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Foliar Dust Deposition Over Various Plant Species and Its Imapct On chlorophyll content of Certain Plant Species Grown Alongside NH-135, (M.P) India

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ABSTRACT:

Vehicular traffic is one of the major contributors to accumulate dust on plants grown alongside roads. Plants intercept tons of dust,absorb noise and serve as acoustic screens on busy Highways.Roadsides trees can play a significant role in capturing these air suspended pollutants , reducing noise pollution , preventing soil erosion and improving overall environmental quality. The objective of this study was to assess the impacts of dust on leaf of plants growing along the roadsides of National highways NH-135 In Rewa Division (Madhya Pradesh). Common plant species namely, Psidium guajava Mangifera indica, Acacia auriculiformis, Syzigum jambolana, Madhuca indica, Tectona grandis, Nerium oleander, Calotropis procera were chosen for this purpose and the findings revealed that tectona grandis expressed highest dust holding capacity while Nerium oleander expressed lowest. Furthermore, the study analyses the impact of dust deposition On the leaf chlorophyll content. Chlorophyll content showed variable response to dust. Calotropis procera expressed Highest chlorophyll content while Tectona grandis expressed lowest .The plant species with tolarance to high dust accumulation on their leaf surfaces are preferable as roadside plants.

Keywords

Dust deposition, Suspended pollutants, Dust holding capacity,Chlorophyll

Introduction

The natural environment is essential for the existence of man and it is the primary source of his life and social production. Man's desire for material wealth and comfort has led him to exploit natural resources by applying all sorts of industrial activities and technological innovations.

At the beginning, when Industrial activities spilled their unwanted wastes into the atmosphere, the ecological system was able to absorb and neutralize the toxicity of these wastes. However as the output of these products increased at exponential rates, the very existence of natural system is threatened.

Air pollution is a major problem faced globally and mainly arising due to from Industrialization,unplanned urbanization, alarming increases in vehicles fleet, population growth (Gupta and Mishra, 1994; Verma and Prakash, 2020).Outdoor air pollution is a major globally public health issue, leading to 6.67 million deaths worldwide and 1.67 million deaths in India annually (Health effects Institute, 2020)

Vehicular emission are one of the major sources of air pollutants and have a powerful negative effect on germination and growth of plants. These pollutants may induce plant responses leading to observable changes in their morphology plant responses may vary depending on the amount of pollutants to which they are exposed. Although this has been an intense area of research which need further studies. More plants at young stage are encouraged to be planted along roadsides as potential species since they apparently indicate the symptoms of pollutants intake in terms of stomatal index and biochemical traits to improve local air quality.

Roadsides trees exhibit changes in P^H value, relative H_2o content & species diversity due to dust fall from both sides of Highways & roads (Rai & panda,2014).A relationship between traffic density & plant photosynthetic activity, total chlorophyll content stomatal conductance & leaf senescence has been reported (Gratani et al.,2000; Honour et al.,2009; Sharma et al.,2017). The response of the plant to dust deposition may vary with plant species depending on their leaf surfaces geometry, leaf pubescence, leaf orientation, phyllotaxy, height & canopy of roadsides plants (Rai et al.,2010; Chaturvedi et al.,2013; Singh & Pal, 2017). Sett(2017) explained that the evergreen trees showed superior PM retention capabilities compared to deciduous trees due to their year-round leaf retention, enhanced surface properties & denser canopies that maximize PM capture.

Reduction in chlorophyll, ascorbic acid and Nitrogen concentration has been observed by Pandey and Pandey (1994) in relation to phytotoxic pollutants in Varanasi. Chlorophyll is an index of productivity of the plant. Whereas certain pollutants increase the total chlorophyll content, others decrease it (Agbaire & Esiefarienrhe,2010).in polluted sites, reduction of 52.4% in the total chlorophyll content in the leaves of Azadiracta indica.

The ability of plant leaves to trap and accumulate dust particulates depends on the level of contaminants in the atmosphere, meteorological status, and wind strength and direction (Rahul & Jain 2014). It also depends on the leaf traits like leaf shape, size, texture, orientation, leaf pubescence, length of petiole, and canopy of plants (Prajapati 2012, Rahul & Jain 2014, Sett 2017, Kameswaran et al. 2019. It was observed that large leaf surface results in better dust capturing (Prajapati 2012). Dust load on urban trees in India, including fig Ficus species, negatively impacts on leaf growth, leaf micro morphological and photosynthetic compound (Chaudhary and Rathore, 2019).

The screening of effective plants for particulate sink is very essential for abatement of dust pollution. In furtherance to the above intention, current study has been conducted to investigate leaf dust accumulation and variation in chlorophyll content in leaves of 8 selected plant species namely, Psidium guajava, Mangifera indica, Acacia auriculiformis, Syzigum jambolana, Madhuca indica, Tectona grandis, Nerium oleander, Calotropis procera grown alongside NH-135. This study compares the capabilities of selected plants with regards to dust accumulation and also provides essential data for recognition and Control of air quality as well as for further environmental study.

Material and Methods

Study Area

National highway 135 is a national highway of India. It is an auxiliary branch of National Highway 35. It originates from Mirzapur in Uttar Pradesh and terminates at Mangawan in Madhya Pradesh. The highway passing through Mauganj, Hanumana, Deotalab towns. It runs from Mirzapur to Mangawa .

Soil

The Mangawan to Hanumana section of NH-135 runs through the Vindhya region of Madhya Pradesh,where the soil is generally a mixed red and yellow type , which is derived from igneous, crystalline rocks, granite, metamorphic gneiss, acid quartzite, old sedimentary sandstone, and clays of highways Thus, the soils have lesser amount of clay. The sandstone is generally forming uplands and flats on weathering, These rocks are forming red and yellow sandy soil, which is predominated here. The red colour is due to a high content of iron oxides while the yellow color results from its hydrated from.

Physiography

The physiography of the National Highway 135 (NH- 135) section from Mangawan to Hanumana is characterized by its location on the Rewa Plateau in eastern Madhya Pradesh. The terrain is defined by the Vindhyan Range, which creates a landscape of undulating plains, flat-topped hills, and scarps.

Sample collection

Common plants occuring in the area were selected for the study (Table-1).In March 2024 to Feb 2025, leaves were randomly collected from selected species from roadside at an intermittent distance of 5 km along the NH-135. And Hanuman Mandir Higher Secondary School ,Mauganj as Control site, were plucked carefully and kept in separate polythene bags and brought to laboratory. The average dust deposition was derived from 4 sites at NH-135. The track was made by GPS essential app and GPS location coordinate & pictures were taken by using Time Stamp Camera. Leaves from the plants were collected in zipper pouches separately & brought to laboratory for analysis.

Table

Table 1. Characteristics of selected plants at the study site

S. N.	Plant Species	Common Name	Family	Habit	Leaf shape	Phyllotaxy
1	Psidium guajava	Guava	Myrtaceae	Tree	Oblong-elliptic	Opposite
2	Mangifera indica	Mango	Anacardiaceae	Tree	Lanceolate to oblong-elliptic	Alternate
3	Acacia auriculiformis	Australian babool	Fabaceae	Tree	Falcate	Alternate and spiral
4	Syzigum jambolana	Jamun	Myrtaceae	Tree	Elliptic-oblong	Opposite
5	Madhuca indica	Mahua	Sapotaceae	Tree	Oblong shaped	Alternate
6	Tectona grandis	Teak/Sagwn	Lamiaceae	Tree	Ovate- eliptic	Opposite Decussate
7	Nerium oleander	Kaner	Apocynaceae	Small tree/Shrub	Linear/lanceolate	Opposite
8	Calotropis procera	Mudar/Aak	Asclepiadaceae	Small tree/Shrub	Orbicular/ovate	Opposite

Dust holding capacity

For the determination dust capturing capacity three samples of leaves of each species were selected. Initial weight of leaf samples with dust particales was taken. Then the leaf sample was thoroughly washed with deionised water. After this the leaves were dried with a clean cotton and blotting sheet to remove dust and the dried leaf samples were Weighted again. The percentage of dust holding capacity of different leaf samples was calculated by using formula (SOP,2015)

$$\text{Dust holding capacity (\%)} = \frac{\text{Weight of dust} \times 100}{\text{Weight of cleaned leaves}}$$

Where, Weight of dust = Weight of uncleaned leaves - Weight of cleaned leaves

Estimation of chlorophyll content:

Total chlorophyll content analysis was done by Arnon Method (Singh et al.,2018) . For determination of chlorophyll content, 2.0 g of fresh leaf samples were finely chopped and kept in 50 ml conical flask containing 20 ml of 80% acetone or methanol.These flasks were tightly corked and kept in dark for 24 hrs. After 24 hrs this mixture was centrifuged at 5000 rpm for 5 minutes.The supernatant was then transferred to a 100 ml volumetric flask and the volume was made up to 100 ml with 80% acetone. This procedure was repeated until the residue was colourless. The absorbance of the solution was read at 663 nm and 665 nm against the blank solvent (80% acetone) using spectrophotometer. The amount of chlorophyll a, chlorophyll b and chlorophyll (a+b) in terms of mg/g fresh leaf, were calculated, using the following formulae given by Thimmaiah,1999)

$$\text{Chlorophyll a (mg/g tissue)} = \frac{12.4\,(A663) - 02.35(A645) \times V}{1000 \times W}$$

$$\text{Chlorophyll b (mg/g tissue)} = \frac{21.82(A645) - 4.69\,(663) \times V}{1000 \times W}$$

$$\text{Total chlorophyll (mg/g tissue)} = \frac{19.47(A645) + 7.71(A663) \times V}{1000 \times W}$$

Where, A =Absorbance of extract at specific wavelength (nm)

V= Final volume of chlorophyll extract in 80% acetone (ml)

W= Weight of the tissue extract (g)

Result And Discussion

Dust accumulation:

Analysis of the data revealed that dust accumulation along national highways significantly affects plant species by blocking stomata, reducing photosynthesis, accumulating heavy metals, and altering physiological processes. The degree of impact depends on the specific plant species, as well as the dust's composition, particle size, and concentration.Dust accumulation was highest during pre-monsoon season as compared to post monsoon months.Plants with specific adaptations like trichomes or particular leaf orientations can better tolerate dust deposition.Thus, plants possess different tolarance capacities depending upon the type of plant species . Total dust deposition on selected plant species at different sites is shown in table 1.

Table:1 Seasonal varition of Foliar Dust Deposition (mg/cm²) Over various plant species growing at different distances along NH-135 from March 2024 to Feb. 2025.

		Control Site			Site No.1			Site No.2			Site No.3			Site No.4		
S. No.	Name of Plant Species	W	S	R	W	S	R	W	S	R	W	S	R	W	S	R
1	P. guava	1.48	1.36	1.05	6.57	4.24	3.18	5.55	3.32	2.89	3.02	2.94	1.98	5.16	3.04	2.15
2	M. indica	2.62	2.21	1.16	8.19	5.44	2.62	6.98	5.9	3.46	4.12	3.25	2.15	5.46	4.63	3.03
3	A. auriculiformis	1.32	1.22	0.99	5.42	3.74	2.38	5.08	3.16	2.28	2.34	1.88	1.75	4.84	3.39	2.07
4	S. jambolane	1.44	1.16	0.96	4.95	3.51	2.19	4.65	3.24	2.14	2.14	2.19	1.68	4.08	3.04	2.02
5	N. indica	1.58	1.39	1.09	8.16	6.12	5.04	5.95	4.23	2.96	4.02	3.12	2.13	5.28	3.46	2.74
6	T. grandis	3.82	2.69	1.89	8.39	6.65	3.91	7.99	6.2	4.12	4.62	3.98	2.29	6.82	5.48	3.66
7	N. oleander	1.28	1.08	0.78	4.25	2.82	1.92	4.58	2.48	1.26	2.05	1.12	1.08	3.82	2.28	1.22
8	C. procera	2.78	2.23	1.78	8.26	6.52	3.65	7.86	5.99	3.48	4.56	3.87	2.24	6.62	4.76	3.61

Where,

Control Site = Hanuman Mandir Higher Secondary School,Mauganj
Site – 1 = SBI Branch ,Mangava

Site – 2 = Deotalab bypass

Site – 3 = Chackmod Mauganj

Site –4 = Masuriya toll plaza ,Hanumana

The statistical results of foliar dust deposition for different sites have been presented in table 1.The observed minimum concentration of foliar dust was 0.78 (mg/cm²) in N. oleander (rainy season) and maximum was 3.82 (mg/cm² leaf area) in T.grandis (winter season) at Control Site,Hanuman Mandir Higher Secondary School, Mauganj. Minimum concentration of foliar dust was 1.92 (mg/cm²) in N.oleander (rainy

season) and maximum 8.39 (mg/cm²) in T.grandis (winter seasom) at Site-1 SBI Branch ,Mangava and minimum concentration of foliar dust was 1.26 (mg/cm²) in N. oleander (rainy season) & maximum concentration was 7.99 (mg/cm²) in T.grandis (winter season at Site-2 , Deotalab (Bypass). Minimum concentration was 1.08 (mg/cm²) in N. oleander (rainy season) & maximum concentration was 4.62 (mg/cm²) in T.grandis(winter season) at site-3 Chackmod, Mauganj .Minimum concentration was 1.22 (mg/cm²) in N. oleander (rainy season) & maximum concentration was 6.82 (mg/cm²) in T.grandis (winter season) at site-4, Masuriya toll plaza ,Hanumana . Among all selected sites, dust deposition was maximum in T.grandis (8.39) at site-1 in winter season while lowest in N. oleander (0.78) at control site in rainy season (Table-1) along NH-135.

The dust accumulation of the selected plant species varied significantly with species, horizontal distances and seasons of the year (Table 1). The order of selected plant species according to dust accumulation was Tectona grandis > Calotropis procera > Mangifera indica >Madhuca indica > Psidium guajava > Acacia auriculiformis > Syzigum jambolana > Nerium oleander, The highest dust accumulation on the leaves of T. grandis may be attributed to its rough leaf texture,presence of hairs and large leaf size contribute to its strong dust trapping ability and prevented dust fall from leaf surface. Lowest amount of dust observed on N. oleander may be attributed to its thick, leathery cuticle with a very smooth surface due to which dust settled on the leaf surface may slip down due to gravitational force or even by wind. The present findings are also in congruence with observations that the dust deposition capacity of plants depends on their surface geometry and leaf external characteristics (Thakar and Mishra, 2010; Joshi and Bora, 2011). This may be ascribed to dense traffic movement nearby the roadside as compared to the distance away from the road. These results are in corroboration with the findings of Rahul and Jain (2014), who reported that high dust deposition on leaf surface at road side with heavy vehicular traffic may be due to spray of unburnt oil residue of diesel or petrol on the leaf surface. Dust accumulation is more in plants growing at roadsides due to high dust intensity which results by the vehicles activity and capturing dust with a gentle wind (Younis et al., 2013). Leaves hold more dust in the winter season ,as dew helps retain dust , and in pre- monsoon season due to increased dust particle availability and lack of washout and lowest in rainy season.

Total Chlorophyll Content

Total chlorophyll content is an indicator of leaf photosynthetic capacity.It is crucial for improving the understanding of plant physiological status. It is a key indicator of a plant's health and its capacity for photosynthesis.

Table:2- Seasonal Variation of chlorophyll 'a' content (mg/g) of selected plant species growing along NH-135 From March 2024 to Feb. 2025,

		Control Site			Site No.1			Site No.2			Site No.3			Site No.4		
S. No.	Name of Plant Species	W	S	R	W	S	R	W	S	R	W	S	R	W	S	R
1	T. grandis	0.9877	1.1027	1.2454	.8321	.8423	.8542	.7244	.7269	.7466	.9771	1.0866	1.1461	.7234	.7248	.7339
2	M. indica	1.1103	1.1123	1.4588	.8363	.8429	.8548	.8424	.8443	.8529	1.0119	1.1039	1.3576	.8386	.8421	.8521
3	S. jambolane	1.1106	1.1128	1.4639	.8457	.8488	.8589	.8582	.8592	.8599	1.1119	1.1345	1.3648	.8388	.8438	.8570
4	N.oleander	1.1211	1.1217	1.5222	.8541	.8561	.8632	.8589	.8588	.8698	1.1167	1.1761	1.4536	.8422	.8496	.8598
5	A. auriculiformis	1.3210	1.3564	1.5321	.8771	.8876	.8922	.8758	.8757	.8982	1.1224	1.2532	1.4631	.8767	.8768	.8789
6	P.guava	1.3226	1.3684	1.5433	.9119	.9134	.9148	.9644	.9774	.9867	1.2258	1.2686	1.5329	.9105	.9119	.9128
7	M. indica	1.3263	1.4264	1.5626	.9515	.9551	.9671	.9859	.9958	.9977	1.2379	1.4156	1.5459	.9512	.9589	.9674
8	C. procera	1.5624	1.5814	1.6844	.9895	.9913	.9933	1.5349	1.5449	1.5876	1.3572	1.4777	1.5843	.9881	.9891	.9899

Where,

Control Site = Hanuman Mandir Higher Secondary School,Mauganj

Site – 1 = Masuriya toll plaza ,Hanumana

Site – 2 = Deotalab bypass

Site – 3 = Chackmod Mauganj

Site –4 = SBI Branch ,Mangava

Table:3- Seasonal Variation of chlorophyll 'b' content (mg/g) of selected plant species growing along NH-135 From March 2024 to Feb. 2025

		Control Site			Site No.1			Site No.2			Site No.3			Site No.4		
S. No.	Name of Plant Species	W	S	R	W	S	R	W	S	R	W	S	R	W	S	R
1	T. grandis	0.9871	1.1123	1.2447	.8312	.8419	.8548	.7834	.7859	.7926	.9782	1.0964	1.1457	.7828	.7838	.7859
2	Madhuca indica	1.1104	1.1129	1.4586	.8353	.8425	.8558	.8414	.8433	.8629	1.0109	1.1029	1.3579	.7986	.7993	.7998
3	S.jambolane	1.1103	1.1138	1.4632	.8447	.8481	.8599	.8572	.8588	.8597	1.1116	1.1349	1.3641	.8389	.8482	.8579
4	N. oleander	1.1215	1.1218	1.5212	.8521	.8551	.8622	.8587	.8596	.8599	1.1163	1.1766	1.4533	.8420	.8533	.8592
5	A. auriculiformis	1.3217	1.3464	1.531	.8778	.8884	.8912	.8766	.8784	.8986	1.1214	1.2522	1.4621	.8668	.8679	.8884
6	P. guava	1.3225	1.3681	1.5432	.9109	.9124	.9139	.9634	.9764	.9861	1.2256	1.2684	1.5324	.9107	.9115	.9124
7	M. indica	1.3466	1.4664	1.5629	.9526	.9541	.9617	.9864	.9962	.9974	1.2363	1.4164	1.5456	.9566	.9754	.9968
8	C. procera	1.5629	1.5811	1.6845	.9885	.9913	.9923	1.5345	1.5443	1.5872	1.3565	1.4767	1.5846	.9889	.9896	.9898

Where,

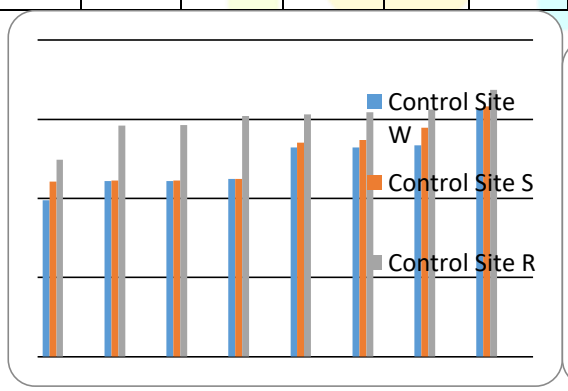
Control Site = Hanuman Mandir Higher Secondary School,Mauganj
Site – 1 = SBI Branch ,Mangava

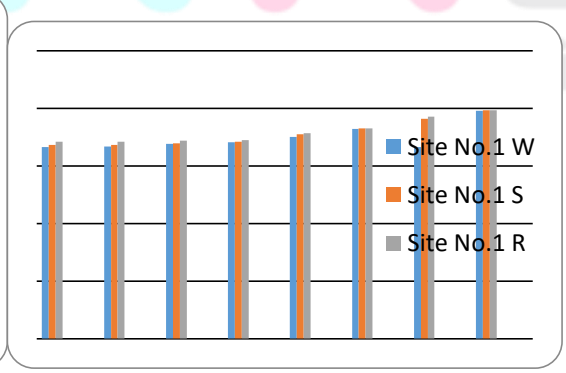
Site – 2 = Deotalab bypass

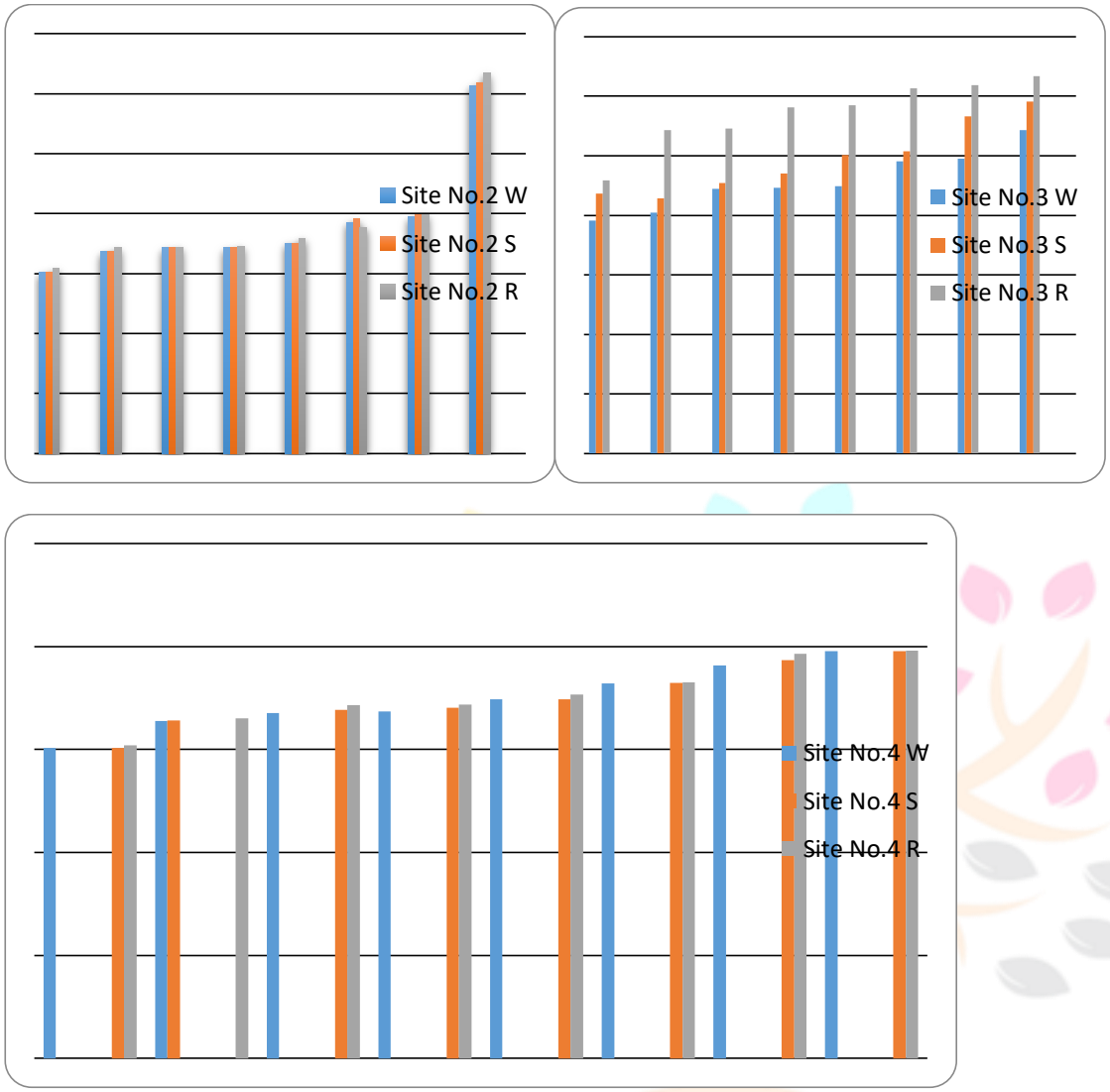
Site – 3 = Chackmod Mauganj
Site –4 = Masuriya toll plaza ,Hanuman

Table:3- Seasonal Variation of total chlorophyll content(mg/g) of selected plant species growing along NH-135 From March 2024 to Feb. 2025Variation in total chlorophyll content of selected plant species in mg/g

		Control Site			Site No.1			Site No.2			Site No.3			Site No.4		
S. No.	Name of Plant Species	W	S	R	W	S	R	W	S	R	W	S	R	W	S	R
1	T. grandis	1.9748	2.2150	2.4901	1.6633	1.6842	1.7090	1.5078	1.5128	1.5392	1.9553	2.1830	2.2918	1.5062	1.50866	1.51998
2	M. indica	2.2207	2.2252	2.9174	1.6716	1.6854	1.7106	1.6838	1.6876	1.7158	2.02228	2.1419	2.7155	1.6372	1.6414	1.6519
3	S. jambolanum	2.2209	2.2266	2.9271	1.6904	1.6969	1.7188	1.7154	1.7180	1.7196	2.2235	2.2694	2.7289	1.6777	1.69200	1.7149
4	N. oleander	2.2426	2.2435	3.0434	1.7062	1.7112	1.7254	1.7176	1.7184	1.7297	2.2330	2.3527	2.9069	1.6842	1.7029	1.7190
5	A. auriculiformis	2.6427	2.7028	3.064	1.7549	1.776	1.7834	1.7524	1.7541	1.7968	2.2438	2.5054	2.9252	1.7435	1.7447	1.7673
6	P.guava	2.6451	2.7365	3.0865	1.8228	1.8258	1.8287	1.9278	1.9538	1.8848	2.4514	2.5370	3.0653	1.8212	1.8234	1.8252
7	M. indica	2.6729	2.8928	3.1255	1.6637	1.9092	1.9288	1.9723	1.992	1.9951	2.4742	2.8320	3.0915	1.9078	1.9343	1.9642
8	C. procera	3.1253	3.1625	3.3689	1.9780	1.9836	1.9836	3.0694	3.0892	3.1748	2.713	2.9544	3.1689	1.9770	1.97867	1.9797







Where,

Control Site = Hanuman Mandir Higher Secondary School,Mauganj
Site – 1 = Masuriya toll plaza ,Hanumana
Site – 2 = Deotalab bypass
Site – 3 = Chackmod Mauganj
Site –4 = SBI Branch, Mangava

This study commonly available plant leaves were used to estimate the chlorophyll content. The total of eight plants were selected for this study along NH-135.These values of total chlorophyll content were estimated and tabulated. Among the all sites the highest total chlorophyll content (a + b) was detected in Calotropis procera (3.3689mg/g), followed by Mangifera indica (3.1255 mg/g), Psidium guava (3.0865mg/g) in rainy season at control site while lowest total chlorophyll content was seen in T. grandis(1.5062 mg/g) in winter season at site-4 (Table:4). Calotropis procera maintains high chlorophyll content by protecting its photosynthetic machinery from environmenal stress like water scarcity and salinity. The amount of leaf chlorophyll a, chl b and total chlorophyll (chl a+b) were reduced by increasing water deficit. The chlorophyll pigments are an indicator of O_2 production and carbon sequestration. It was found that most of plant species were affected by dust deposition and the amount of total chlorophyll was found to reduce in them.It was also

noticed that maximum reduction was during winter followed by summer season and minimum reduction was seen during rainy season. The amount of chlorophyll-a, chl b and total chlorophyll in dusted leaves was found to be lower than that in Control leaves of the same age.

Conclusion

Heavy dust load on plant leaves negatively impacts chlorophyll content, leading to a significant reduction in chlorophyll levels and consequently a decrease in the plant's ability to photosynthesize. This phenomenon is due to dust physically blocking light from reaching the chlorophyll, causing stomatal closure and interfering with the leaf's physiological functions. Studies show a strong, inverse correlation between dust accumulation and total chlorophyll content. Leaves tend to hold more dust in the winter season because dew on the leaves helps to retain more dust. While some research indicates higher dust accumulation in the pre-monsoon season shows high levels of dust retention due to factors like increased dust and dew. The study indicated that the high dust holding capacity was shown by T. grandis and C. procera plants whereas low dust accumulation was found on N. oleander. Traits including leaf shape, petiole, length, leaf hairs, phyllotaxy and plant height are important factors influencing dust deposition. A high chlorophyll content was observed in C. procera while lowest in T. grandis along NH-135 . The extent of change in chlorophyll content depends on plant tolerance towards dust and on the chemical nature of the dust. The study provides baseline data for future study in the study area including the implications of deposited dust on vegetation and the importance of leaf traits in influencing the dust deposition.

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