



## **Phytomonitoring of selected plant species and its correlation with air quality at Ayodhya**

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### **Abstract**

Plant leaves are continuously exposed to atmosphere and so the main receptor of dusts. The deposition of dusts on leaves surface depends upon wind speed, surface geometry, phyllotaxy and leaf external characteristics such as hairs or cuticles. Dust deposition on leaf surface causes reduction in rate of photosynthesis and increases temperature of the leaves; this causes decrease in the synthesis of pigments. Present investigation was carried out from February to April and it was reported that small vertically oriented leaves of Sheesham shows less deposition of particulates, whereas big, hairy and horizontally oriented leaves of Banyan hold more dust or particulates. It was also reported that in the month of April when wind speed is high deposition is less.

**Keywords:** pigments, air quality, dust deposition, phytomonitoring

### **Introduction**

Plants act as natural filters of particulate matters as dust particles or particulates get deposited on leaves. So plants play important role in the improvement of air quality (Joshi & Swami 2007; Chauhan & Sanjeev 2008) <sup>[1, 2]</sup>. Plants act as sink of other air pollutants. Roadside vegetation particularly trees, shrubs and intense hedge can help significantly in reducing the adverse effect of gaseous pollutants (Rai & Panda 2014) <sup>[3]</sup>. Plants growing road side are more affected by air pollutants such as particulates and gaseous pollutants, alone or in combination because of heavy traffic load, and due to this they show several changes in morphology, physiology, anatomy, and biochemistry of leaves (Chauhan & Joshi 2010; Seyyednejad *et al.*, 2013) <sup>[4, 5]</sup>. Leaves are sensitive parts of plant because of abundance of stomata on surface, through which pollutants penetrate into the sensitive tissues of leaves (Giri *et al.*, 2013) <sup>[6]</sup>.

The physical and chemical characteristics of particulate matters vary with the location. Common chemical constituents of particulate matter include sulphates, Nitrates, ammonium, other inorganic ions of Ca, Cl, K, Mg and Na; organic and elemental carbons: crustal material; particle-bound water; metals (including Cd, Cu, Ni, V and Zn); and polycyclic aromatic hydrocarbons (PAH). In addition, biological components such as allergens and microbial compounds are found in particulate matters (Kyungdeok *et al.*, 2019) <sup>[7]</sup>. Plants have ability to reduce air pollution but air pollutants cause reduction in yield, nutritional quality and growth of plants (Antisari *et al.*, 2015; Zhang *et al.*, 2018) <sup>[8, 9]</sup>. Beside this, the dust on the leaves blocks stomata causing sorting out sun light and hinders gaseous exchange (CO<sub>2</sub> & O<sub>2</sub>) due to which photosystem II is affected (Shah *et al.*, 2017; Sett 2017) <sup>[10, 11]</sup>. Plant response to air pollution can be used to assess the quality of air that may provide early warning signals of air pollution trends. The dying rates, changes with respect to apparent injury, chlorophyll reduction, and cell size reduction and

reduction in leaf area are used as parameters for monitoring air pollution impacts on plant metabolism (Le Blanc and Rao, 1975) <sup>[12]</sup>.

The present investigation was carried out to study the effect of particulate matter on chlorophyll a, b, total chlorophyll and carotenoides in the plants growing in residential area and near national highway (NH 28), Ayodhya.

### **Material and Methods**

#### **Species selection**

Six plant species *Neolmarckiakadamba* (Kadamb), *Dulbergiasisso* (Sheesham), *Azadiracticaindica* (Neem), *Magniferaindica* (Mango), *Ficusvirens* (Banyan), *Ficusreliagosa* (Peepal) were selected for study. All species have different morphology and phyllotaxy.

#### **Site selection**

Two sites where above six tree species were present, selected for collection of sample. The two sites selected were

1. National Highway near Jogitara road, Ayodhya
2. Near A.N.D. Boys Hostel in the Main Campus of Dr. Rammanohar Lohia Avadh University, Ayodhya.

#### **Dust deposition**

Dust deposition on mature leaves was assessed by randomly collecting leaves of selected plant species. The leaves were collected randomly in early morning from lower branches and were quickly transferred to the laboratory in polythene bag kept in ice box further analysis within 24 hours of their harvesting.

The amount of dust deposition was assessed by taking the initial and final weight of washed leaf surface and it was calculated using following formula

$$Dd = \frac{Ld - Lw}{Al}$$

Where

Dd = Dust deposition mg/cm<sup>2</sup>

Ld = weight of leave with dust

Lw= weight of washed and dried leaf

Al= Total area of leaf in cm<sup>2</sup>

**Particulate analysis**

PM<sub>10</sub> and PM<sub>2.5</sub> were calculated by gravimetric method as per guideline of CPCB (2011) [13]. In this method, for PM<sub>10</sub> glass fibre filter paper (8 × 10 inch) and for PM<sub>2.5</sub> Poly Tetra FluoroEthylene (PTFE; 47 mm dia.) was used. The sampling was done in three cycles of 8 hours each and the PM was calculated using following formula –

$$PM = \frac{(Finalweight - Initialweight)}{Volumeofairsampled}$$

$$Vol. of air sampled = \frac{(initial flow rate + Final flow rate)}{2} \times 840$$

**Pigment analysis**

Chlorophyll a, b, c, total chlorophyll and Carotenoides in the leaves of six selected species were analysed as per method described in Handbook of Methods in Environmental Studies (S.K. Maiti, 2004) [14]. In this method 200mg fresh green leaves

were taken and homogenised using 20 ml of 90% acetone and a pinch of Magnesium Carbonate in mortar pestle. Further after centrifuging the content at 3000 rpm for 15 minutes, supernatant was collected and absorbance were taken at 664, 647 and 630 nm and Chlorophyll a, b, c, total chlorophyll were determined using following formula-

$$\text{Chlorophyll a (mg/l)} = 11.85(A_{664}) - 1.54 (A_{647}) - 0.08 (A_{630})$$

$$\text{Chlorophyll b (mg/l)} = 21.03(A_{647}) - 5.43 (A_{664}) - 2.66 (A_{630})$$

$$\text{Chlorophyll c (mg/l)} = 24.52(A_{630}) - 7.60 (A_{647}) - 1.67 (A_{664})$$

The Chlorophyll a, b and c concentrations in mg/m<sup>3</sup> were calculated using following formula–

$$\text{Chlorophyll a, b or c } \left(\frac{\text{mg}}{\text{m}^3}\right) = \frac{\text{Chlorophyll a, b or c } \left(\frac{\text{mg}}{\text{l}}\right) \times \text{Extrat Volume (L)}}{\text{Volume of sample (m}^3\text{)}}$$

$$\text{Total Chlorophyll} = \text{Chlorophyll a} + \text{Chlorophyll b}$$

$$\text{Carotenoides} = 7.6 (A_{480}) - 1.49 (A_{510}) \times V/1000 \times d \times w$$

Where A= Absorbance, w= weight of sample, V= Final volume, d= Length of light path

**Result & Discussion**

**Air quality at national highway and university campus**

The PM<sub>10</sub> and PM<sub>2.5</sub> values (µg/m<sup>3</sup>) at both the sites were assessed and found as given in Table no. 1.

**Table 1:** PM<sub>10</sub> and PM<sub>2.5</sub> values (µg/m<sup>3</sup>) at national highway and university campus

Month		National Highway		University Campus	
		PM10	PM2.5	PM10	PM2.5
February	Week-1	311±12.5	120±9.0	110±6.8	71±5.0
		325±11.0	134±11.6	100±7.5	85±7.0
	Week-2	316±23.6	125±13.2	98±10.1	76±11.9
		275±2.1	84±16.2	109±8.2	65±12.6
	Week-3	315±24.7	124±2.6	95±13.5	75±7.8
		300±12.5	109±7.0	85±4.9	60±2.1
	Week-4	311±23.4	120±8.1	101±5.3	71±9.8
		324±12.0	133±23.4	98±6.8	84±3.5
March	Week-1	325±4.9	134±12.0	110±4.9	85±1.7
		322±11.9	131±3.5	108±4.4	82±1.5
	Week-2	318±9.3	127±8.7	100±4.7	78±5.0
		321±2.9	130±1.7	107±2.5	81±7.6
	Week-3	305±9.9	114±3.2	89±4.5	65±1.5
		319±11.2	128±10.2	83±5.9	79±3.1
	Week-4	275±12.5	84±8.0	91±6.0	93±10.1
		300±10.6	109±5.1	102±8.2	60±2.5
April	Week-1	295±14.5	104±6.6	79±13.4	55±6.4
		289±9.9	98±5.0	71±3.6	49±3.5
	Week-2	271±16.0	80±2.6	60±3.6	47±7.6
		280±6.0	89±10.4	65±9.1	51±6.0
	Week-3	300±14.5	109±10.4	76±4.2	60±5.3
		298±10.7	107±1.5	72±3.1	58±6.5
	Week-4	279±10.5	88±12.7	84±3.6	39±4.6
		311±5.9	120±3.8	99±2.0	61±4.0

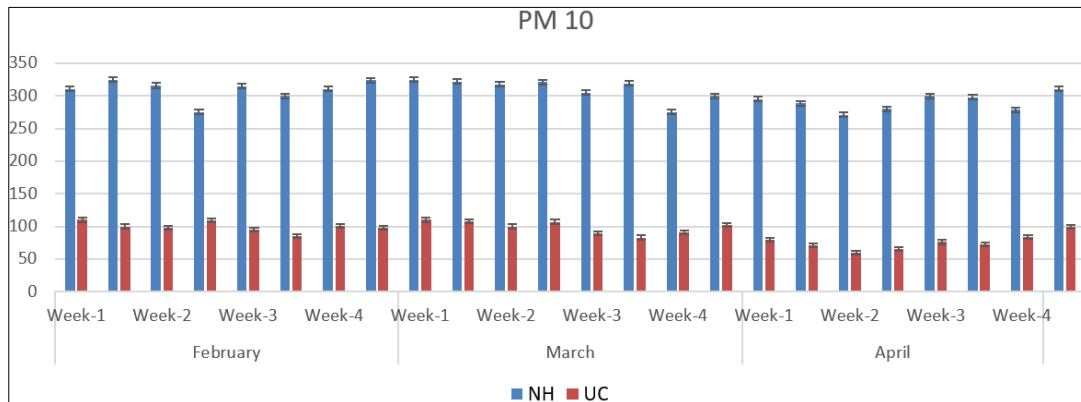
Figure No. 1.1 & 1.2 clearly indicates that the values of PM10 and PM2.5 are significantly higher on National Highway than University Campus. This may be due to high traffic load on National Highway. Kyungdeok *et al.* (2019) [7] also observed that

the PM values near the highways generally remains higher than industrial and residential areas.

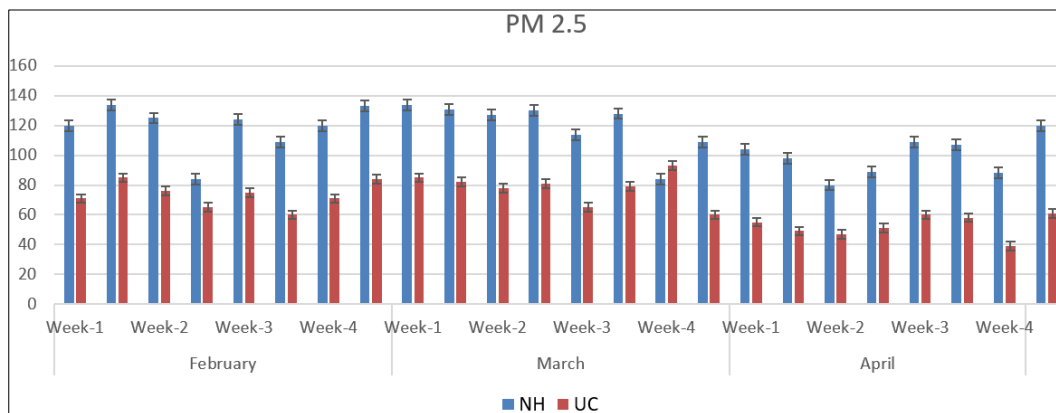
The average PM values (PM10 & PM2.5) are more or less same for the month of February and March, but its value is higher in the month of April at both locations. This may be due to high

wind speed during month of April. From 21<sup>st</sup> March the sun begins to move towards tropic of Cancer from Equator due to this low pressure is generated on Indian land mass, which ultimately

leads to high wind velocity. Rai & Panda (2014)<sup>[3]</sup> observed that high wind velocity is an important factor in the dispersion of particulate matters.



**Fig 1:** PM10 values (µg/m<sup>3</sup>) at National Highway and University Campus.



**Fig 2:** PM2.5 values (µg/m<sup>3</sup>) at National Highway and University Campus.

**Dust deposition**

Dust deposition on the leaves of different selected plants at national highway and in university campus are given in Table no. 2 and 3.

**Table 2:** Dust deposition on leaves at national highway.

Name of Plants	Dust Deposition (mg/cm <sup>2</sup> ) at NH		
	February	March	April
Banyan	0.072±.001	0.091±.003	0.069±.001
Mango	0.069±.003	0.078±.002	0.058±.005
Kadamb	0.049±.001	0.052±.001	0.042±.003
Neem	0.038±.002	0.043±.002	0.035±.002
Peepal	0.032±.002	0.036±.004	0.029±.001
Sheesham	0.028±.001	0.031±.001	0.02±.001

**Table 3 :** Dust deposition on leaves at university campus.

Name of Plants	Dust Deposition (mg/cm <sup>2</sup> ) at UC		
	February	March	April
Banyan	0.038±.002	0.041±.002	0.034±.001
Mango	0.036±.004	0.039±.001	0.03±.004
Kadamb	0.029±.001	0.031±.003	0.027±.002
Neem	0.026±.005	0.029±.005	0.024±.001
Peepal	0.018±.001	0.022±.002	0.015±.003
Sheesham	0.014±.002	0.019±.001	0.012±.001

The value of dust deposition at National Highway is more than University campus. Table 2.1 & 2.2 clearly depicts that there is more deposition of dust during February and March, whereas in the month of April it is on the lower side. This may be due to high wind velocity during April.

The size, orientation and surface of leave also affect dust holding capacity of leaves. The results of the investigation are in consonance with this (Prajapati, 2012)<sup>[15]</sup>.

### Pigment analysis

Pigments such as chlorophyll a, b, total chlorophyll and carotenoid were assessed for six selected plant species at National Highway and in University Campus, results are given in Table no. 4 and 5.

**Table 4:** Pigments in selected plant species at National Highway.

National Highway				
Name of Plants	Pigment	February	March	April
Sheesham	Chl-a	2.81	2.79	2.83
	Chl-b	2.22	2.17	2.26
	Total Chl	5.03	4.96	5.09
	Carotenoid	0.058	0.055	0.058
Peepal	Chl-a	2.69	2.65	2.72
	Chl-b	1.40	1.39	1.43
	Total Chl	4.09	4.04	4.15
	Carotenoid	0.050	0.047	0.053
Neem	Chl-a	2.65	2.61	2.68
	Chl-b	1.36	1.33	1.41
	Total Chl	4.01	3.94	4.09
	Carotenoid	0.047	0.045	0.047
Kadamb	Chl-a	2.37	2.33	2.41
	Chl-b	1.30	1.27	1.36
	Total Chl	3.67	3.60	3.77
	Carotenoid	0.046	0.042	0.049
Mango	Chl-a	2.31	2.29	2.35
	Chl-b	1.01	0.99	1.04
	Total Chl	3.32	3.28	3.39
	Carotenoid	0.045	0.044	0.047
Banyan	Chl-a	2.16	2.11	2.21
	Chl-b	1.00	0.97	1.03
	Total Chl	3.16	3.08	3.24
	Carotenoid	0.033	0.032	0.034

**Table 5:** Pigments in selected plant species in University Campus.

University Campus				
Name of Plants	Pigment	February	March	April
Sheesham	Chl-a	3.39	3.31	3.43
	Chl-b	1.98	1.93	2.01
	Total Chl	5.37	5.24	5.44
	Carotenoid	0.073	0.072	0.075
Peepal	Chl-a	3.13	3.08	3.15
	Chl-b	1.37	1.36	1.39
	Total Chl	4.50	4.44	4.54
	Carotenoid	0.072	0.070	0.071
Neem	Chl-a	3.01	2.98	3.06
	Chl-b	1.32	1.29	1.37
	Total Chl	4.33	4.27	4.43
	Carotenoid	0.064	0.063	0.650
Kadamb	Chl-a	2.81	2.76	2.87
	Chl-b	1.29	1.27	1.32
	Total Chl	4.10	4.03	4.19
	Carotenoid	0.058	0.057	0.061
Mango	Chl-a	2.80	2.74	2.86
	Chl-b	1.12	1.09	1.15
	Total Chl	3.92	3.83	4.01
	Carotenoid	0.058	0.055	0.064
Banyan	Chl-a	2.56	2.51	2.60
	Chl-b	1.01	0.98	1.04

	Total Chl	3.57	3.49	3.64
	Carotenoid	0.041	0.039	0.045

The results clearly indicate that Chlorophyll a, b, total chlorophyll & carotenoids are more in the leaves of selected plant species in University Campus rather than National Highway. Monthly variation indicates more pigments in April and least during March. There general observation that the pigment concentration decreases in following sequence Sheesham > Peepal > Neem > Kadamb > Mango > Banyan. This may be due to shape, size and orientation of leaves. The leaves of sheesham tree are small, wax coated and oriented vertically that is why less particulates are deposited on it, whereas in case of banyan tree the leaves bigger, hairy and are horizontally oriented, leading to increased particulate holding capacity. Hong *et al.* (2014)<sup>[16]</sup> reported that the dusts on the leaves block the stomata, which lowers their conductivity to CO<sub>2</sub> and so affects the Photosystem II (Sett, 2017)<sup>[11]</sup>. Agbaire (2009)<sup>[17]</sup> reported that air pollutants make their entrance into the tissues through the stomata and cause partial denaturation of the chloroplasts and decreases pigment contents in the cells of polluted leaves.

### Conclusion

The results of present investigation reveal that the pigment of the leaves is affected by wind speed, phyllotaxy and geometry such as hair and cuticles. Small leaves with smooth surface and vertical orientation holds less dust on its surface, whereas rough leaves with horizontal orientation holds more dust on its surface. Beside this wind speed also affects the dust deposition. High wind speed causes less deposition of dusts.

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