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ENVIRONMENTAL SCIENCE

A Study of Air Pollution Status by Estimation of APTI of Certain Plant Species Around Pratapnagar Circle in Udaipur City

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ABSTRACT

The sensitivity level of plants to air pollutants is evaluated by air pollution tolerance index (APTI). Parameters of leaf like pH, relative water content, chlorophyll, ascorbic acid were analyzed for the computation of air pollution tolerance index (APTI). In the present research, leaf sample of different plant species like *Ficus religiosa (Peepal), Nerium indicum (Kaner), Azadirachta indica (Neem), Mangifera indica (Aam), Cassia fistula (Amal tas), Eucalyptus (Nilgiri), Ficus religiosa (Peepal) and Calotropis procera (Aak)* were taken from Pratapnagar Circle of Udaipur city, which is connected from national highways and has a heavy load of vehicles. The results obtained showed highest APTI values of *Eucalyptus* (Nilgiri), followed by *Mangifera indica* (Aam), *Azadirachta indica* (Neem), *Ficus religiosa* (Peepal) and *Nerium indicum* (Kaner).

Highlights

- Changes in the parameters such as total chlorophyll, ascorbic acid, pH and relative water content of leaf extract were evaluated to know the tolerance level of plant species to air pollution.
- Chlorophyll content, pH and relative water content decreased when compared to the control sample, while ascorbic acid content of the plants increased showing the susceptibility level of plant species to various air pollutants
- Study reveals that plantation of *Eucalyptus (Nilgiri), Mangifera indica (Aam), Azadirachta indica (Neem) and Calotropis procera (Aak)* can be proved useful from the biomonitoring point of view and their green belts can be developed for reducing air pollution in the particular area

Keywords: APTI, pH, relative water content, chlorophyll, ascorbic acid

Anthropogenic activities such as urbanization, industrialization and increased number of vehicles release various types of air pollutants such as NOx, SOx, Ozone, Carbon Monoxide, SPM, RSPM and volatile organic compounds into the environment posing a threat to the ecosystem and producing harmful effects on plants (Karmakar *et al.* 2016). Air Pollution Tolerance Index (APTI) in plants is the estimation of the susceptible limit of plants to air pollutants, using four parameters i.e. total chlorophyll, relative water content, ascorbic acid content and pH value of leaf extract. For the ranking of plant species with respect to their susceptibility to air pollution, Air pollution tolerance index is calculated. The root cause for the addition of toxic gases and other harmful substances in the environment are the large scale development of the automobile industries (Bhattacharya *et al.* 2013). The air pollutants released from the industries and automobile smoke are the operating ecological factors responsible for degradation in the environmental quality (Shah *et al.* 1989). The most apparent effect of air pollution are visible on the leaves as they are most abundant and the prime receptor of a huge number of air pollutants acting as a good indicator of pollution (Lohe *et al.* 2015; Dohmen *et al.* 1990). Although a large number of plans exist for controlling atmospheric pollution, the best natural way has been provided by vegetation by giving a huge leaf area for encroachment, immersion and gathering of air pollutants level in the environment (Varshney 1985; Lui and Ding 2008; Escobedo *et al.* 2008; Das and Prasad 2010). Plants showing high APTI values are more tolerant to air pollutants. The response of plants to air pollution both at physiological and biochemical levels can be evaluated by calculating air pollution tolerance index (APTI). It is a species dependent plant attribute that expresses the inherent ability of a plant to encounter stress arising from pollution. The APTI determination provides a well-grounded method for screening large number of plants with respect to their sensitivity to air pollutants. The identification and categorization of plants into sensitive and tolerant group is important as the former can act as indicators and later as swamps for the abatement of air pollution. APTI of plant species indicates an ideal tool for landscape planting in the locality of the polluted zones (Rai and Panda, 2013). In the present study, an attempt has been made to find the Air Pollution Tolerance Index (APTI) values of plants growing at Pratapnagar circle, Udaipur, Rajasthan.

MATERIALS AND METHODS

Study area

Pratapnagar circle is located in Udaipur district. Udaipur also known as the city of lakes is situated in the Southern part of Rajasthan state between 24°35′N latitude and 73°42′E longitude (Fig. 1).

Fig. 1.

The leaf samples were collected in triplicates from Pratapnagar circle area and further analysis has been performed for APTI calculation. The plant species studied were *Azadirachta indica (Neem), Mangifera indica (Aam), Eucalyptus (Nilgiri), Calotropis procera (Aak), Ficus religiosa (Peepal), Cassia fistula (Amal tas), Nerium indicum (Kaner), Plumeria (Champa).*

Relative Water Content (RWC) Estimation

For relative water content (RWC), the fresh weight of the leaf samples were taken. The leaves were allowed to get fully saturated with distilled water for 24 hours and weighed to obtain the saturated weight and then the dry weights were taken to determine the RWC as follows:

$$RWC\% = \frac{Fresh\ Weight - Dry\ Weight}{Saturated\ \ Weight - Dry\ Weight} \times 100$$

Estimation of leaf pH

For leaf extract pH, homogenized 2 gm of leaf sample with 20ml deionized water measured the pH of suspension with a pH meter. The pH meter was pre-calibrated prior to its usage using buffer solution of pH 4 and 9. The exercise was triplicated and the averages of the three readings were used.

Ascorbic Acid Estimation

Ascorbic acid was determined by titrimetric method (Sadasivam, 1987). A known volume of working standard has been used with oxalic acid and titrated against the dye 2, 6- dichloro phenol indophenol for blank reading (V_1 ml). Similarly the sample was extracted with oxalic acid and then titrated with the dye solution for sample reading (V_2 ml) and further amount of ascorbic acid in the sample was calculated as:

Ascorbic Acid (mg/100gm) =

$$\frac{0.5mg}{V1ml} \times \frac{V2ml}{5ml} \times \frac{100ml}{Weight\ \ of\ \ sample} \times 100$$

Total Chlorophyll Estimation

Total Chlorophyll was determined by the spectrophotometric method (Arnon, 1949). 1gm of the leaf sample was blended and then extracted with 20ml of 80% acetone, left for 15 mins and centrifuged at 5000 RPM for 5mins. The supernatant was collected and its absorbance was measured at 645nm and 663nm using spectrophotometer.

Further by using the values of the four parameters, Air Pollution Tolerance Index (APTI) was calculated using the formula of (Singh and Rao, 1983) as follows:

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

A = Ascorbic Acid (mg/gm)

T = Total Chlorophyll (mg/gm)

P = pH

R = Relative Water Content (RWC) (%)

RESULTS AND DISCUSSION

In our study changes in the parameters such as total chlorophyll, ascorbic acid, pH and relative water content of leaf extract were evaluated to know the tolerance level of plant species to air pollution. For APTI estimation all these biochemical parameters play a significant role to determine the resistance and susceptible levels of plant species (Mahecha *et al.* 2013). The reduction in the relative water content of plants is due to the impact of air pollutants on the transpiration rate in leaves (Chouhan *et al.* 2012). Meanwhile the plants showing high relative water content under polluted condition may be tolerant to pollution. Relative water content of a leaf is the water present in it relative to its full turgid state.

High relative water content in the plants helps to maintain its physiological balance under stressed out situations like exposure to air pollutants when actually the transpiration rates are very high. It also acts as a drought resistor for plants. Because of air pollution there is a decrease in the transpiration rate and harm occurs to the leaf engine, which is responsible for pulling up the water from the roots due to which the plants neither bring minerals nor cools down the leaf. Decreased relative water content is due to the effect of pollutants on the transpirational rate of leaves (Lohe *et al.* 2015 & Swami *et al.* 2006) (Fig. 2).

Photosynthesis is hampered in plants with low pH values. In the presence of acidic pollutants, the leaf pH comes to a decline and is the lowest in the sensitive species. Apart from that higher pH values show resistance of species against environmental stresses. (Chouhan *et al.* 2012) (Fig. 3).

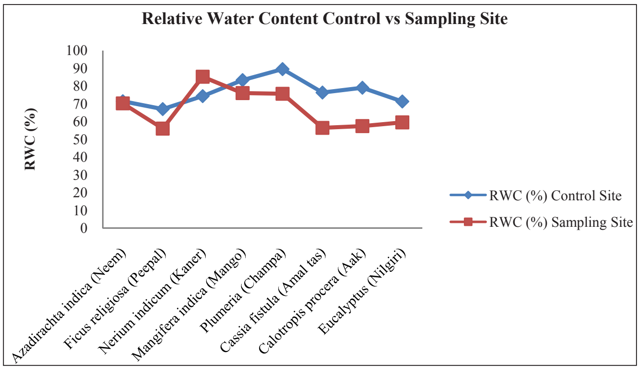

Fig. 2: Showing the Relative Water Content (%) of Control vs Sampling Site

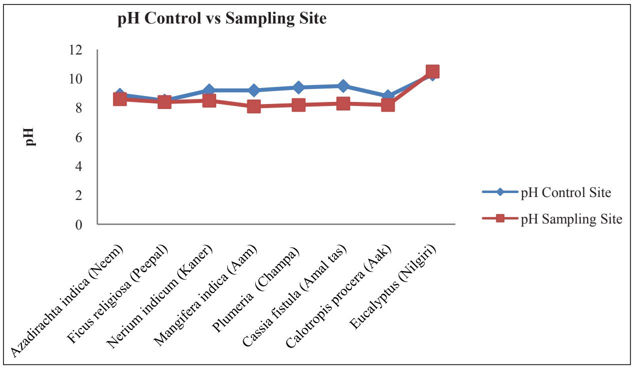

Fig. 3: Showing pH of Control vs Sampling Site

Ascorbic acid is an anti-oxidant, which the growing plant parts possess in large quantity and acts as a resisting factor of the plant to adverse environmental condition. As it is a stress reducing factor, during stressful conditions the plants release it in a large amount thus, the ascorbic acid content of samples from the polluted site will be much more when compared to the control site (Rai *et al.* 2013). Ascorbic acid content of all plant species increases in polluted condition because of the increment in the production rate of reactive oxygen species during the photo oxidation process and other opinion regarding the increased ascorbic acid level is that it is an indicator of the tolerance level of the plants against SO_2 pollution (Tripathi and Gautam, 2007 Varshney and Varshney, 1984). The ascorbic acid content of Azadirachta indica (Neem), Calotropis procera (Aak), Eucalyptus (Nilgiri) and Mangifera indica (Aam) is higher and this shows their tolerance to air pollution (Fig. 4).

Chlorophyll content is very essential for plants and a decline in it indicates air pollution. The reduction in the total chlorophyll content mainly occurs due to the deposition of particulate matter on the leaf

Table 1: Results of APTI Computation by calculating the parameters of pH, Ascorbic acid content, Relative water content and Total chlorophyll

S.No.	Name of plant	Leaf extract pH		RWC (%)		Total Chlorophyll (mg/g)		Ascorbic acid (mg/g)		APTI	
		Control	Sample	Control	Sample	Control	Sample	Control	Sample	Control	Sample
1	*Azadirachta indica (Neem)*	8.9 ± 0.15	8.6 ± 0.20	71.4 ± 0.51	70.2 ± 0.83	0.845 ± 0.030	0.401 ± 0.004	4.83 ± 0.04	10.32 ± 0.03	11.93 ± 0.03	16.19 ± 0.03
2	*Ficus religiosa (Peepal)*	8.5 ± 0.40	8.4 ± 0.41	67.0 ± 0.20	56.0 ± 0.20	0.564 ± 0.002	0.221 ± 0.002	1.54 ± 0.05	8.82 ± 0.04	8.11 ± 0.02	13.43 ± 0.03
3	*Nerium indicum (Kaner)*	9.2 ± 0.30	8.5 ± 0.30	74.3 ± 0.30	85.2 ± 4.61	0.664 ± 0.003	0.535 ± 0.005	3.11 ± 0.10	4.02 ± 0.06	10.48 ± 0.02	11.89 ± 0.01
4	*Mangifera indica (Aam)*	9.2 ± 0.30	8.1 ± 0.20	83.3 ± 0.60	76.0 ± 0.25	0.443 ± 0.007	0.430 ± 0.001	2.41 ± 0.03	10.55 ± 0.05	10.62 ± 0.05	16.61 ± 0.03
5	*Plumeria (Champa)*	9.4 ± 0.45	8.2 ± 0.25	89.5 ± 1.36	75.6 ± 0.41	0.730 ± 0.001	0.607 ± 0.003	1.62 ± 0.05	6.46 ± 0.05	10.46 ± 0.03	14.12 ± 0.03
6	*Cassia fistula (Amal tas)*	9.5 ± 0.25	8.3 ± 0.20	76.3 ± 4.76	56.4 ± 0.45	0.573 ± 0.003	0.568 ± 0.002	4.15 ± 0.05	8.50 ± 0.30	11.31 ± 0.04	13.60 ± 0.03
7	*Calotropis procera (Aak)*	8.8 ± 0.30	8.2 ± 0.35	79.0 ± 0.25	57.4 ± 0.30	0.493 ± 0.002	0.397 ± 0.002	4.00 ± 0.04	10.44 ± 0.03	11.42 ± 0.05	15.70 ± 0.04
8	*Eucalyptus (Nilgiri)*	10.3 ± 0.35	10.5 ± 0.36	71.3 ± 0.49	59.5 ± 0.35	0.341 ± 0.001	0.332 ± 0.002	3.44 ± 0.03	9.92 ± 0.02	10.80 ± 0.03	16.85 ± 0.03

surface (Dipti *et al.* 2016). The loss in the total chlorophyll content of the leaves support the fact that chloroplasts are the major site for the attack of air pollutants in plants (Tripathi and Gautam, 2007).

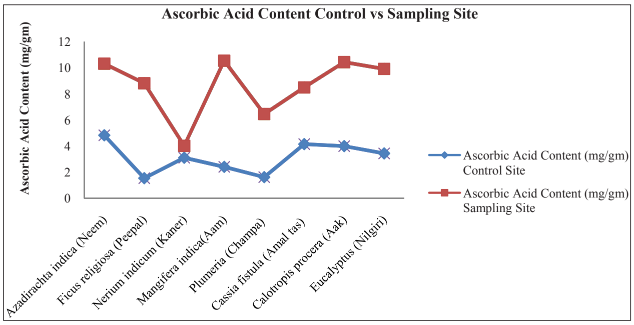

Fig. 4: Showing Ascorbic Acid Content (mg/gm) of Control vs Sampling Site

Polluted and dusted leaf surface is responsible for the decline in the photosynthetic activity and thereby hampering the chlorophyll content (Kalyani & Singaracharya, 1995) (Fig. 5).

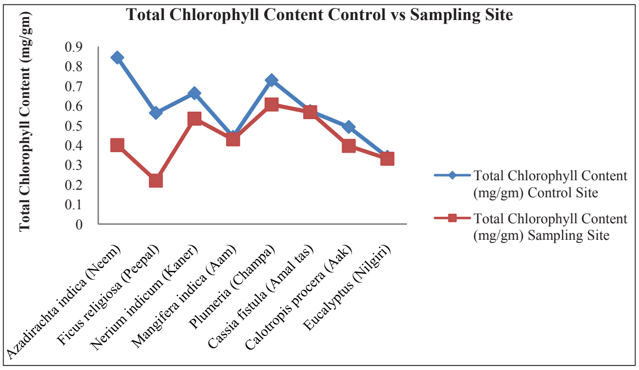

Fig. 5: Showing Total Chlorophyll Content (mg/gm) of Control vs Sampling Site

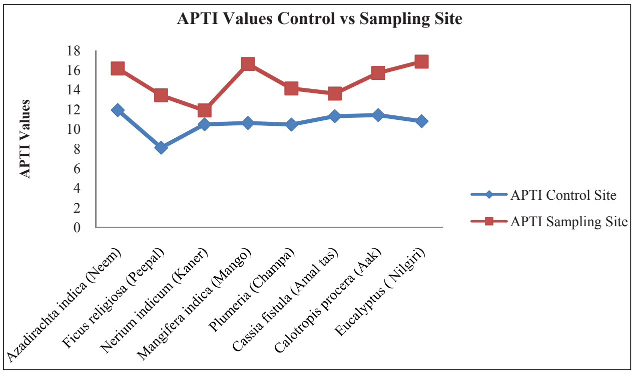

Fig. 6: Showing APTI Values of Control vs Sampling Site

Chlorophyll content, pH, relative water content decreased when compared to the control sample, while ascorbic acid content of the plants increased showing the susceptibility level of plant species to various air pollutants. In our study, the highest APTI was recorded in *Eucalyptus* (Nilgiri), followed by *Mangifera indica* (Mango), *Azadirachta indica* (Neem), *Ficus religiosa* (Peepal) and *Nerium indicum* (Kaner). So these plants can be used for plantation on the roadsides and polluted areas to trap the air pollutants to an extent (Fig. 6).

CONCLUSION

Air pollution Tolerance Index determination is of prime importance as with the increased vehicular movements, urbanization and rapid increase in the industries the pollution stress is on rise. Gases and some particulate pollutants are absorbed by the leaves, which naturally purify the atmosphere as the plants have a very large surface area for trapping the pollutants (Bhattacharya *et al.*). An overview of the study reveals that plantation of *Eucalyptus (Nilgiri), Mangifera indica (Aam), Azadirachta indica (Neem) and Calotropis procera (Aak)* can be proved useful from the biomonitoring point of view and their green belts can be developed for reducing air pollution in the particular area. Suitable plant species with high APTI values can be selected for plantation along roadside and polluted areas, which may become one of the strategies for checking out air pollution in cities and industrial areas (Mahecha *et al.* 2013).

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