the year, although occasional heat waves can make summer somewhat uncomfortable.

(http://www.thehindu.com/2005/05/18/stories/2005051818670300.html). Coolest month is January with an average low temperature of 15.1 °C (59.2°F) and the hottest month is April with an average high temperature of 35 °C (95°F). (India Meteorological Department-2007). Bengaluru receives rainfall from both the northeast and the southwest monsoons and the wettest months are September, October and August in that order. The summer heat is moderated by fairly frequent thunderstorms, which occasionally cause power outages and local flooding (Sumangala et al., 2018).

Method

To estimate dust accumulation by trees, the method by Uzma Younis et al. was followed. Sample collection was made during months of April, May and June. Leaves are randomly but carefully removed from the branches and are wrapped in pre-weighed glazed papers then put in polythene bags and brought to the laboratory. The wrapped leaves were carefully taken out from the bags, glazed paper was spread in a glass chamber and dust present on the leaves was cleaned using a fine brush. All the dust was collected on the glazed papers. They were reweighed and the amount of dust collected from each leaf was recorded. Leaf area (cm^2) measurements were taken using leaf area meter (BioVis Leaf Area Meter) and capacity of dust accumulation was calculated following Prajapati and Tripathi (2008) as under:

$W = (w_2 – w_1)/a$

Where W is dust content (g/m^2), w_1 is initial weight of glazed paper, w_2 is final weight of glazed paper with dust, and "a" is total area of the leaf (m^2).

RESULTS AND DISCUSSION

The highest dust accumulation per tree was seen in UVCE, KR Circle and the least in Banaswadi police Station. AQI of KR Circle during the months of April and May was Satisfactory with prominent Pollutant being PM_{10} and index value of 51, the lowest of all locations monitored (https://kspcb.gov.in/AQI-Apr_2019.pdf).

AQI for Banaswadi was unavailable. *Pongamia* at KR Circle had accumulated the highest dust quantity of 3.5769g/m^2. This may indicate that the trees at this location help in reduction of atmospheric

particulate matter by absorption thereby improving air quality.

Species-wise analysis of dust accumulation shows that *Broussonetia papyrifera* is the highest accumulator of dust at 3.2492 g/m^2. *Ficus elastica* was found to be least efficient in dust accumulation at 0.3722 g/m^2. This could be explained by their morphological features, *Broussonetia papyrifera* has rough and lobed leves while *Ficus elastica* has smooth and simple, entire leaves. *Peltopforum pterocarpus, Grevillea robusta, Mallingtonia hortensis* and *Tabebuia sps.* were also found to be good dust accumulators which could be attributed to high surface area of their compound leaves. Trees with simple leaves such as *Ficus benghalensis, Polyalthia longifolia, Neolamarckia cadamba* and *Michelia champaka* were found to be less efficient in dust accumulation. However, Tamarindus indica and Caesalpinia pulcherrima, although having compound leaves were found to have accumulated lesser dust than other compound leaved trees mentioned earlier, perhaps this could be because of variation in atmospheric particulate matter concentration at the time of colection or washing of leaves by previous rain providing cleaner surface for fresh dust deposition. Dust accumulation by leaves is a cummulative effect of windblow, rainwash and size, shape and concentration of dust besides morphological features of leaf. Table1 and 2 shows the details of dust accumulated by trees location-wise and species-wise.

Correlation analysis of biochemical parameters viz., ascorbic acid, total chlorophyll and pH with dust accumulation showed no association between biochemical parameters and dust accumulation.

FIG 1 MAP OF BANGALORE

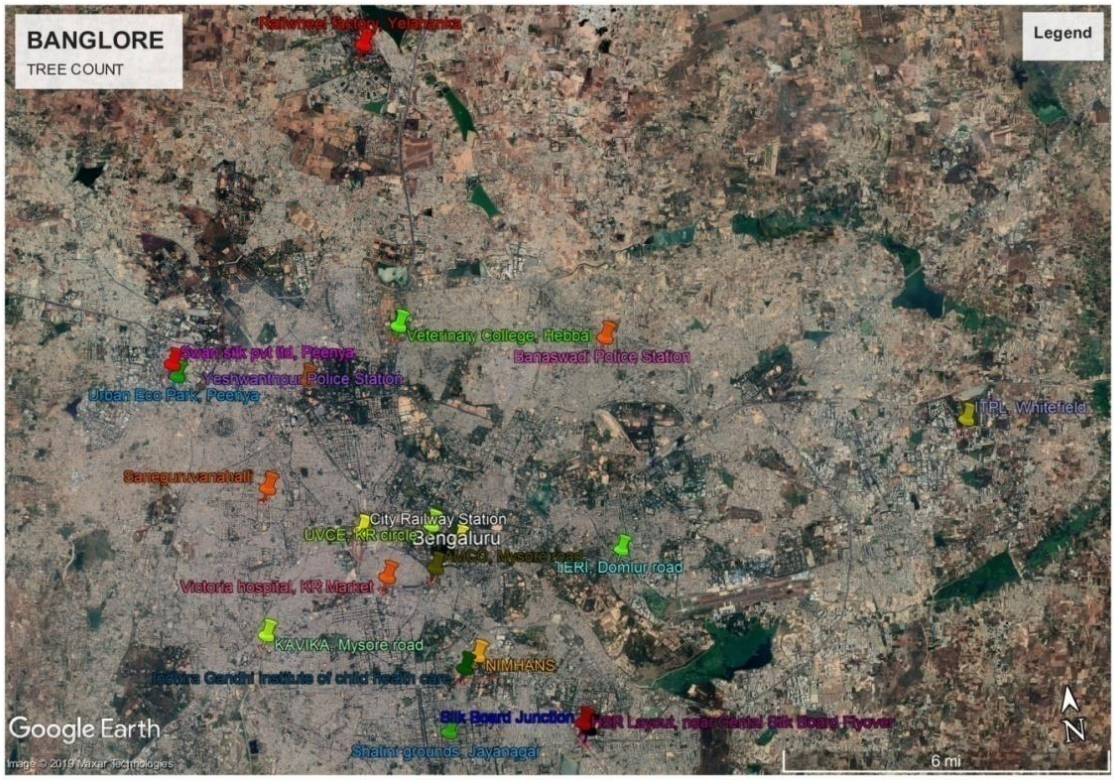

Table 1 Location-wise dust accumulation

					Air quality Index (April-May)		
Name of the Monitoring Station	**Ascorbic acid (mg/g)**	**Total chlorophyll(mg/FW))**	**pH**	**Dust (g/sq.m)**	**Index Value**	**Category**	**Prominent Pollutant**
UVCE, KR circle	0.30	2.73	4.8	2.9573	51	Satisfactory	PM10
City Railway Station	0.25	2.63	5.8	2.7996	*	*	*
Central Silk Board, Hosur Road	0.27	1.82	5.8	2.6298	110.5	Moderate	PM10
Rail Wheel factory, Yelahanka	0.31	0.81	5.4	2.6056	57.5	Satisfactory	*
KAVIKA, Mysore road	0.51	0.95	4.9	2.3209	*	*	*
HSR Layout	0.40	1.62	5.6	2.0509	*	*	*
Rajeev Gandhi Child care Institute, NIMHANS	1.31	1.57	6.5	1.9597	*	*	*
TERI, Domlur road	0.24	1.89	16.9	1.8806	73	Satisfactory	PM10
Saneguruvanahalli	0.24	3.85	5.6	1.8712	*	*	*
ITPL, Whitefield	0.27	1.27	5.3	1.8393	100.5	Moderate	PM10
Yeshwanthpur Police Station	0.27	2.53	5.2	1.6558	89	Satisfactory	PM10
Veterinary College, Hebbal	0.33	1.03	5.9	1.6224	*	*	*
Shalini grounds, Jayanagar	1.52	1.51	5.0	1.5635	*	*	*
AMCO, Mysore road	0.18	4.69	5.8	1.4802	98	Satisfactory	PM10
Victoria hospital, KR Market	0.33	1.03	5.9	1.4537	62.5	Satisfactory	PM10
Indhira Gandhi institute of child health care	0.31	1.76	5.9	1.0183	65.5	Satisfactory	PM10
Banaswadi Police Station	0.33	2.64	5.4	0.9829	*	*	*

Table 2 Species-wise dust accumulation

sl no	**Species**	**Ascorbic acid (mg/g)**	**Total chlorophyll(mg/FW)**	**pH**	**Dust (g/sq.m)**	**no. Of locations found in**
1	*Broussonetia papyrifera*	0.33	3.61	5.0	3.2492	1
2	*Peltopforum pterocarpus*	1.20	2.39	6.8	2.9530	2
3	*Ficus racemosa*	0.25	1.27	7.0	2.9247	1
4	*Grevillea robusta*	0.33	1.24	6.5	2.8556	1
5	*Mallingtonia hortensis*	0.43	2.27	7.0	2.7827	1
6	*Tabebuia sps.*	1.21	1.28	6.3	2.7146	5
7	*Dalbergia*	0.21	3.52	5.5	2.6612	1
8	*Parkia biglandulosa*	0.21	1.88	6.0	2.6347	1
9	*Alstonia scholaris*	0.30	2.92	5.8	2.6149	1
10	*Muntigia calabura*	0.27	1.75	5.1	2.5980	3
11	*Bamboosa*	0.37	1.01	6.5	2.5063	1
12	*Syzygium cumini*	0.45	2.26	4.7	2.4347	3
13	*Ficus benjamina*	0.26	1.77	6.0	2.4136	2
14	*Acacia sps.*	0.37	1.63	8.0	2.3527	1
15	*Acacia decurrens*	0.35	1.94	7.0	2.3510	1
16	*Pongamia*	0.39	1.89	4.6	2.3263	9
17	*Terminalia arjuna*	0.38	2.05	4.0	2.3080	1
18	*Dolichandrone platycalyx*	0.24	1.70	5.3	2.2816	4
19	*Sweitenia sps.*	0.20	1.93	5.5	2.0729	5
20	*Samanea saman*	0.35	2.30	6.6	1.9735	7
21	*Cassia spectabilis*	0.22	2.46	5.8	1.8395	3
22	*Delonix regia*	0.35	1.62	4.4	1.8201	5
23	*Bauhinia sps.*	1.40	1.69	7.0	1.7689	2
24	*Terminalia catappa*	0.30	2.87	5.5	1.5723	4
25	*Acacia luecophloea*	0.38	1.33	4.3	1.5666	2
26	*Ficus religiosa*	0.29	2.24	19.2	1.5571	7
27	*Spathodea companulata*	0.35	2.91	5.8	1.4834	1
28	*Ficus benghalensis*	0.26	1.63	5.0	1.3766	1
29	*Polyalthia longifolia*	0.53	2.75	5.8	1.2403	5
30	*Neolamarckia cadamba*	0.31	2.20	7.0	1.0666	1
31	*Michelia champaka*	0.29	4.83	5.0	1.0436	2
32	*Tamarindus indica*	0.44	4.03	5.8	0.6315	2
33	*Caesalpinia pulcherrima*	0.30	0.81	7.0	0.3851	1
34	*Ficus elastica*	0.24	3.44	5.8	0.3722	1

CONCLUSION

Air pollution has been ranked in the top 10 causes of deaths in world, in global burden of diseases 2010 report. Trees/vegetation cover act as sinks not just for gaseous pollutants but for particulate matters as well (Nowak et al., 2006). Plants are indispensable part of ecosystems and their sensitivity to air pollution is more considerable than standards of air pollution (Thomas, 1991). Urban vegetation such as roadside trees, vertical gardens, roof gardens etc., help in decreasing particulate concentration (McPherson et al., 1994). Various morphological features of plants attribute to their ability to trap/accumulate particulate matter such as roughness of leaf surface; epidermal cell arrangement; frequency, length, size and density of trichomes; Phyllotaxy (compound leaves capture more dust); wax deposition, distribution of stomata and petiole length. Trees with compound leaves can be used as they have more surface area for dust accumulation when compared to simple leaved trees. A Significant amount of atmospheric air pollutants are removed by trees and hence must be considered an intergral part of any sustainable plan intended to improve air quality.

Appropriate strategies to combat air pollution is essential at the national as well as regional level. Planting trees may not be the immediate solution for problem arising from air pollution. Necessary and rigorous steps must be taken to curb pollution at the very source of it.

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Conflict of Interest:

IIHR Bengaluru, Karnataka State Pollution Control Board are the supporting pioneer.

Author Contributions: Madhurya L and Anusha L- Young professional.

Aswath C- Principal Scientist, Laxman R H- Principal Scientist.

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IOSR Journal of Pharmacy and Biological Sciences (IOSR-JPBS) e-ISSN: 2278-3008, p-ISSN: 2319-7676. *6*(4), (May. – Jun. 2013), PP 35-42 www.iosrjournals.org www.iosrjournals.org 35 | Page Dust Interception Capacity And Alteration Of Various Biometric And Biochemical Attributes In Cultivated Population Of Ficus Carica L. Uzma Younis, Tasveer Zahra Bokhari, Muhammad Hasnain Raza Shah, Seema Mahmood and Saeed Ahmad Malik Institute of Pure and Applied Biology, Botany department, Bahauddin Zakariya University, Multan, Pakistan.

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