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Research Article

Alteration in the plant pigmentation of roadside plant

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A R T I C L E I N F O

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A B S T R A C T

The current research work is concerned to know the plant pigmentation changes in roadside plants under the air pollution stress. The research work caried out in the upper-northern Rajasthan that contains the two districts naming, Sri Ganganagar and Hanumangarh, which have similar environmental condition including vegetation. 11 Sampling sites and 8 commonly growing roadside plant species were marked to take the samples from the study area. The research work taken the samples of the leaves from the commonly grown roadside plants and analysed for the Chlorophyll 'a', Chlorophyll 'b', Total Chlorophyll, and Total Carotenoids. At the same time the research work calculated the vehicular flow/density of the selected sampling sites. The study found a significant difference in the concentration of plant pigments of reference/control site and polluted sites. The polluted sites have decreased amount of the plant pigments; and plant pigments exhibit the relationship with the vehicular densities.

K E Y W O R D S

Plant Pigments | Vehicular Density | Air Pollution | Chlorophyll

C I T A T I O N

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Introduction

All forms of human progress inevitably result in some level of environmental degradation. Rapid industrialization, urbanisation, and an increase in the density of traffic are three factors that are contributing to a significant increase in environmental pollution. These types of pollutants have a direct as well as indirect impact on the functioning of living systems. There are significant parts of the industrialised world where the levels of air pollution have reached a level that is considered to be fatal, and this may be interfering with the biochemical and physiological mechanisms of the plants that further going to result in yield losses (Heck *et al.,* 1988).

The ever-increasing numbers of vehicles on the road have led to a considerable rise in air pollution, which has had a negative impact not only on human but also on natural ecosystems including plants and animals. Roadside plants frequently serve as the first line of defence against the emissions produced by vehicles, which helps to reduce the negative effects of pollution. On the other hand, they are susceptible to these contaminants themselves, albeit to varied degrees depending on their capacity for tolerance. This calls for a scientific inquiry to determine the role that roadside plantations play in the better management and planning of urban sprawl, where specific trees could be grown to reduce the negative effects of dangerous pollutants.

It is found that the level of chlorophyll in plants tend to decrease when they are subjected to pollution stress (Spedding and Thomas, 1982). Under field conditions, plants that have a high chlorophyll content tend to have a higher level of tolerance to the pollutants in the air. According to Lichtenthaler (1996), a prolonged exposure of plants to stress can cause a photo-oxidative chlorophyll breakdown, which results in a decreased chlorophyll concentration in the plants.

The current study aimed to investigate the long-term influence of elevated concentrations of automobile exhaust [Oxides of sulphur (SO_X) and Oxides of nitrogen (NOx)] on common roadside plants in study area with respect to plant pigmentation.

Material and Methods

Study Area

The present study covered the Sri Ganganagar and Hanumangarh Junction Cities that were situated in the upper northern Rajasthan and have similar environmental conditions. The samples were taken from the marked 10 high vehicular density places of these cities (sampling sites) and from one reference sampling site, which has negligible vehicular density. The location of sampling sites marked in the map, and their respective code number and characters are described in the table 1 and fig. 1.

Sample

The leaves were collected from the eight commonly grown roadside plants, available at each sampling site. Systematically, each sample represents, leaves of eight selected plant species of a sampling site. A sample contains 24 leaves of 8 different plant species of a particular sampling site, or a sample contains 8 sub-samples of a particular sampling site. A sub-sample is composed by the 3 leaves of a particular plant species from particular sampling site. In each sub-sample three leaves were collected from the same plant and analysed for the plant pigment contents independently, further their results were shown as an average value of a sub-sample. From a plant/tree, three leaves were plucked from outer canopy.

To know the effect of the air pollution on roadside plants, references for the same plants are needed. Thus, samples were taken from the agriculture lands of Kaliyan village. This site can be considered as unpolluted site since it is much far away from urban area and has negligible vehicle density. To make the comparison between the plants of the polluted site and unpolluted site.

S. No.	Sample Identity	Name	Character
1.	S-0	Kaliyan Village	Control/Reference Site
2.	S-1	Suratgarh Road, Sri Ganganagar	Polluted Site
3.	S-2	Hanumangarh Road, Sri Ganganagar	Polluted Site
4.	S-3	Padampur Road, Sri Ganganagar	Polluted Site
5.	S-4	Abohar Road, Sri Ganganagar	Polluted Site
6.	S-5	City Area, Sri Ganganagar	Polluted Site
7.	S-6	Manaksar Circle, Suratgarh	Polluted Site
8.	S-7	Sri Ganganagar Road, Hanumangarh Junction	Polluted Site
9.	S-8	Sangria Road, Hanumangarh Junction	Polluted Site
10.	S-9	Hanumangarh Junction-Town Road	Polluted Site
11.	S-10	City Area, Hanumangarh Junction	Polluted Site

Table 1: Sampling site and their respective codes and characters

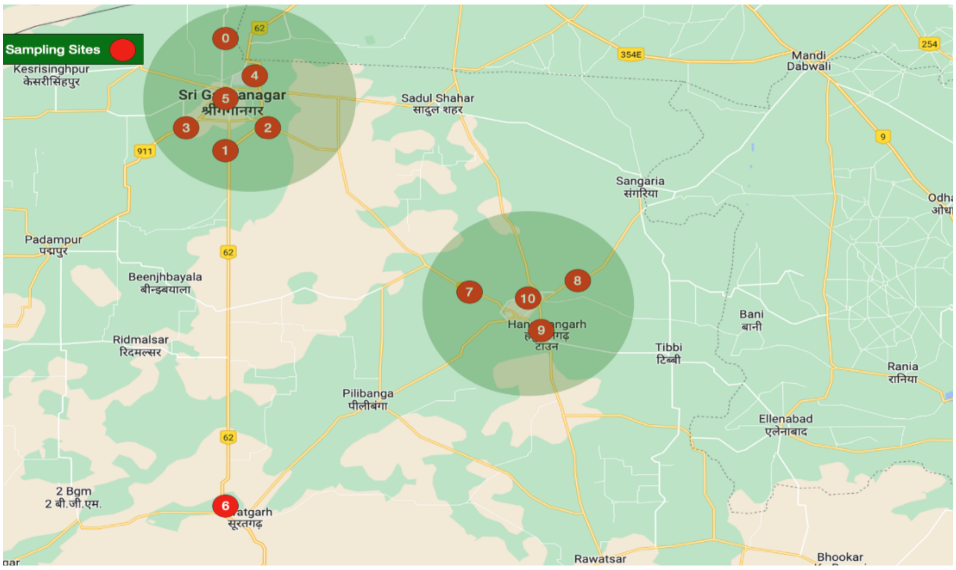

Fig. 1: Location of the sampling sites as marked in the map

S. No.	Common Name	Scientific Name
1.	Peepal tree	Ficus religiosa
2.	Chinaberry tree	Melia azedarach
3.	Banyan	Ficus benghalensis
4.	Bougainvel	Bougainvillea spectabilis
5.	False Ashoka	Polyalthia longifolia
6.	Indian Rosewood	Dalbergia sissoo
7.	Java Plum	Syzygium cumini
8.	Safada Tree	Eucalyptus lanceolatus

Table 2: Sampled plant species and their common names

Vehicular Flow/Density

The vehicular flow/density of the particular sampling site was measured by the manual counting the automobile objects. In measurement process, first a mark was painted on the road at suitable place, afterward, total number of automobile objects passing (*in flow* + *out flow*) from the marked point for 30 minutes was counted. This step was performed 3-4 times to get the precise value through average.

Code	Name	Vehicular Density (Vehicle/Hour)	Pollution Level (On Qualitative Scale)
S-0	Kaliyan Village	0	Negligible
S-1	Suratgarh Road, Sri Ganganagar	776	High
S-2	Hanumangarh Road, Sri Ganganagar	538	Moderate
S-3	Padampur Road, Sri Ganganagar	330	Low
S-4	Abohar Road, Sri Ganganagar	395	Low
S-5	City Area, Sri Ganganagar	816	High
S-6	Manaksar Circle, Suratgarh	262	Low
S-7	Sri Ganganagar Road, Hanumangarh Junction	234	Low
S-8	Sangria Road, Hanumangarh Junction	216	Low
S-9	Hanumangarh Junction-Town Road	490	Moderate
S-10	City Area, Hanumangarh Junction	506	Moderate

Table 3: Vehicular flow/density at different sampling sites

Biochemical Analysis

In the present study eight biochemical attributes of the sampled leaves were analysed, namely, Chlorophyll ‘a’, Chlorophyll ‘b’, Total Chlorophyll, and Total Carotenoids. The analysis of the biochemical attributes was performed by the standards methods given in the relevant literature (Lichtenthaler and Buschmann 2001).

Result and Discussion

The present research work included the field work and biochemical analysis of the plant leaves for pigmentation. Thus, the results are presented in the following headings.

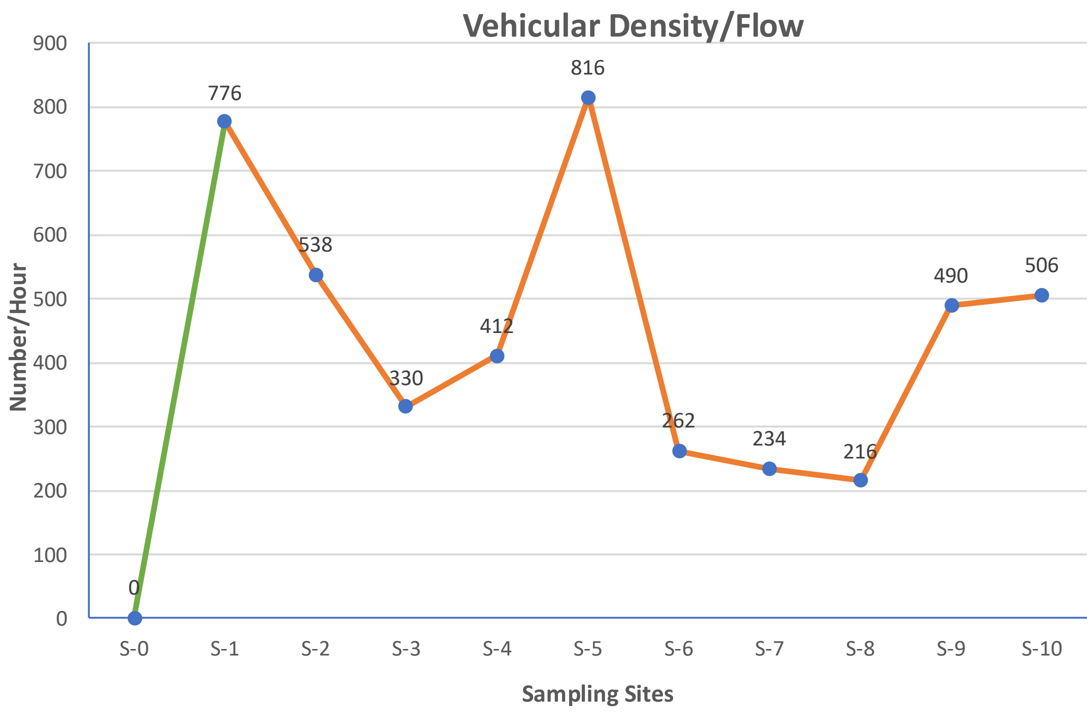

Fig. 2: Vehicular Density/Flow in sampling sites (Measured as Number/hour)

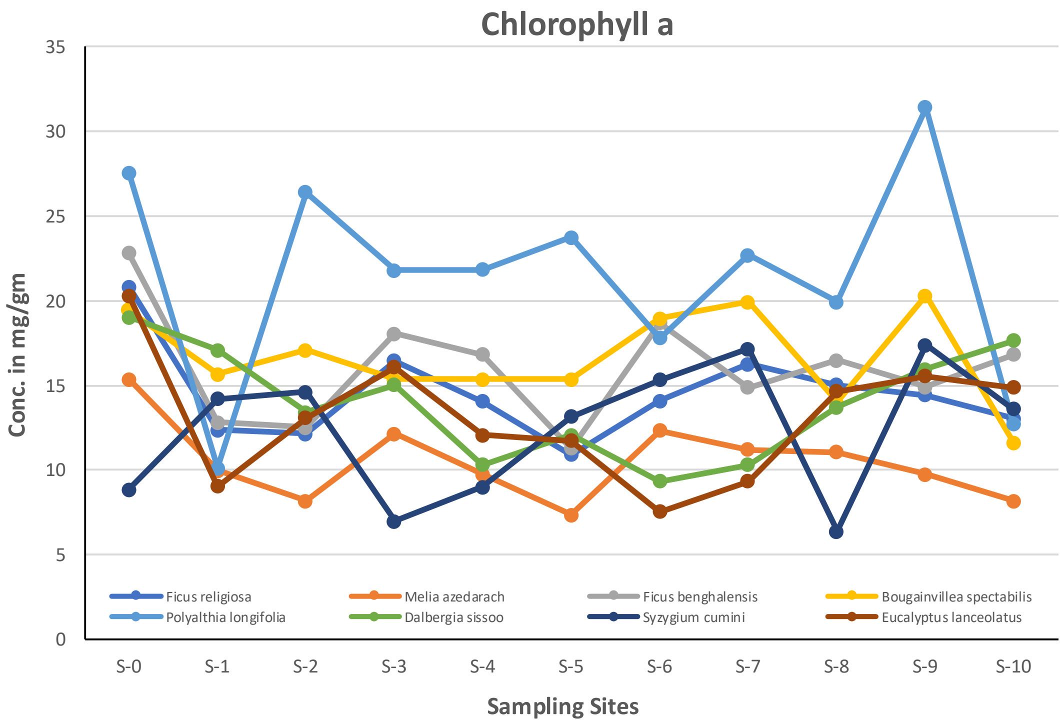

Fig. 3: Concentration of Chlorophyll a in different plant species at different sampling sites

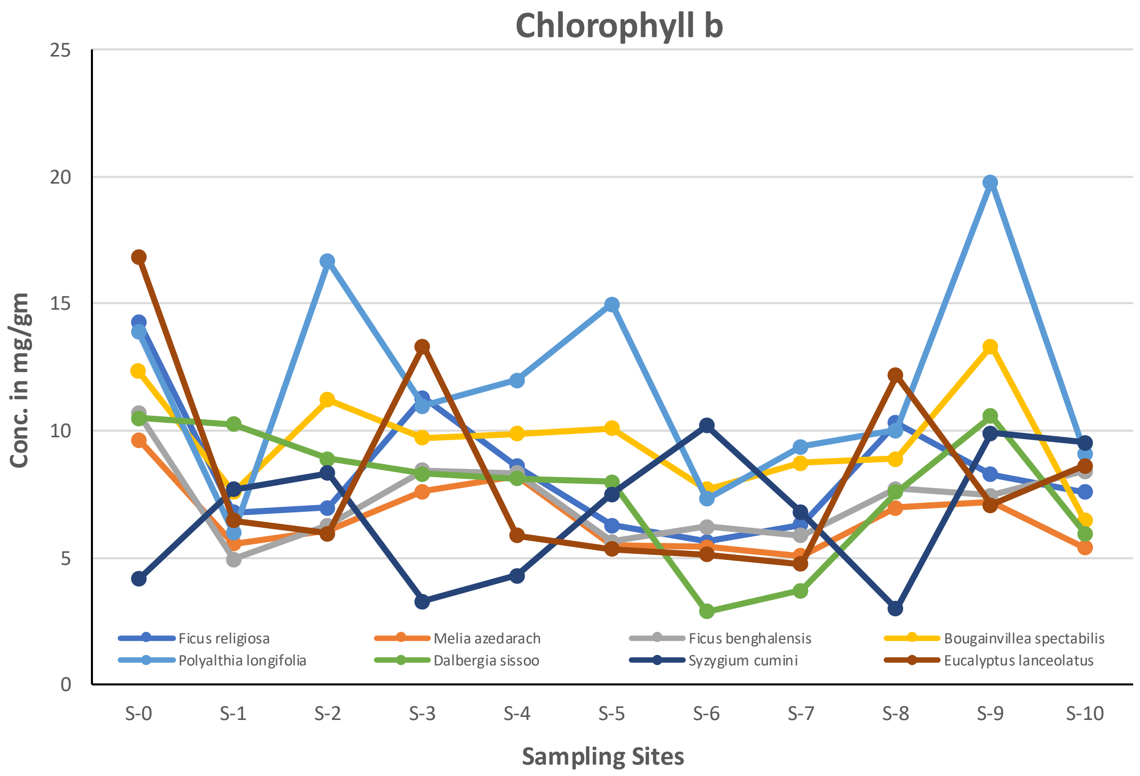

Fig. 4: Concentration of Chlorophyll b in different plant species at different sampling sites

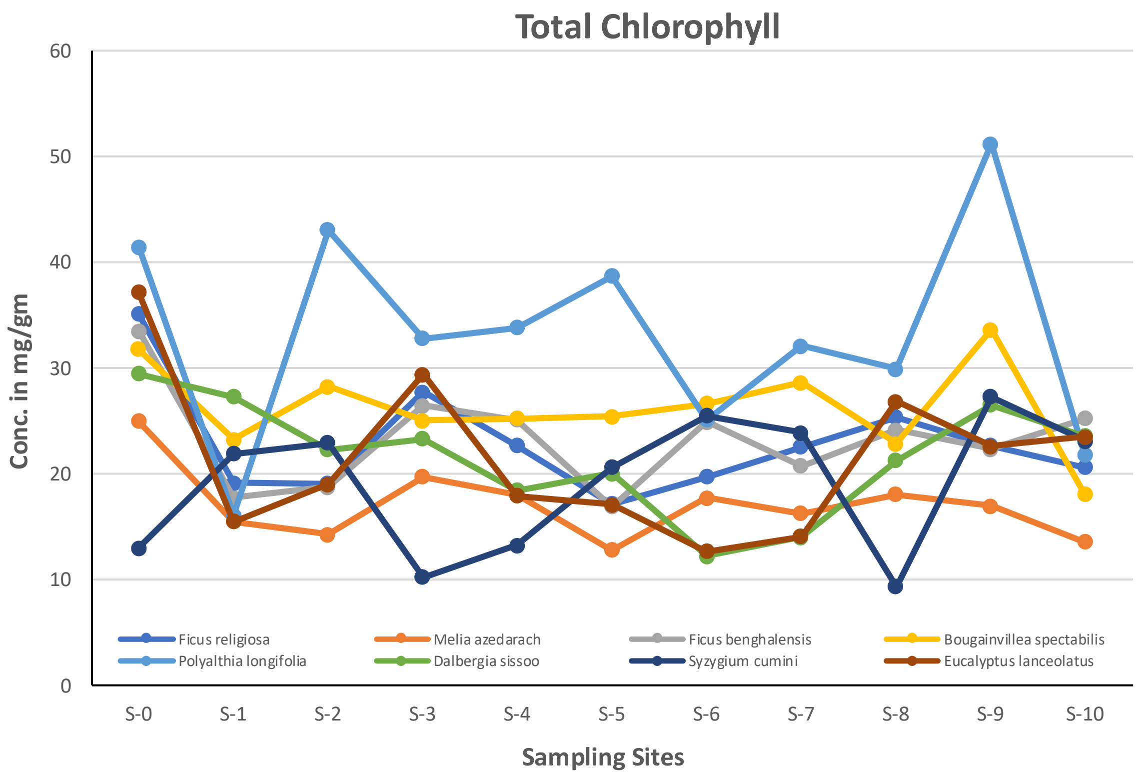

Fig. 5: Concentration of Total Chlorophyll in different plant species at different sampling sites

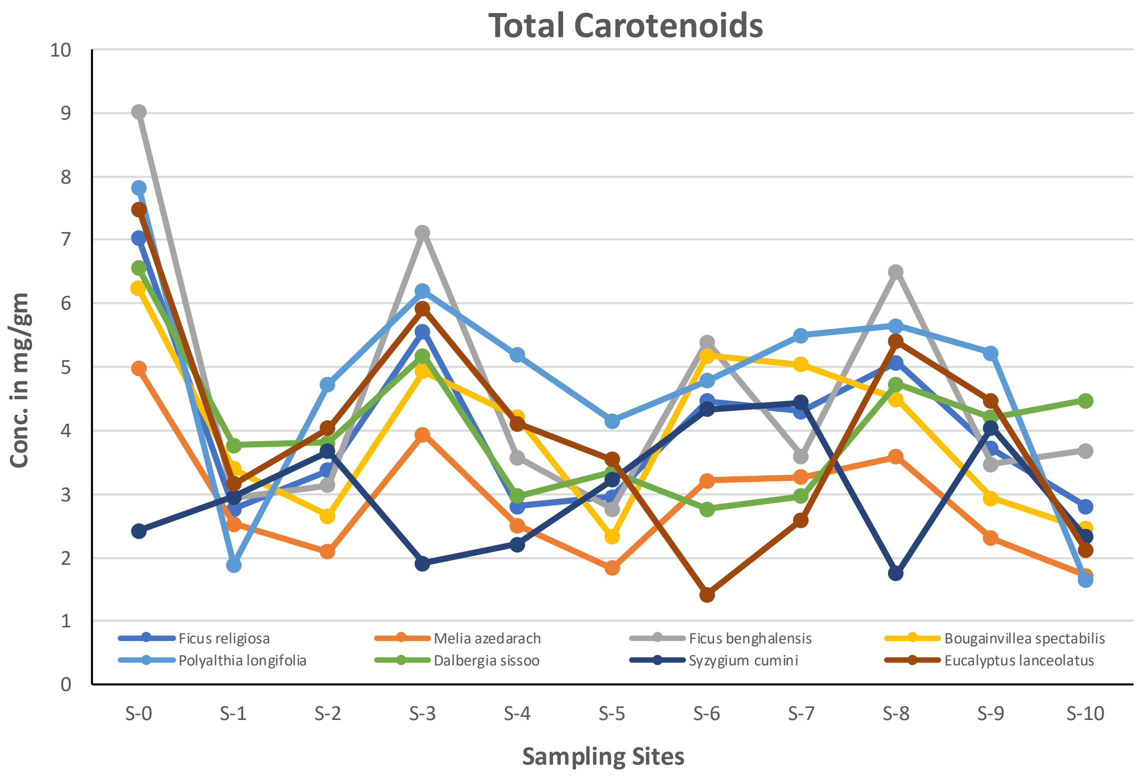

Fig. 6: Concentration of Total Carotenoids in different plant species at different sampling sites

Vehicular Flows/Densities

The vehicular flows/densities of different sampling sites were found as per the Table-3 and on the basis of the vehicular flow/density, sampling sites were categorised as Low (1-300 vehicle/hour), Moderate (301-600 vehicle/hour) and High (600-900 vehicle/hour). It was observed that sampling site S-1 and S-5 have the highest vehicular flows/densities (776 vehicles/hour, 816 vehicle/hour) among all the sampling sites (Fig.-2), which can be further connected that these sites have highest air pollution as air pollution load is a function of vehicular flow/density (Liu *et al.* 2017).

Accordingly, sampling sites S-2, S-9, S-10 has vehicular flows/densities between 301-600 vehicle/hour, therefore these have moderate level of air pollution. Similarly, sampling sites S-3, S-4, S-6, S-7, and S-8 have vehicular flows/densities between 1-300 vehicle/hour and can be categorised as low air pollution sites.

Constitutionally, sampling sites S-1 can be described for high vehicular flows since it is situated on the National Highway Number-15, and it is main trade route for the Sri Ganganagar city. Correspondingly, it is obvious to have the higher vehicular flow. Sampling site S-5 is enclosing the Sri Ganganagar city are where localised automobiles are contributing for higher vehicular flow.

Alteration in Plant Pigments

Chlorophyll is a key factor in the physiological processes that take place in leaves. The chlorophyll content of leaves can be quantified, which can provide information on the physiological state of the leaves. Chlorophyll levels in plants have a tendency to drop precipitously whenever the plant is experiencing stress or when the leaves are becoming senescent (Gitelson and Merzlyak, 1994). An indicator of senescence, stress, and damage to the plants is the ratio of chlorophyll (a+b) to carotenoids (Lichtenthaler and Buschmann 2001).

The plant pigment concentrations were analysed in the fresh leaf of the specified 8 plant species from the 11 sampling sites, including 1 control site. The results were found as per the Table-4. It is observed that chlorophyll 'a' content in the fresh leaf of the sampled plants, residing in the control site, were found almost highest compared to same plants of the other sampling sites (Polluted sites). More precisely, in the case of control site, chlorophyll 'a' content, *Polyalthia longifolia* is showing highest value (27.56 mg/gm) and *Syzygium cumini* is showing lowest value (8.84 mg/gm) and in the case of polluted sites, all the sampling plant species are showing a decrease in the chlorophyll 'a' content according to the sampling site pollution load (Fig.-3). Subsequently, among the polluted sites, *Polyalthia longifolia* is exhibiting almost higher values for chlorophyll 'a' *Melia azedarach* is exhibiting almost lower values for the same. It explains that the effect of the air pollutants less visible on the *Polyalthia longifolia* and severely visible on the *Melia azedarach*, considering as chlorophyll 'a' as a factor.

The careful examination of the chlorophyll 'a' content in different plant species of all the sampling sites, suggests that there is no common decline trend has been identified for chlorophyll 'a' in studied plant species. Each plant manifests its own distinguished characteristics to normalise the air pollutants through biochemical pathway. The decline in the chlorophyll 'a' were also reported in the previous studies by several workers (Malhotra, 1984; Hutchinson & Meema, 2013; Lohe *et al.,* 2015).

In the case of chlorophyll 'b' content in control site, *Eucalyptus lanceolatus* is showing highest value (16.84 mg/gm) and *Syzygium cumini* is showing lowest value (4.16 mg/gm) and in the case of polluted sites, all the sampling plant species are showing the decrease in the chlorophyll 'b' content according to the sampling site pollution load (Fig.-4). Subsequently, among the polluted sites, *Polyalthia longifolia* and *Eucalyptus lanceolatus* are exhibiting almost higher values for chlorophyll 'b' *Melia azedarach* and *Syzygium cumini* are exhibiting almost lower values for the same. It explains that the effect of the air pollutants less visible on the *Polyalthia longifolia* and *Eucalyptus lanceolatus*; and severely visible on the *Melia azedarach* and *Syzygium cumini*, considering as chlorophyll 'b' as a factor. Similarly, there is no common decline trend has been identified for chlorophyll 'b' in studied plant species. Each plant manifests its own distinguished characteristics to normalise the air pollutants through biochemical pathway.

In the case of Total chlorophyll content in control site, *Eucalyptus lanceolatus* is showing highest value (41.45 mg/gm) and *Syzygium cumini* is showing lowest value (13.00 mg/gm) and in the case of polluted sites, all the sampling plant species are showing the decrease in the Total chlorophyll content according to the sampling site pollution load (Fig.-5). Successively, among the polluted sites, *Polyalthia longifolia* and *Eucalyptus lanceolatus* are exhibiting almost higher values for Total chlorophyll and *Melia azedarach* and *Syzygium cumini* are exhibiting almost lower values for the same. Correspondingly, it suggests that the effect of the air pollutants is less visible on the *Polyalthia longifolia* and *Eucalyptus lanceolatus*; and severely visible on the *Melia azedarach* and *Syzygium cumini*, considering as Total chlorophyll as a factor. Further, there is no common decline trend has been identified for Total chlorophyll in studied plant species. Each plant manifests its own distinguished characteristics to normalise the air pollutants through biochemical pathway. The degradation of plant pigments under air pollution load extensively reported and it favour the current study (Malhotra, 1984; Hutchinson & Meema, 2013; Lohe *et al.,* 2015).

In the case of Total Carotenoids content in control site, *Ficus benghalensis* is showing highest value (9.01 mg/gm) and *Syzygium cumini* is showing lowest value (2.42 mg/gm) and in the case of polluted sites, all the sampling plant species are also showing the decrease in the Total Carotenoids content according to the sampling site pollution load (Fig.-6). Successively, among the polluted sites, *Ficus benghalensis* and *Dalbergia sissoo* are exhibiting almost higher values for Total Carotenoids and *Melia azedarach* and *Syzygium cumini* are exhibiting almost lower values for the same. The careful examination of the decline in the Total Carotenoids content suggests that the decline severity is less prone for the Total Carotenoids in comparison to the Total chlorophyll content. The earlier studies have also proved that Carotenoids are resistant for the degradation for environmental strass or pollution load (You *et al*., 2021).

	Average values	**Sampling Sites**										
	(For all plants)	**S-0**	**S-1**	**S-2**	**S-3**	**S-4**	**S-5**	**S-6**	**S-7**	**S-8**	**S-9**	**S-10**
1	Chlorophyll a	19.26	12.66	14.68	15.24	13.65	13.20	14.26	15.22	13.91	17.45	13.57
2	Chlorophyll b	11.54	6.90	8.79	9.12	8.16	7.91	6.31	6.32	8.33	10.45	7.63
3	Total Chlorophyll	30.80	19.56	23.47	24.36	21.81	21.11	20.57	21.54	22.23	27.90	21.20
4	Total Carotenoids	6.45	2.93	3.44	5.09	3.45	3.02	3.94	3.96	4.65	3.80	2.66
5	pH	6.4	5.5	5.7	5.9	5.9	5.5	5.8	5.9	5.9	5.8	5.7
6	RWC	74.70	70.50	68.73	74.85	72.67	66.24	74.58	71.43	71.45	67.23	65.96
7	Ascorbic Acid	1.512	1.515	2.177	1.196	1.677	1.927	2.403	2.212	1.091	2.354	1.811
8	APTI	62.86	45.58	71.69	43.19	52.49	58.87	71.91	68.23	37.40	87.75	55.02
9	Proline	2.140	2.588	2.363	1.969	2.104	2.675	2.121	2.193	2.307	2.471	2.410
10	Total Soluble Carbohydrates	4.263	3.997	3.967	4.323	4.165	3.685	4.349	3.990	4.139	3.668	3.976

Table 4: Average values of biochemical attributes for all plants with respect to sampling sites

Conclusion

The study concluded that there is significant difference in the concentration of plant pigments of reference/control site and polluted sites. The polluted sites have decreased amount of the plant pigments; and plant pigments exhibit the relationship with the vehicular densities. The total carotenoids tend to decline more rapidly than total chlorophyll by the rise of vehicular density or elevated concentration of air pollutants. The plants *Polyalthia longifolia, Eucalyptus lanceolatus*, and *Ficus benghalensis* exhibites are found to resistant for plant pigment dissociation under air pollution load and *Melia azedarach* and *Syzygium* found as sensitive plants for the same.

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