EVALUATION OF AIR POLLUTION TOLERANCE INDEX OF SELECTED PLANT SPECIES ALONG ROADSIDES IN MEERUT CITY

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ABSTRACT:

To develop the usefulness of plants as bioindicators requires an appropriate selection of plant species which entail an utmost importance for a particular situation. In present study evaluation of air pollution tolerance index (APTI) of selected plant species such as *Cassia occidentalis* L., *Cassia obtusifolia* L., *Sida veronicaefolia* and *Abutilon indicum* G. Don. at different roadsides. A view finds out the APTI as well as sensitivity of the plant species at the all study sites. Among the plant in the road side areas studied, (plant *Abutilon indicum* and *Cassia occidentalis* expressed highest APTI values and proved to be a tolerant variety and the others are sensitive species to air pollutants *Cassia occidentalis* is much tolerant variety and the others are sensitive species to air pollutant *Cassia occidentalis* is much tolerant as compared to other selected plants.

Key Words: Chlorophyll, RWC, APTI, Ascorbic Acid, Leaf extract pH, Vehicular exhaust pollution.

INTRODUCTION:

Our environment is a complex mixture of a number of constituents like air, water, soil, plants and animals, all of which maintain a dynamic inter-relationship and interdependence. Existence of human beings is largely dependent upon a natural balance of all the surrounding elements. The modification of natural system into an artificial and highly productive system by man due to enormous exploitation of natural resources has resulted into environmental pollution. Plant are integral basis for all ecosystems and also most likely to be affected by air borne pollution which are identified as the organisms with most potential to receive impact from ambient air pollution. Also the effects are most often apparent on the leaves which are usually the most abundant and most obvious primary receptors of large number of air pollutants.

Biomonitoring of plants is an important tool to evaluate the impact of air pollution. Hence the response of plants towards air was assessed by air pollution tolrence index. The usefulness of evaluating APTI for the determination of tolerance as well as sensetiveness of plants was followed by several authers (Agarwal and Tiwari, 1997; Sasmita Das and Pramila Das (2010); Diwedi et al., 2008); Moh. Kuddus, R. K., and P.W. Ramteke (2011) and Seyyed nejad et al., (2011). These studies provided valuable informations for landscapes and greenbelt designers to select the sensitive as well as tolerant varieties of plant species for using them to identify the pollution loads of different roadsides and also to use the tolerant varieties for curbing the menace of air pollution. The results of these studies showed that the plants with higher APTI values were found to be resistant to air pollution.

In the present study, evaluation of APTI of some selected plant species studied. Sensitive plant species have a higher pH than tolerant species (Scholz and Reck, 1977). Similar observations were made in *Helianthus annus* (Goswami, 2002) and in *Gladiolus gandavensis* (Poonia *et al*., 2002). Prakash *et al*, (1989) reported that chlorophyll a more sensitive than chlorophyll b in *Lycopersicon esculentum* when exposed to 0.25 and 0.5ppm SO_2 for two hour daily. Similar observations were made in *Brasica campestris* (Tomer and Prakash, 1989); *Cajanus cajan* (Kumar and Prakash, 1990); and *Oryza sativa* and *Phaseolus aureus* (Panigrahi *et al*., 1992); *Cicer* *arietinum* (Pratibha and Sharma , 2000)., *wheat* (Verma and Agarwal , 2001) and *Zea mays* L (Jeyakumar *et al*., 2003). Wath *et al.* (2006) was observed that vethe plants along at roadside with heavy traffic and markets are affected by vehicular emissions. Which cause a significant decrease in total chlorophyll. Prakash and Chauhan (2008) reported that much exposure of air pollutants affect the plants biochemical parameters. They observed that chlorophyll a, chlorophyll b, and total chlorophyll contents in rice (*Oryza sativa*) degraded due to much exposure of air pollutants in a rapidly growing industrial area of Haridwar.

Ascorbic acid being a strong reductant activates many physiological and defense mechanisms and its reducing power is directly proportional to its concentration (Lewis, 1980). Similar observations were made by Keller and Schwager (1977) in *Picea excelsa* and *Larix deciduas*. Chaudhary and Rao (1977) correlated pollution tolerance of plants with their ascorbic acid levels and that the higher the level of ascorbic acid the greater the tolerance. Shahare (1995) reported that SO_2 pollution stress even for comparatively shorter duration and at low concentrations affect asorbic acid content. He observed that ascorbic acid content in decreased from 3.23 to 39.77 % in naturally growing trees at in Delhi due to pollution. Ramakrishnaiah and Somasekhar (2003) studied the impact of automobile pollution on higher plants and observed significant reduction in ascorbic acid content. It showed inverse relationship with traffic density. Similarly, pH followed an exponential decrease with increase in traffic pollution and drifted towards the acidic range.

MATERIALS AND METHODS:

Fully mature leaves were collected in morning hours from the selected plants at different study sites. Fresh leaf (0.5 gm) sample was homogenized using 25 ml deionized water and the supernatant obtained after centrifugation was collected for detection of pH using digital pH meter. The fresh leaf samples were analyzed for Chl a, Chl b, total Chl, RWC, Ascorbic Acid and APTI using the standard procedures of Arnon (1949), Keller and Schwager (1977), Singh and Rao (1983), and Siva Kumaran and Hall (1987). Chlorophyll was extracted in 80 % acetone and the absorption at 663nm and 645nm were read in a spectrophotometer. Using absorption coefficient Chlorophyll was calculated.

$$\text{Chl a (mg/g f.wt)} = [12.7(A_{663}) - 2.69\,(A_{645})] \times \frac{V}{1000 \text{ x } W}$$

$$\text{Chl b (mg/g f.wt)} = [22.9(A_{645}) - 4.68\,(A_{663})] \times \frac{V}{1000 \text{ x } W}$$

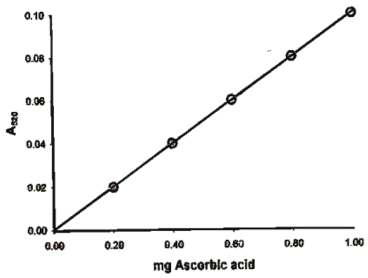
$$\text{Total (mg/g f.wt)} = [22.2(A_{645}) + 8.02\,(A_{663})] \times \frac{V}{1000 \text{ x } W}$$

Whereas, A = Absorbance at specific wavelength, V = Final volume (ml) of chlorophyll extract with 80% acetone, W = Weight (g) of leaf tissue.

To determine the ascorbic acid content, 5gm. of fresh leaf sample was homogenized in 20 ml extracting solution prepared by dissolving 5ml oxalic acid and 0.075 gm EDTA in 100ml distilled water. After centrifusing the homogenate for 15 min. at 3000 rpm, 1ml of homogenate was mixed with 5ml of dichlorophenol indophenol (DCPIP, 20 mg/ml). After shaking it well it was measured for its optical density at 520 nm wavelength. The following formula was used for calculating ascorbic acid content (Keller and Schwager, 1977).

Ascorbic acid content **(mg) = (∑o-∑t) x F** (Factor) where, ∑o, ∑s and ∑t denote optical densities of blank, plant sample and sample with one drop of 1% ascorbic acid added to it respectively. A calibration curve was prepared by using chemically pure ascorbic acid. Factor (F) is calculated from the standard curve.

Calibration Curve:



RWC was calculated with the by the following formula:

$$\text{RWC (\%)} = \frac{\text{Initial wt.} - \text{dry wt.}}{\text{Saturated wt.} - \text{dry wt.}} \times 100$$

$$\text{APTI} = \frac{[A\ (T+P)] + R}{10}$$

(Singh and Rao, 1983) Where, A = Ascorbic acid content, T = Total chlorophyll content, P = Leaf extract pH, R = relative water content

The results were statistically analyzed and interpreted by three way ANOVA. All the data were subjected to statistical analysis to find out Critical Difference at (CD) 5% and 1% level (Fisher 1951), is superscripted with single star (*) and double star (**) respectively.

RESULTS AND DISUSSION

All the parameters studied exhibited significant variation at 5% and 1% level.

CHANGES IN LEAF EXTRACT pH: The leaf pH values of selected plants for different sites are depicted in fig. 5.A reduction in leaf pH was observed among the plants he Delhi road and it was 15%, 14.2%, 12.4% and 8.2% *Cassia obtusifolia*, *Sida veronicaefolia*,*Cassia occidentalis* and *Abutilon indicum* respectively. Leaf pH of plant cell is also affected by air pollution. Leaf extract pH, an indicator of increasing acidity was found to be reduced, i.e. shifted towards acidic pH when plants were studied at all site. The lower the concentration of pollutants, higher was the pH of the leaf extract. This may be due to acidic nature of gases such SO_2, NO_2 which forms H_2SO4, H_2SO_3 and HNO_3 in contact with water inside the leaf tissue and thus lowering the leaf extract pH of affected plants (Mc lean *et.al*, 1968). In alteration in the level of pH affects different pH dependent enzymatic activities of the plant, thus influencing plant growth and development. Lower pH was observed in present study. Similar findings were reported to be in sensitive plant species which have higher pH than tolerant species (Scholz and Reck, 1977; Prasad and Rao, 1982; Yunus *et al*., 1985; Poonia *et al*. 2002). The leaf extract pH values were reduced in all the four test plants. The reduction of leaf pH maximum was in *Cassia obtusifolia* followed by *Sida veronicaefolia, Cassia occidentalis* and *Abutilon indicum*. The reductive effects increased with an increase in the intensities of pollutant exposure. The decline in leaf extract pH is attributed to the acidic nature of the pollutant.

CHANGES IN CHLOROPHYLL CONTENT: A reduction was observed in total Chl content in all the four plants at polluted sites and it was maximum at Delhi road. The decrease in the value of Chl a was found to be higher than Chl b.

In *Cassia occidentalis* a/ Chl b content were recorded 14.272/18.2223mg/gmf.wt of leaves at University road and 9.8677/ 11.7237 mg/gmf.wt of leaves at Delhi road (fig.1).

Cassia obtusifolia Chl a and Chl b contents were 2.5407**/4.3074** mg/gf.wt of leaves at Delhi road and 12.1087/ 19.391 mg/gf.wt of leaves at University road and 8.2537**/ 13.6351* at Garh road and 11.2430*/ 19.2254 mg/gf.wt at Railway road. (Fig.2)

Sida veroniceafolia Chl a and Chl b contents were minimum 6.8379*/ 10.9303** mg/gf.wt at Delhi road and 14.272/ 18.2223 mg/gf.wt at University road.(Fig.3)

Abutilon indicum Chl a and Chl b contents were 10.1215/ 15.9191 mg/gf.wt at Delhi road and 12.1285/18.2341 mg/gf.wt at Delhi road, 11.2033/18.0818 mg/gf.wt at Railway road (fig.4).

Total Chlorophyll was recorded a gradual decrease with increase in automobile pollution. In *Cassia occidentalis* the total

Chl was 21.2897 mg/gf.wt at Delhi road and maximum 3 3.9211 mg/gf.wt at University road. In *Cassia obtusifolia* the total Chl was 8.8501 mg/gf.wt at Delhi road and 32.3985 mg/gf.wt at University road. In *Sida veroniceafolia* the total Chl 18.8510 at Delhi road and 33.9211 mg/gf/wt at University road was observed. In *Abutilon indicum* total Chl was 27.2904 mg/gf.wt at Delhi road and 308564 mg/gf.wt at University road (Fig.1, 2, 3 and 4).

Chlorophyll content of plants signifies its photosynthetic activity as well as the growth and development of biomass. It is well evident that Chlorophyll content of plant varies from species to species age of leaf and also with the pollution level as well as with other biotic and abiotic conditions. Degradation of photosynthetic pigment has been widely used as an indication of air pollution (Ninave et al., 2001).

Maximum reduction in pigment concentrations was observed at Delhi road. Much reduction in chl a and chl b was observed in *Cassia obtusifolia* 80.0% and 79.7 % chlorophyll b respectively followed by *Cassia obtusifolia, Sida veronicaefolia, Cassia occidentalis* and *Abutilon indicum*. Reduction in total chlorophyll was also maximum in *Cassia obtusifolia*. It was 74.3% in *Cassia obtusifolia* at Delhi road.

Air pollutants are known to cause reduction in Chlorophyll pigments (Katz and Shore; 1955, Agrawal et al., 1991).Present study revealed that chlorophyll content in all plants varies with the pollution status of the area i.e higher the pollution level in the form of vehicular exhausts lower the chlorophyll content. It also varies with the tolerance as well as the sensitivity of the plants i.e. higher the sensitive nature of the plants lower the chlorophyll content. Tripathi and Gautam (2007) also suggest that high levels of automobile pollution decreases chlorophyll content in higher plants near roadsides. Significant decrease in total Chl a and protein was observed with reduced leaf area (Wath et al., 2006).

CHANGES IN ASCORBIC ACID CONTENT: Being a very important reducing agent, Ascorbic acid also play a vital role in cell wall synthesis. Ascorbic acid Ascorbic acid content is indicator of pollution stress. It recorded a decrease significant in comparison to control at Delhi road, the most polluted site. The reduction at Delhi road was 63.4%, 62%, 48% and 43.3% in *Cassia obtusifolia, Sida veronicaefolia, Cassia occidentalis* and *Abutilon indicum* respectively (Fig.6). The loss of Ascorbic acid content was maximum in *Cassia obtusifolia* which was about 63%. Ascorbic acid scavenges photooxidative products (Halliwell, 1982) and helps in maintaining the stability of plant cell membrane during pollution stress (Dhindsa *et al.*, 1982), therefore the decrease in ascorbic acid content of plants on roads reduces the tolerance level of these plants against the existing ambient air quality and soil conditions. Agrawal and Agrawal (1989) have suggested that the free radicals induce degradation of chlorophyll in plants which is due to decrease in Ascorbic acid content. Some recent investigations have established direct relationship between level of Ascorbic acid and susceptability to pollutants (Lee *et al.*, 1984; Singh *et al.*, 1991).). Maximum decline in the level of ascorbic acid was found in *Cassia obtusifolia* followed by *Sida veronicaefolia Cassia occidentalis* and *Abutilon indicum*.Pollution load dependent increase in ascorbic acid content of all the plants may be due to increased rate of production of reactive oxygen species during photo-oxidation of SO_2 to SO_3 where sulfites are generated from SO_2 absorved. Chaudhary and Rao (1977) and Varshney and Varshney (1984) are the opinion that higher ascorbic acid content of plant is a sign of its tolerance against sulphur di oxide pollution. And concluded that resistant plants contain high amount of ascorbic acid while sensitive plants possess low levels of Ascorbic acid. Low level of ascorbic acid at high concentration of pollutant on roads. In the present case, ascorbic acid content was reduced to a greater extent in *Cassia obtusifolia* and *Sida veronicaefolia* at Delhi road. Tripathi and Gautam (2007); reported increase in concentration of Ascorbic acid in the levels of Mangifera indica near roadsides due to enhanced pollution loads of automobiles ; khan and Khan (2011) also observed a definite reduction with increase in vehicular density in comparison control.

CHANGES IN RWC: The relative water content was low at Delhi road. RWC decreased with increase in the automobile pollution. In *Cassia occidentalis* the RWC reduction % was 48.5% at Delhi road and 13.14% at University road. In *Cassia obtusifolia* RWC reduction % 73.5% at Delhi Road and 3.6% at University road. These figures were closed to control. In *Sida veroniceafolia* RWC reduction % was 61.8% at Delhi road and 1.9% at University road. In *Abutilon indicum* RWC reduction % 38.5% at Delhi road and 20.4% at University road (Table.1). RWC is associated with protoplasmic permeability in cells causes loss of water and dissolved nutrients, resulting in early senescence of leaves. The relative water content (RWC) of a leaf is the amount of moisture present in it, relative to its full turgidity level. The moisture content was more in control site than the other sites investigated because most of the plants at the control site were regularly watered and therefore had increased soil moisture content. More water in plant body helps to maintain its physiological balance under stress conditions of air pollution, when transpiration rate is usually high. A significant reduction was recorded in RWC in the leaves of all the plants selected for investigation growing in the close vicinity of areas with vehicular exhaust pollution, the result were in conformity with the observations reported by Agrawal and Tiwari (1997) and Qayoommir et al.,(2008).

CHANGES IN APTI: The results of air pollution tolerance index (APTI) calculated for each plant studied at different roadsides in table. 1. The air pollution index (APTI) is the measure of tendency of the plant to resist the pollution effect. The lowest value of APTI was recorded in *Cassia obtusifolia* as a decrease of 75.0 percent followed by 63.9% in *Sida veronicaefolia,* 50.8% in *Cassia occidentalis* and 42.2% in *Abutilon indicum*.Therefore, the increasing order of the plants show tolerance to automobile pollution is in *Cassia obtusifolia* <*Sida veronicaefolia* < *Cassia occidentalis* < *Abutilon indicum.*

The site wise reduction in APTI value was Delhi road > Garh road > Railway road > University road.

The maximum reduction in APTI value was shown by *Cassia obtusifolia* followed by *Sida veronicaefolia*, *Casia occidentalis* and minimum by *Abutilon indicum.*

Different plant species shows considerable variation in their susceptibility to air pollution. The plants with high and low APTI can serve as tolerant and sensitive species respectively.(Agarwal and Tiwari, 1997). The air pollution index (APTI) is the measure of tendency of the plant to resist the pollution effect. The lowest value of APTI was recorded in *Cassia obtusifolia* as a decrease of 75.0 percent followed by 63.9% in *Sida veronicaefolia,* 50.8% in *Cassia occidentalis* and 42.2% in *Abutilon indicum* (Table.2). Therefore, the increasing order of the plants show tolerance to automobile pollution is in *Cassia obtusifolia* <*Sida veronicaefolia* < *Cassia occidentalis* < *Abutilon indicum.*

It concluded that due to higher concentration of pollutants on roadsides, plants showed reduction in leaf pH, Chl a , Chl b, total Chl, Ascorbic acid, RWC and APTI contents. The site wise reduction in APTI value was Delhi road > Garh road > Railway road > University road.The maximum reduction in APTI value was shown by *Cassia obtusifolia* followed by

Sida veronicaefolia, *Casia occidentalis* and minimum by *Abutilon indicum.*

It is inferred that as compared to *Cassia obtusifolia* and *Sida veronicaefolia* and *Cassia occidentalis* and *Abutilon indicum* are relately are tolerant (Table 2). Sensitivity order in study plants: *Cassia obtusifolia* > *Sida veronicaefolia* > *Cassia occidentalis* > *Abutilon indicum* and less sensitive but tolerant and the order of tolerance: *Abutilon indicum* > *Cassia occidentalis* > *Sida veronicaefolia* > *Cassia obtusifolia.*

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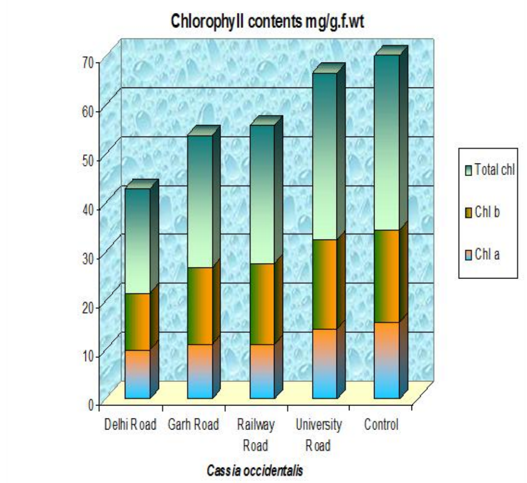
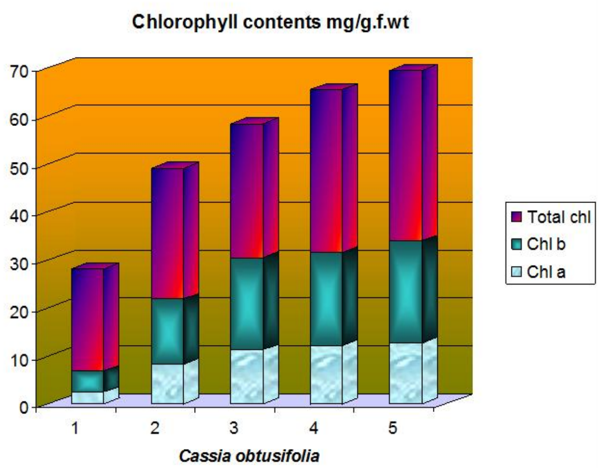


Fig:1



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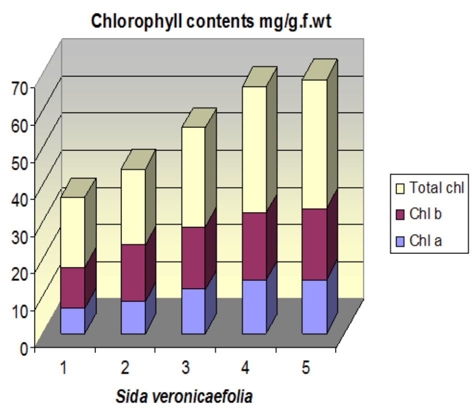

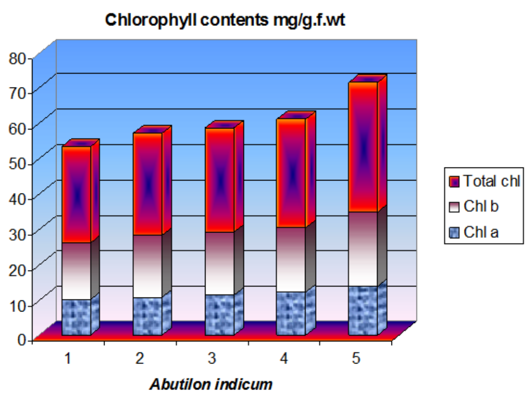

Fig:3 Fig:4

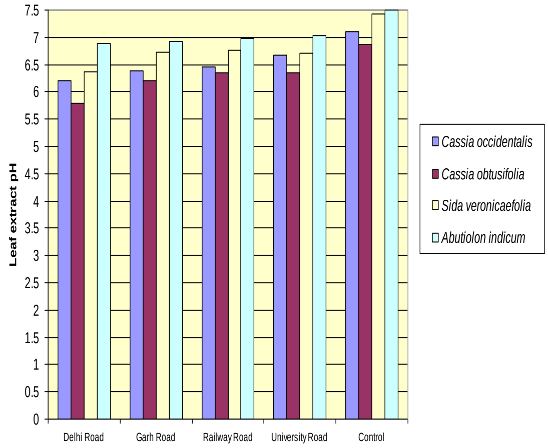

Fig: 5

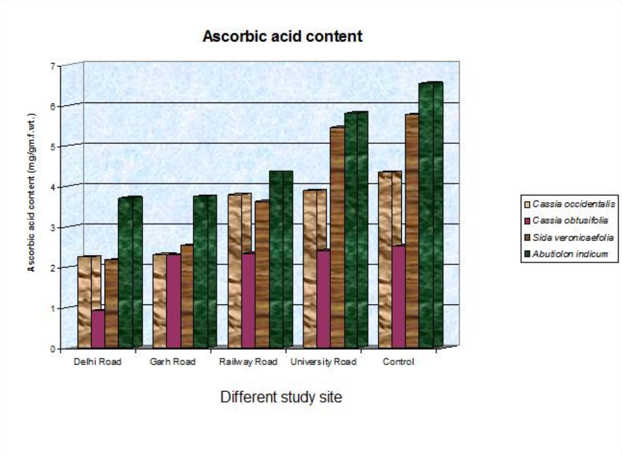

Fig:6

Table: 1 Relative water content (RWC) in different plant species at different sites in Meerut city.

RWC	Different Study Sites						
	Control	Delhi Road	Garh Road	Railway Road	University Road	CD 5%	CD 1%
Cassia Occidentalis	90.5790 ± 2.2802	46.6374** ± 3.9985	72.2318** ± 0.8874	73.5246** ± 3.4408	78.6708* ± 9.7123	6.658	15.870
Cassia Obtusifolia	73.55 ± 2.06	19.4627** ± 6.0462	61.7154* ± 7.9474	65.2403* ± 4.7193	70.85** ± 2.06	6.015	14.337
Sida veronicaefolia	143.74 ± 2.5193	54.785** ± 3.2349	55.0482** ± 3.4051	76.22** ± 3.3711	140.967 ± 6.386	7.356	17.534
Abutilon Indicum	97.707 ± 1.7016	60.0757* ± 7.2489	49.5047** ± 0.955	54.5338** ± 3.6946	77.7** ± 8.314	4.968	11.843

Table: 2. Air Pollution tolerance index (APTI) of different plant species at different site in Meerut city.

APTI Index	Different Study Sites				
	Control	Delhi Road	Garh Road	Railway Road	University Road
Cassia occidentalis	108.457	52.893	80.0217	86.528	94.0915
Cassia obtusifolia	83.675	20.888	68.4551	74.2090	80.175
Sida Veronicaefolia	167.49	60.341	61.9559	88.2600	162.9309
Abutilon indicum	125.960	72.77	62.963	70.2878	99.610

Values are mean ± Standard Error.

Values are statistically significant at * <CD5% and ** <CD1%

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