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Impact of Dust Pollution on Physical and Chemical Parameters of Leaf of Shrub Plants at Indore, Madhya Pradesh

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Abstract : *With increasing of population, number of vehicles have also increase and causes particulate matter pollution. The vegetation along the roadside is highly affected through these particulate matter and dust. The dust deposition causes harmful effect on morphological and structural character of leaves. In this study, impact of dust pollution on some plant species Alastonia scholaris (L.) R. Br., Calotropis gigentea, Mimusops elengi, and Ziziphus mauritiana at two sampling sites were studied. The parameter examined were Leaf Area, Dust deposition capacity, Light transmittance (artificial and natural), cell sap pH and Leaf temperature. The result represented that the species growing in polluted area were found affected in comparison to reference area.*

Key Words : *Vegetation, Dust pollution, Leaf area, Light transmittance and Leaf temperature.*

1. INTRODUCTION:

In the present scenario, dust is the main component of air pollution driven through vehicles traveling on roads. The dust particles of road made up of different components, like vehicle exhaust deposition, industrial exhaust, dust of construction , etc. The environment was full of particulate matter, which was produced from road dust. In developed cities control of road dust was problematic. Dust deposition is harmful to plants and affects various physiological activities such as transpiration, respiration, photosynthesis, etc. Due to these adverse effects productivity or growth of plants were generally decreased. The dust particle may affect function of stomata by clogging them and reducing photosynthesis. In this way the dust particles present in the atmosphere inhibit or reduce the growth of plants. Deposition of particulates on leaves may interfere with leaf optical characteristics and absorption of radiant energy.
The dust deposition capacity of tree species and the leaf surface area was correlated [1]. The leaf morphology of *Mangifera indica*, *Azadirachta indica*, *Cassia siamea* and *Polyalthia logifolia* have been found affected through air pollution [2]. The difference in particulate matter retention capacity in plant species *E. japonica*, *Pittosporum tobira*, *P. orientalis V. odoratissimum*, *Photinia serrulate* and efficacy on leaves studied [3]. Changes in morphological, biochemical, epidermal, and stomata functions, soil conditions, and soil nutrition, as well as species communities, reveal that dust pollution has a harmful impact on plant species [4]. The morphological features of a minute portion of dust or particles, such as their shape and size, as well as the plant type, influence dust deposition [5]. Particulates may produce unfavorable changes in leaf surface ultrastructure, limit plant growth, lower leaf area, and hence diminish total biomass, depending on the dust load, duration, and tolerance of the plants [6]. Plant morphological characteristics are crucial in influencing plant resilience to pollution, like thickness of cuticle, sunken stomata, dense and small size of cells, special type of cell walls inhibiting the entry of pollutants into cell of leaves [7]. Necrotic spots on the leaves of *Mangifera indica* are caused by dust particles. It forms into a hard adherent crust in the presence of moisture, which can damage plant tissue and limit growth [8].

The present study indicated about the influence of the dust pollution on physical and chemical properties of plant such as Leaf area, dust deposition capacity, light transmittance (artificial and natural), cell sap pH and leaf temperature. The study was conducted on leaves of some plants like- Calotropis gigantea (L.) W. T. Aiton, Alastonia scholars (L.) R. Br., Mimusops elengi L., and Ziziphus mauritiana Lam.

2. METHODOLOGY

2.1 Study area:

The study was conducted at two sampling stations in Indore city. To analyze the effects of dust pollution in major road areas, a preliminary survey was carried out. On the basis of air pollution level, traffic density and commercial activates. Site-1 was DAVV University campus, khandhwa road and it has been considered as reference area (NPA) as in this area there is very low traffic and industries are absent. Site-2 was Manik bagh over bridge, which is a major polluted area of Indore city, so the Site -2 has been considered as polluted site (PA).

2.2 Plant Material:

From both the sites, four plants- *Alastonia scholaris*, *Calotropis gigentea*, *Mimusops elengi*, *and Ziziphus mauritiana*, were selected. The study was conducted in month of January to May. Randomly collected leaf samples from both the observation sites. Plant leaves were plucked from a height of 1 to 2 meter. Plucked leaves were fully mature and 10 in number. The leaves were kept in polybags.

2.3 Physio-chemical parameters

As far as possible following parameters are worked out in investigated plant leaves at polluted and non-polluted region. These are Leaf Area, Dust deposition capacity, Light transmittance, Leaf temperature and cell sap pH. The deposition was recorded in month of January, February, and March.

2.3.1. Leaf area and Dust deposition

The dust deposition was calculated by weighing the dusted leaf by digital balance MH-Series model. The area of the leaves was determined using planimeter. The amount of dust deposition on phylloplane or leaves of these plants was calculated by putting the recorded values in the following formula-

Total amount of dust (g/m^2) = Weight of leaf with dust – Wt. of leaf without dust

2.3.2 Light transmittance

Light cut off from adaxial surface of leaves were determined by using a digital luxmeter LX- 101 A model. The light cut off of leaves in both natural and artificial condition was calculated from the following formula-

Light cut off (Lux) = Reading of dusted leaf – Reading dust free leaf

2.3.3 Leaf temperature

The leaf surface temperature of dusted and dust free leaves was determined by using an infrared thermometer (FLUKE 62 Mini). The leaf surface temperature was recorded from adaxial as well as abaxial surface. The temperature of dust free leaf was taken after a gap of five minutes. The dust was removed with the help of a dry cotton swab.

2.3.4 Cell sap pH

Mature leaf of selected plant species was sampled for the determination of cell sap pH. The leaves were washed with distilled water and after washing cut into small pieces (avoiding veins) and take small piece of 1 gm samples were grounded with 50 ml. of distill water in a glass pestle. The grounded sample along with washings was collected in a small beaker. The pH of cell sap was measured by digital pH meter Cl 210.

3. RESULT AND DISCUSSION :

In polluted area considerable reduction of leaf area (mm^2) observed in all four sample plant leaves of *Alastonia scholaris, Calotropis gigentea, Mimusops elengi, and Ziziphus mauritiana*, as compare to reference. Table (1 and 2) and graph (1 and 2) revealed that the leaf area of *Calotropis gigentea* ($1.07m^2$) was mostly affected and *Alastonia scholaris* was least ($25.8m^2$) affected due to deposition of particulate matter. In polluted area average value of maximum dust deposition of three months was recorded on *Mimusops elengi* 39.4 mg/m^2 and minimum was recorded on Calotropis 26.8 mg/m^2. The difference in leaf size, shape of lamina and character of leaf surface can be ascribed by that specific variation. The effect of dust deposition on the leaf parameter of four tree species along the roadside was studied [9]. The effect of dust pollution on different parameters of plants studied [10]. They also found reduction in the leaf area and chlorophyll content due to deposition of dust. Different plant character such as agroclimatic suitability, structure of canopy, leaf pattern, height of tree, inflorescence, pollution tolerant ability and dust scavenging capacity found affected by dust and air pollution [11]. Previous studied have also emphasized that deposition of particulate greatly influenced by epidermal and cuticular feature, phyllotaxy and orientation of leaves

[12]. It has been reported that evergreen trees regarded as better dust collector [13]. Present finding supports this observation as maximum deposition was observed like *Mimusops elengi* which is also an ever-green tree.

Effect of Light cut off due to dust deposition was observed in sample plant leaves. The light cut off or transmittance was measured in both artificial and field light. Table 3 and graph (3.1 and 3.2) represented average value of all three months light transmittance of field light in polluted area. It was maximum in *Mimusops elengi* and minimum in *Ziziphus.* In artificial light similar trends was observed in maximum light absorbance but minimum in *Calotropis*. Leaf surface temperature of selected plants was also observed from both polluted and non-polluted area (Table 4 and graph 4.1 and 4.2). It was measured from dusted and dust free leaves and both upper and lower surface of leaves. In general, table 5 and graph (5.1 and 5.2) showed that the leaves of plants growing in polluted area have relatively higher leaf surface temperature as compare to plants growing in non-polluted area. After removing of dust from leaf surface increased of temperature were observed in all selected plant leaves (graph 6.1 and 6.2). Change in leaf surface temperature can be accounted to the particulate matter deposited on the leaves. Two to four degree centigrade increase in leaf surface temperature of plants growing along road sides due to marked increase in absorbance in infrared region reported [14]. Researcher had also reported increase in temperature due to fly ash deposition in both visible and infra-red region [15]. The effect of dust deposition on temperature of cotton leaves was studied [16]. They observed temperature of the dust deposition leaves was always higher than the control. The cell sap pH of different plant species growing at polluted area was presented in Table 6. The significant change was observed in polluted area plants compare with reference. The cell sap was found slightly more acidic in plants of reference area. *Calotropis gigantea* appeared be very little affected. The particulate matter deposited on the leaf surface must have entered the leaf this is proved by the change in pH of cell sap of all the species worked out. The penetration may be either directly or indirectly through stomata and epidermis. The change in the pH of cell sap must have affected the metabolism of leaf along with the toxic effect of pollutant, which may be due to the presence pollutants in the ambient air causing a change in pH of leaf sap towards acidic side [17]. Least change in cell sap pH of *A. scholaris* can be due to its smooth leaf surface which might have not allowed the pollutant.

Leaves of polluted area showed curling, folding, necrosis etc., due to dust so, leaf area becomes less, similar result was observed [18], [19], [20] and [21] revealed retarded growth and reduced leaf due to emission of pollutants. Effect on leaves of plant grows in the industrial area and near the major road observed [22]. The temperature difference in *Mimusops elengi* was less observed in present study. In the polluted area, unicellular trichome, developed on the abaxial surface have been observed but absent in non-polluted region. The development of trichomes have been maximum at near stomatal cells [23].

Table 1: Average leaf area and dust deposition (g/m^2) on the leaves of selected plant in Reference area

Name of the plant		Leaf With dust(A)	Leaf Without dust(B)	Weight of dust(A-B)	Leaf area	Dust deposition in (g/m^2)
Alstonia scholaris	Jan.	1.10±0.20	0.99±0.18	0.09±0.02	42.0±9.77	24.2±7.97
	Fab.	1.12±0.18	1.05±0.19	0.07±0.02	44.9±6.36	16.7±4.36
	Mar.	1.09±0.21	1.06±0.21	0.04±0.03	43.1±9.58	11.4±9.08
Mimusops elengi	Jan.	1.12±0.19	0.821±0.40	0.10±0.03	42.0±9.85	25.3±9.04
	Fab.	1.10±0.18	0.80±0.37	0.10±0.03	42.2±9.94	24.7±9.95
	Mar.	0.85±0.136	0.79±0.137	0.07±0.02	42.8±8.01	16.8±5.93
Ziziphus mauritiana	Jan.	0.07±0.02	0.05±0.02	0.01±0.006	6.7±3.83	29.0±14.11
	Feb.	0.08±0.02	0.05±0.02	0.02±0.007	9.3±0.83	21.0±11.2
	Mar.	0.08±0.01	0.07±0.01	0.01±0.005	9.0±1.14	15.6±5.78
Calotropis gigentea	Jan.	1.81±0.50	1.6±0.44	0.21±0.07	141±12.7	16.0±6.13
	Feb.	1.72±0.54	1.68±0.47	0.13±0.03	145±9.05	9.13±2.42
	Mar.	1.76±0.88	1.69±0.88	0.06±0.02	102±63.1	9.85±7.26

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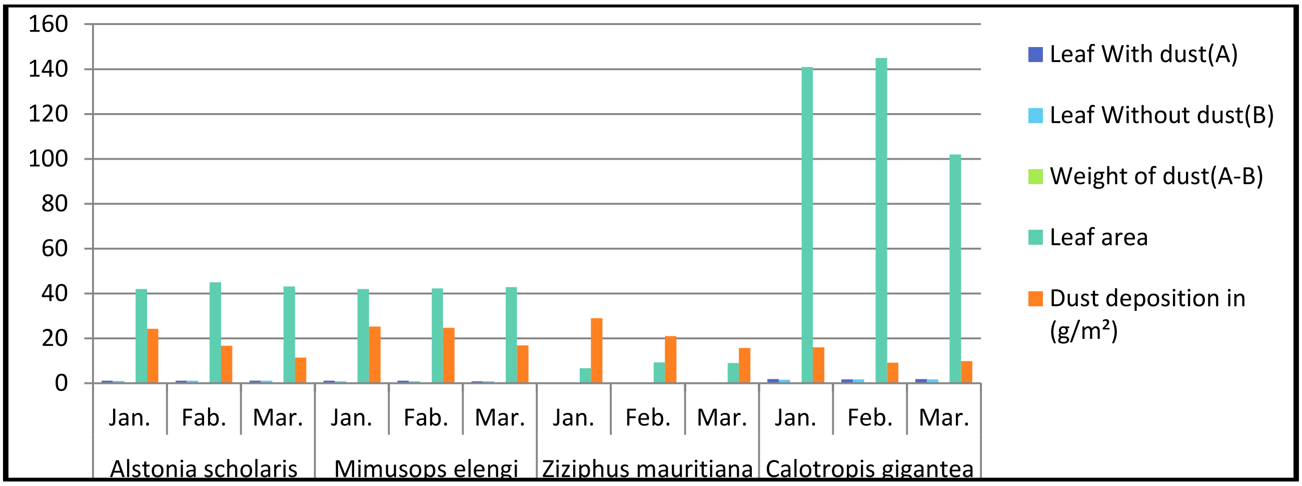
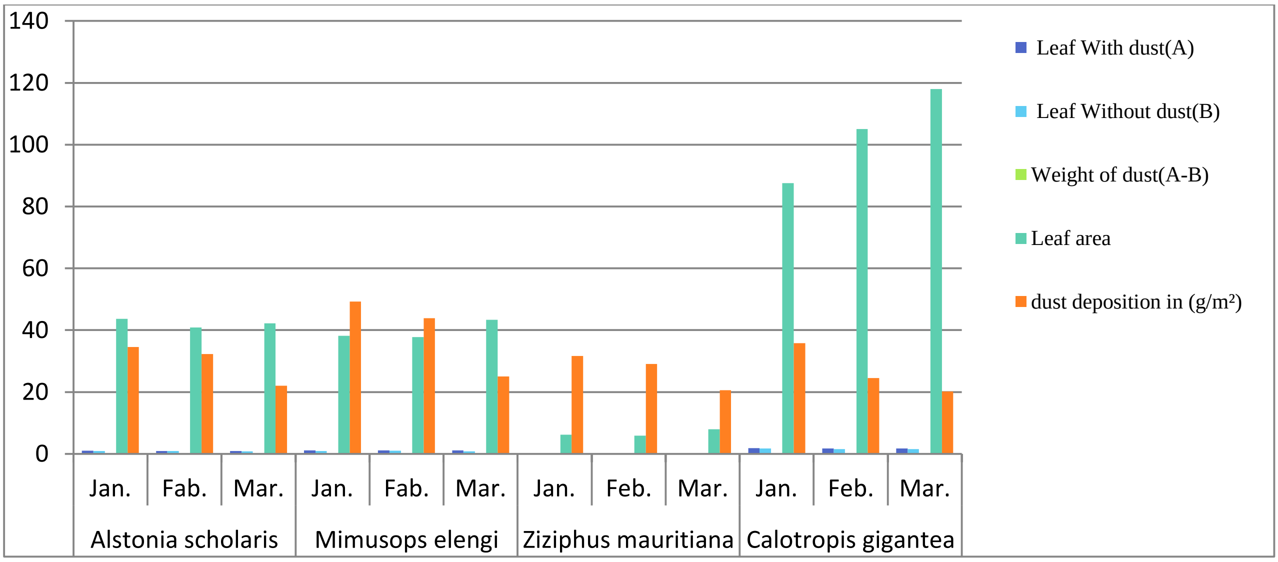


Graph 1: Average leaf area and dust deposition (g/m^2) on the leaves of selected plant in Reference area

Table 2: Average Leaf area and Dust deposition (g/m^2) on the leaves of selected plant in Polluted area

Name of the plant	Month	Leaf With dust(A)	Leaf Without dust(B)	Weight of dust(A-B)	Leaf area	dust deposition in (g/m²)
Alstonia scholaris	Jan.	1.02±0.16	0.88±0.17	0.14±0.03	43.7±12.5	34.5±11.4
	Fab.	0.89±0.16	0.87±0.15	0.02±0.01	40.9±8.04	32.3±11.2
	Mar.	0.87±0.12	0.78±0.11	0.09±0.01	42.2±1.81	22.0±4.57
Mimusops elengi	Jan.	1.12±0.19	0.95±0.17	0.17±0.05	38.2±1.61	49.3±17.6
	Fab.	1.13±0.22	0.97±0.17	0.16±0.11	37.8±1.12	43.9±0.27
	Mar.	1.11±0.18	0.80±0.37	0.10±0.02	43.4±7.36	25.0±5.91
Ziziphus mauritiana	Jan.	0.07±0.02	0.06±0.01	0.01±0.006	6.2±1.64	31.6±16.0
	Feb.	0.07±0.02	0.06±0.02	0.01±0.007	5.9±2.30	29.1±14.0
	Mar.	0.08±0.02	0.06±0.02	0.01±0.006	7.9±1.14	20.6±9.29
Calotropis gigentea	Jan.	1.81±0.91	1.78±0.90	0.03±0.01	87.5±66.4	35.8±24.3
	Feb.	1.72±0.52	1.50±0.48	0.22±0.04	105±39.5	24.5±12.9
	Mar.	1.69±0.49	1.50±0.47	0.23±0.06	118±30.2	20.2±6.60



Graph 2: Average Leaf area and Dust deposition (g/m^2) on the leaves of selected plant in Polluted area

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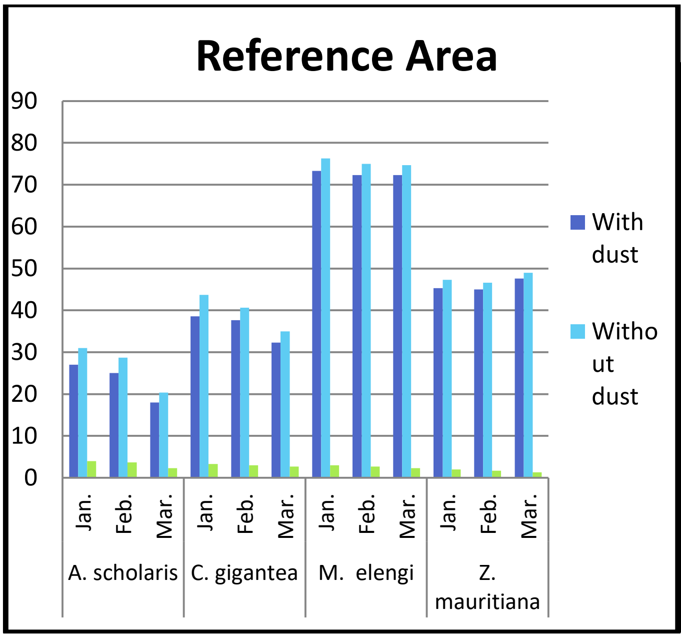
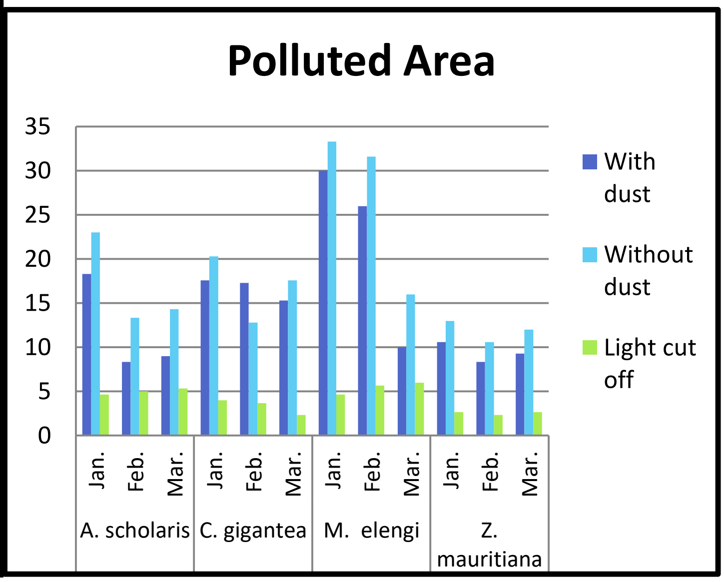
Table 3:- Light transmittance (Lux) from the leaves of selected plant species under artificial light source.

(Incident light: 1250lux)

Selected Plants	Month	Reference Area			Polluted Area		
		With dust	Without dust	Light cut off	With dust	Without dust	Light cut off
Alstonia scholaris	Jan.	27±4.58	31±2.64	4±2.64	18.3±2.51	23±1.73	4.66±1.15
	Feb.	25±5	28.66±6.50	3.66±1.52	8.33±1.52	13.33±2.88	5.0±2.0
	Mar.	18±3	20.33±3.51	2.33±0.57	9±5	14.33±4.04	5.33±1.15
Calotropis gigantea	Jan.	38.6±5.68	43.66±9.07	3.33±0.57	17.6±1.52	20.3±0.57	4.0±0.00
	Feb.	37.66±6.42	40.66±7.23	3±1	17.3±1.52	12.8±2.64	3.66±1.15
	Mar.	32.33±2.51	35±2.64	2.66±0.57	15.3±3.05	17.6±3.21	2.33±1.52
Mimusops elengi	Jan.	73.33±3.05	76.3±1.52	3±1.73	30±3	33.3±3.51	4.66±0.57
	Feb.	72.33±2.51	75±3	2.66±0.57	26.0±5.29	31.6±5.77	5.66±1.15
	Mar.	72.33±3.21	74.66±3.78	2.33±0.57	10±2.64	16±2	6.0±1.00
Ziziphus mauritiana	Jan.	45.3±4.72	47.3±4.61	2±1	10.6±2.08	13±1	2.66±0.57
	Feb.	45.0±5	46.6±5.03	1.66±0.57	8.33±2.08	10.6±3.51	2.33±1.52
	Mar.	47.6±3.05	49±3	1.33±0.57	9.3±1.52	12±1	2.66±0.57





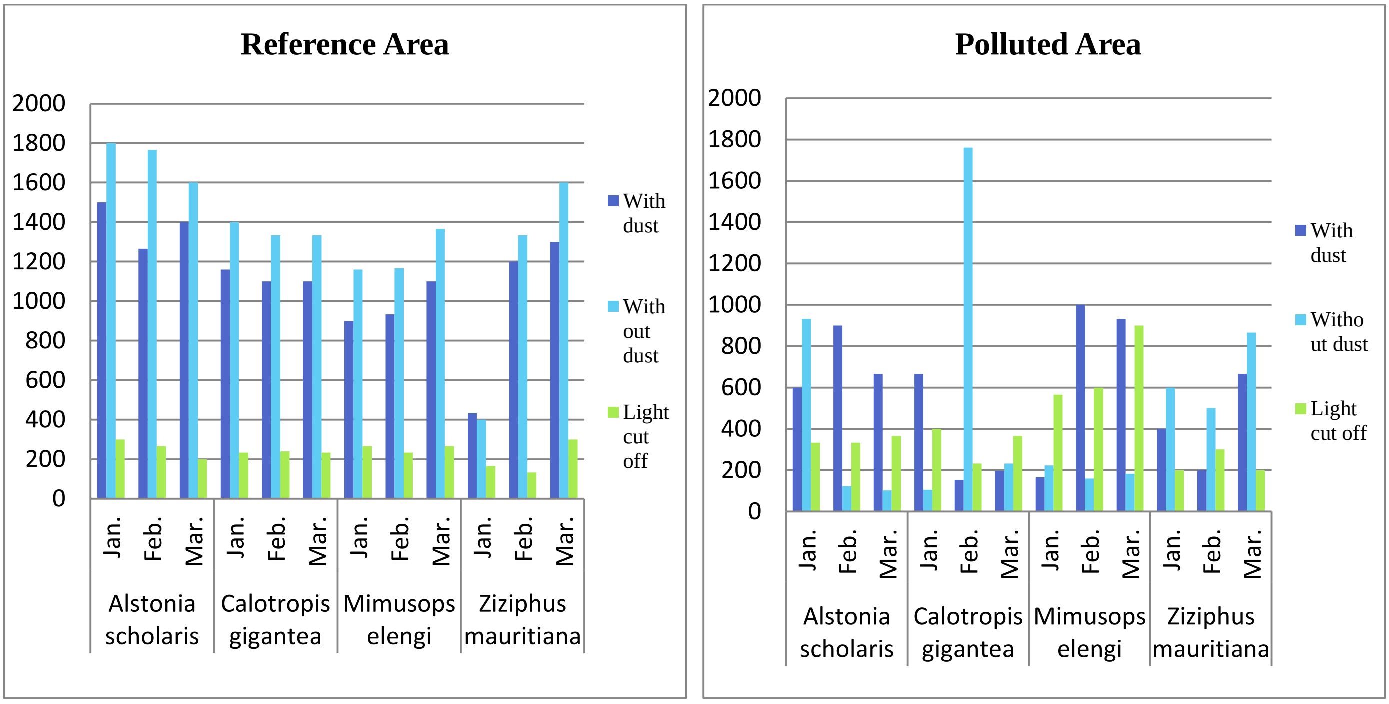
Graph 3.1 and 3.2: Light transmittance (Lux) from the leaves of selected plant species under artificial light source.

Table 4: - Light transmittance (Lux) from the leaves of selected plant species under field condition.

(Incident light: 80.0 thousand lux)

Selected Plants	Month	Reference Area			Polluted Area		
		With dust	Without dust	Light cut off	With dust	Without dust	Light cut off
Alstonia scholaris	Jan.	1500±458	1800±435	300±100	600±200	933±152	333±057
	Feb.	1266±208	1766±305	266±57.7	900±500	123±450	333±57.7
	Mar.	1400±100	1600±100	200±100	666±251	103±152	366±115
Calotropis	Jan.	1160±378	1400±529	233±152	666±152	106±152	400±000

gigantea	Feb.	1100±346	1333±321	240±57.7	153±305	1760±321	233±152
	Mar.	1100±173	1333±152	233±57.7	196±208	233±305	366±152
Mimusops elengi	Jan.	900±200	1160±251	266±057	166±251	223±472	566±230
	Feb.	933±57.7	1166±152	233±115	1000±264	160±200	600±100
	Mar.	1100±100	1366±152	266±57.7	933±251	183±208	900±264
Ziziphus mauritiana	Jan.	433±152	400±173	166±152	400±173	600±100	200±100
	Feb.	1200±100	1333±57.7	133±57.7	200±100	500±100	300±173
	Mar.	1300±100	1600±100	300±0	666±230	866±152	200±100

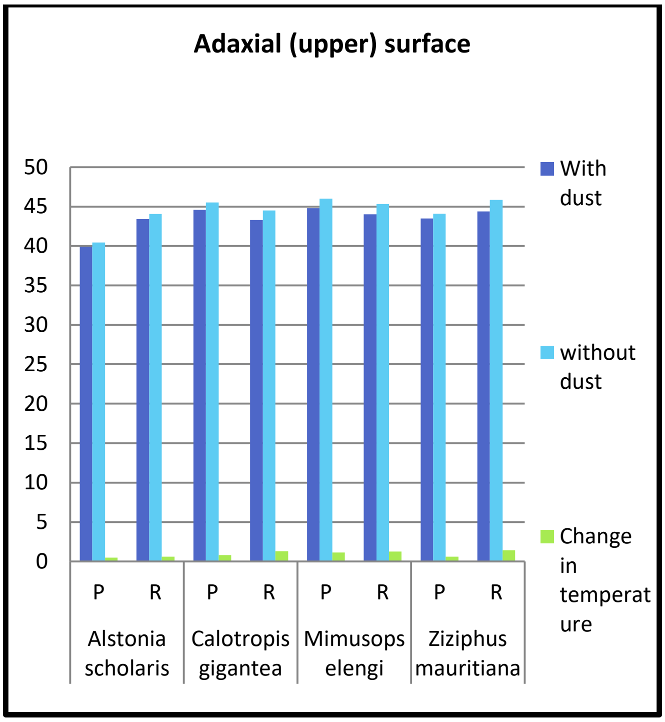


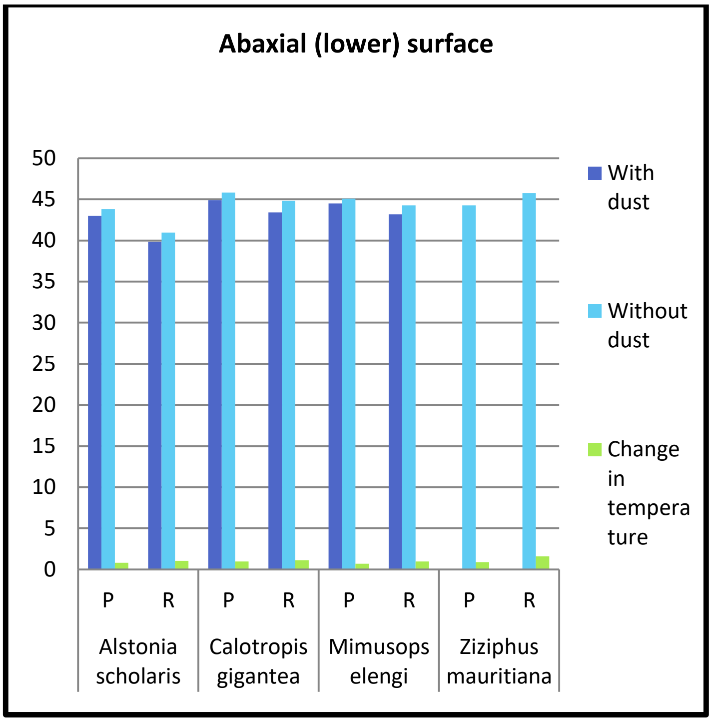
Graph 4.1 and 4.2: Light transmittance (Lux) from the leaves of selected plant species under field condition.

Table 5: - Leaf surface temperature (˚C) of selected plants with and without dust.

Plant		adaxial (upper) surface			Adaxial (lower) surface		
		With dust	without dust	Change in temperature	With dust	Without dust	Change in temperature
Alstonia scholaris	P	39.9±2.38	40.45±2.38	0.48±0.14	43±1.66	43.82±1.50	0.82±0.66
	R	43.4±1.05	44.04±1.39	0.59±0.38	39.85±1.47	40.98±1.56	1.03±0.37
Calotropis gigantea	P	44.6±0.98	45.5±0.93	0.82±0.30	44.88±1.19	45.82±1.29	0.98±0.43
	R	43.3±1.63	44.5±1.40	1.3±0.45	43.4±0.98	44.8±0.86	1.1±0.41
Mimusops elengi	P	44.8±1.02	46±1.03	1.15±0.80	44.49±1.25	45.1±1.22	0.68±0.19
	R	44.0±1.22	45.3±1.17	1.26±0.74	43.2±1.56	44.2±1.27	0.96±0.56
Ziziphus mauritiana	P	43.5±0.78	44.1±0.88	0.61±0.23	44.16±0.89	44.28±1.66	0.87±0.60
	R	44.4±1.61	45.85±1.27	1.44±0.89	44.16±0.89	45.74±0.94	1.58±0.93

*P= Polluted area *A= Reference area

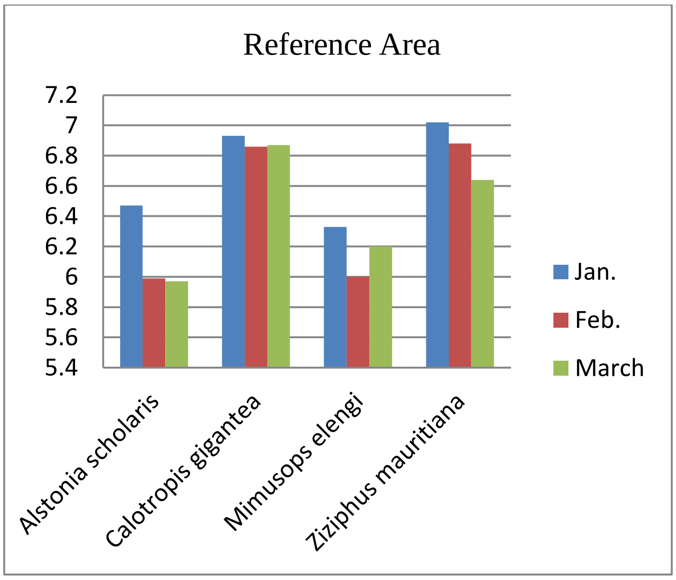


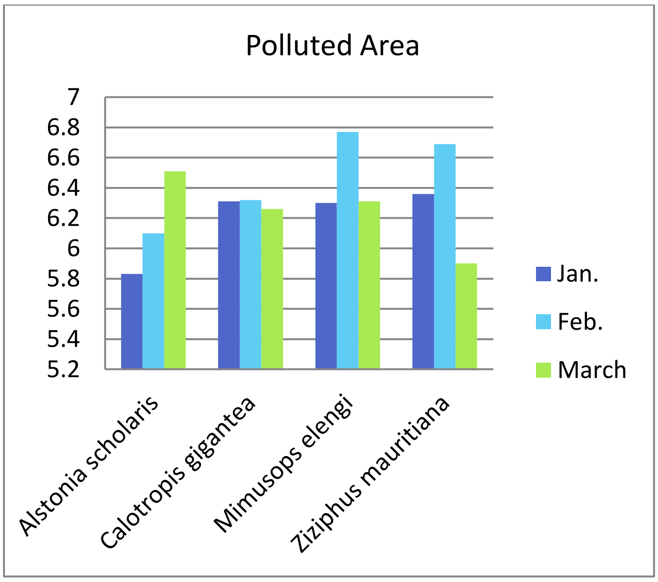


Graph 5.1 and 5.2: Leaf surface temperature (˚C) of selected plants with and without dust

Table:-6 Average Cell sap pH of plants growing in Polluted and Reference area.

Selected Plants	Reference Area				Polluted Area			
	Jan.	Feb.	March	Average	Jan.	Feb.	March	Average
Alstonia scholaris	6.47	5.99	5.97	6.14±0.28	5.83	6.10	6.51	6.14±0.34
Calotropis gigantea	6.93	6.86	6.87	6.88±0.03	6.31	6.32	6.26	6.29±0.03
Mimusops elengi	6.33	6.00	6.20	6.17±0.16	6.30	6.77	6.31	6.43±0.22
Ziziphus mauritiana	7.02	6.88	6.64	6.84±0.19	6.36	6.69	5.9	6.34±0.43





Graph 6.1 and 6.2: Average Cell sap pH of plants growing in Polluted and Reference area.

4. CONCLUSION:

The study on four plant samples of Alstonia scholaris, Calotropis gigentea, Mimusops elengi, and Ziziphus mauritiana growing at polluted and non-polluted area represented that dust pollution causes significant changes in the physiological properties of leaves. The study concluded that dust pollution affected some physiochemical parameters of leaves. The dust deposition on sample plant leaves were found maximum in polluted area compare to the reference. The particulate matter deposition capacity of leaves has been observed to be different in all four sample plant species. The maximum dust deposition has been found on Mimusops elengi leaves and minimum on Calotropis gigentea. This indicates that plant species with small and simple leaves have more dust deposition capacity as compare to large and thicker leaves. The temperature difference between upper and lower surface of leaves were also observed during study. The temperature difference was more in all sample plants without dust, except in Mimusops elengi.

Significance- the study was represented that the dust pollution affected some physiochemical parameters of leaves.

5. ACKNOWLEDGEMENT

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