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BIOMONITORING OF DUST POLLUTION OF ROAD SIDE OF KATHMANDU VALLEY USING AIR POLLUTION TOLERANCE INDEX (APTI)

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Abstract: Biological monitoring and assessment studies due to urban-road pollutants were carried out using Air Pollution Tolerance Index (APTI) of plants. Four plant (leaf) parameters--namely ascorbic acid, total chlorophyll, relative water content and leaf extract pH were combined together in a formulation signifying the APTI of plants. APTI was calculated for five different shrub species *viz. Bougainvillea glabra, Duranta repens, Lantana camara, Ricinus communis* and *Sambucus hookeri* growing in three different areas, *i.e.* control area and along the roadsides in Kathmandu valley. The control site was selected in the Tribhuvan University, Campus area. Reduction in total chlorophyll content and pH was found in the leaf samples of all selected plants collected from less polluted sites (control) when compared with samples from more polluted site, whereas APTI, ascorbic acid and RWC were found to be higher in the plant samples of more polluted site as compared to less polluted site (control). From the results obtained, it has been observed that *Bougainvillea glabra* and *Duranta repens* were the most tolerant species since they have high APTI values. Tolerant plant species can be used in green belt development as they tend to serve as barriers and act as sink for air pollutants. The sensitive species were *Lantana camera* and *Ricinus communis*. They can be used as bio-indicators to air quality. Such studies will help in future planning of the roadside landscape in order to reduce pollution.
Keywords: Air Pollution Tolerance Index (APTI); Ascorbic acid; Dust; Total chlorophyll content.
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INTRODUCTION

Air Pollution is one of the serious problems in the world especially in urban areas of developing countries due rapid growth of population, increase in number of vehicles and industrialization. Air pollutants, affect not only the ambient air quality of urban area, but also affect public health and associated with respiratory and cardiovascular problems (Harisson *et al.,* 1997). Plants play an important role in purification of atmosphere and considered a natural tool for reducing the air pollution by absorbing toxic substances and capturing particulate matter. Leaves provide large surface area for impingement, absorption and accumulation of air pollutants and act as environmental sink (Liu and Ding, 2008). Moreover, the roadside plant leaves are in direct contact with air pollutant, and may act as stressors for these pollutants, hence to be examined for their biomonitoring potential (Pandey *et al.*, 2005; Sharma *et al.,* 2007). A number of air pollution biomonitoring studies have been performed using leaves of different plant species. It is possible to estimate the overall effect of a large number of pollutants as total pollution by measuring changes in the plant (Agbaire and Esiefarienrhe, 2009). Plants are different in their ability to remove and tolerate pollutants. Therefore, plants are classified according to air pollution tolerance index (APTI); tolerant and sensitive. The parameters used in defining sensitivity and resistance of plants towards different concentration of air pollutants

are ascorbic acid content (Keller and Schwager, 1977), relative water content, leaf extract pH (Chaudary and Rao, 1977). The impacts of air pollution on ascorbic acid and chlorophyll contents, leaf extract pH, and relative water content have been extensively studied (Rai and Panda, 2014; Kaur and Nagpal, 2017). Singh and Rao (1983) developed Air Pollution Tolerance Index (APTI) for evaluation of tolerance level of plant species towards air pollution using different leaf parameters as total chlorophyll content, total ascorbate (AA), leaf extract pH and relative water content (RWC). Air pollution tolerance level of each species is different and plants do not show uniform behaviour. It is seen that plants having higher index value are more tolerant to air pollution and can be used as filter or sink to mitigate air pollution; and plants having low index value are sensitive to air pollution can be used as pollution indicator species. The sensitive species can serve as biological indicators for air pollution, whereas, the tolerant ones are considered as sink, able to be used to combat pollutants' level in that specific environment (Prajapati and Tripathi, 2008; Maity *et al.*, 2017). According to Zhang *et al.* (2016), not only do tolerant plants help attenuate air pollution, they also maintain the ecological balance, controlling soil erosion and improving aesthetic aspects of such polluted areas. The heavy traffic load on the roads and construction activities have polluted the environment of the Kathmandu valley. The accumulation of dust on leaves of plant is very common in the valley. Due to increased transportation activities in the area the leaf dust load may also contain toxic metals which are considered harmful to all forms of life. Therefore, plants which act as biological indicator of air pollution, needs to be categorized according to their sensitivity. Therefore, the present study was conducted to determine the tolerance of some plant's species around and within the city.

EXPERIMENTAL

Selection of Plant species: Plant species *viz. Bougainvillea glabra, Duranta repens, Lantana camara, Ricinus communis* and *Sambucus hookeri* which have been widely grown along road side of Kathmandu valley had been selected for study. Plant species were selected on the basis of availability of species at all sites.

Study area: The present study was conducted in Kathmandu valley (27° 37'30" N and 27° 45'0" N latitude, and 85° 15'0" E and 85° 22'30" E longitude). It is about 1400 m above sea level with bowl –like structure surrounded by Phulchowki Hill (3132m) in South east, Shivapuri (2713m) in North, Champa Devi (2400m) in South West and Nagarjun (2100 m) in the West. The air pollutants become trapped and accumulate in the valley without dilution by vertical dispersion (Sapkota and Dhaubadel, 2002). It lies in central Nepal with mean temperature from minimum 10 (January) to maximum about 25°C(July) in different months. The area receives monsoon rain from June to September, which accounts about 80% of the total annual rainfall (2244 mm). Rest of the months are dry with few showers of winter rain. Population of Kathmandu Valley is 2.5 million with annual population growth rate of 4.2% and population density 2,799.8/Km^2 (CBS, 2011). Total suspended particulate matters (TSPMs) has been a major problem in roadsides of Kathmandu valley. For evaluation of air pollution tolerant index of plant species, plant samples from three different sites Thamel area, Lazimpat area and Tribhuvan Uiversity Campus area, Kirtipur as the control site for the comparative study were selected (Table 2). On the basis of particulate matters study site were categorized as heavily polluted, moderately polluted and least polluted (control site) (Table 1).

Table 1. Ambient air quality of study sites (24 hours' average data May 2017, Source: GoN, 2017)

Study Site	TSPMs (µg/m^3)	$PM_{2.5}$ (µg/m^3)	PM_{10} (µg/m^3)	SO_2	NOx
Thamel (Heavily polluted)	1289	147	696	<0.02	9.40
Lajimpat (Moderately polluted)	467	95	278	<0.02	0.30
Kirtipur (Least polluted; control)	305	13	149	<0.02	0.30

Table 2. Site Description

S. No.	Site Name	Characteristics
Site 1	Thamel Area	Crowded, Touristic area, flow of vehicles high
Site 2	Lazimpat	High flow of vehicle, road connecting the northern part of the Kathmandu
Site 3	Kirtipur-Coronation garden	University area, less flow of vehicles

Collection of samples: Leaf samples of *Bougainvillea glabra, Duranta repens,Lantana camara, Ricinus communis* and *Sambucus hookeri* were collected from different polluted and less polluted sites during winter (December-January). In order to study the impact of dust and other pollutants generated by vehicular activities on physiological characteristics viz. total chlorophyll content, ascorbic acid content, relative water content of leaves, and leaf extract pH of plants, the horizontal distance of 0-10m were selected from both sides of the road. The plants growing at selected sites on both sides of the road at iso-ecological sites having approximately same height and canopy were considered to maintain the uniformity. Five leaves from each of the three selected individuals at each location were collected for study. Fully mature leaves were collected in the morning hours (8 to 10 AM) at breast height (ca.1.3m). The collected leaf samples were then transported to the laboratory in zipper plastic and washed with tap water and then with 0.1N HCl followed by washing with distilled water.

Biochemical Analysis: The fresh leaf samples were analyzed for total chlorophyll, ascorbic acid, leaf extract pH, and relative water content for determining APTI by following standard procedure.

Total Chlorophyll Content: Total chlorophyll content in the leaves was estimated following the method of Arnon (1949) by using a spectrophotometer. The fresh and clean leaves of selected plants (0.25 gm) were blended in 80% acetone using mortar and pestle. The mixture was filtered and the filtrate was made to 50 mL. Absorbance of the extract was measured at 645nm, 663nm and 652nm using spectrophotometer (sepctronic 21, Milton Roy Company).

$$\text{Chlorophyll a} = 12.7 \times A_{663} - 2.69 \times A_{645} \times \frac{V}{1000 \times W}$$

$$\text{Chlorophyll b} = 22.9 \times A_{645} - 4.68 \times A_{663} \times \frac{V}{1000 \times W}$$

$$\text{Total Chlorophyll} = \frac{A_{652} \times 1000}{34.5 \times 1000} \frac{V}{W}$$

Where, V = Volume of the filtrate = 50 mL
W = Weight of leaf = 0.25 g

Ascorbic Acid (AA) Content Analysis: Ascorbic acid content (expressed in mg/g) was measured using spectrophotometric method (Bajaj and Kaur, 1981). One gram of fresh foliage was added to a test-tube containing 4 mL oxalic acid – EDTA extracting solution, 1 mL of orthophosphoric acid, 1 mL tetra-oxosulphate (5%), 2 mL of ammonium molybdate and 3 ml of water. The solution was then allowed to stand for 15 min and absorbance was recorded at 760 nm with a spectrophotometer. The concentration of ascorbic acid in the samples was then extrapolated from a standard ascorbic acid curve.

Leaf extracts pH: Mature leaves (5 g) were homogenized in 10 mL distilled water and supernatant obtained after centrifugation was collected for determination of pH (Apriyantono *et al.,* 1989). The leaf extract pH was estimated by using pH meter (Model- ESICO 1013) by standardizing with buffer solution of pH 4 and 9.

Relative Water Content (RWC): The relative water content was estimated by using the method prescribed by Barr and Weatherly (1962). First the fresh leaves were cleaned to remove dust particles; then fresh weight was taken. The leaves were then immersed in distilled water over night, blotted dry and then weighed to get the turgid weight. Leaves dried overnight in an oven at 70°C and reweighed to obtain the dry weight.

$$\text{Relative water content (RWC) (\%)} = \frac{FW - DE}{TW - DW} \times 100$$

Where, FW= Fresh weight of leaf sample
DW= Dry weight of leaf sample
TW= Turgid weight of leaf sample

Air Pollution Tolerance Index (APTI): By using chlorophyll content, leaf pH extract, relative water content and ascorbic acid content, the air pollution tolerance index was computed by using following equation (Singh and Rao, 1983):

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

Where, A is ascorbic acid (mg/g) of leaf sample
T is total chlorophyll (mg/g) of leaf sample
P is leaf extract pH of leaf sample
R is relative water content (%) of leaf sample

Statistical Analysis: The significance of the difference between the means of measured biochemical parameters and ATPI among plant species at different sites was analyzed by one-way analysis of variance (ANOVA), followed by multiple range test (Duncan test). Statistical Package for Social Science (SPSS, version, 17, was used for all statistical analyses.

RESULTS AND DISCUSSION

The biochemical characteristics and the APTI for plants from different location of Kathmandu valley are presented in Tables 3-7.

Total Chlorophyll content

Photosynthetic pigment degradation has been widely considered as an indication of air pollution (Mir *et al*., 2008; Wagh *et al*., 2006). Amount of chlorophyll in the leaf tissue is significantly affected by the pollution load. Many plant species are able to maintain their normal chlorophyll content while under stress. Chlorophyll content of plants signifies its photosynthetic activity as well as the growth and development of biomass (Achakzai *et al.,* 2017). This varies from species to species, age of leaf and also with the pollution level as well as with other biotic and abiotic conditions (Katiyar and Dubey, 2001). It is well evident that chlorophyll content varies with tolerance as well as the plant species' sensitivity. In other words, the higher the sensitive nature of the plant to pollution stress, the lower the chlorophyll content (Rai and Panda, 2014). In the present study, the total chlorophyll content of species ranged from 1.55 to 3.40 mg/g. Among the five species studied *Bougainvillea glabra* had maximum total chlorophyll content of 3.40 mg/g in their leaves. This was followed by *Lantana camara, Ricinus communis, Sambucus hookeri*, and *Duranta repens*, with respective values of 2.80, 2.69, 2.21, and 1.55 mg /g. Further, the variations in total chlorophyll content of plant species varied significantly with the pollution status of the area with higher value at less polluted site and least at heavily polluted site (Table 3). Similar decrease in chlorophyll content in higher plants near road sides due to automobile pollution have already been reported by Mir *et al.* (2008). This is due to the properties of certain pollutants that can reduce the chlorophyll content as has been reported by Rai *et al*. (2013). The decrease in foliar chlorophyll concentration in plants might also be due to the destruction of chlorophyll or due to reversible swelling of thylakoids (Horsman and Welburn, 1975) and inhibition of *RuBp carboxylase*. In the present study decrease in total chlorophyll content may be due to the accumulation of dust on the plant leaf that prevents the gaseous exchange process or the intensity of light that affect photosynthesis and metabolism.

Table 3. Total Chlorophyll content (mg/g) of selected samples at different location. [The data were expressed as Mean ±S.D. and statistical analysis using One Way ANOVA for obtaining F and P value. Significance difference between mean value among different pollution level are indicated by different letters (Duncan multiple comparison test, P< 0.05. (n=15)]

Plant Species	Location			Mean	F-value	p-value
	Heavily polluted	Moderately polluted	Least Polluted (Control)			
Bougainvillea glabra	3.43±1.01a	3.43±0.98a	3.47±1.82a	3.40± 1.00	1.78	0.082
Lantana camara	2.82±0.23b	2.78 ±0.23a	2.86±0.23b	2.80± 0.12	21.13	0.003
Duranta repens	1.60±0.12b	1.50±0.11a	1.63±0.21b	1.55±0.35	35.78	0.001
Sambucus hookeri	1.68±0.03a	2.38±0.36b	2.65±0.31c	2.21±0.28	47.34	<0.001
Ricinus communis	2.49±0.31b	2.39±0.23a	3.41±0.34c	2.69±0.25	32.71	<0.001

Relative Water Content

Water in plants plays an important role to maintain the temperature, nutrient conduction and helps in metabolic processes (Otuu *et al.,* 2014). It was reported that air pollutants increase cell permeability, causing loss of water and dissolved nutrients, resulting in early senescence of the leaves (Bakiyaraj and Ayyappan, 2014). Moreover, reduction in leaves relative water content (RWC) of plant species, grown inside the polluted zone, could be explained by the reduction of transpiration rate in the leaves. High water content within a plant body will help to maintain its physiological balance under stress condition such as exposure to air pollution when the transpiration rates are usually high (Lakshmi *et al.,* 2009). High RWC favors drought resistance in plants. There was significant variation in leaf relative water content (RWC) among selected plant species growing at different pollution level. Among the plant species, the highest RWC (86.8%) was recorded in *Bougainvillea glabra* at heavily polluted site and least RWC (73.86%) was recorded in *Lantana camera* at least polluted site (control) (Table 4). The highest RWC in *Bougainvillea glabra* may be ascribed due to its higher resistant capacity to stress conditions. Dedio (1975) reported that high RWC helps plants to maintain its physiological balance under stress condition and it favors the drought resistance in plants. High leaf RWC under stress condition is an indication of plant species' tolerance (Rai and Panda, 2014). In a study by Innes and Haron (2000) was reported that greater the exposure of plants to pollution stress, larger is the quantity of RWC. The higher leaf RWC in the plants growing at highly polluted site may be attributed to more dust accumulation on the leaves of the selected plants, which might have clogged stomatal opening, severely affecting the transpiration rate. The results are in line with the findings of Rai and Panda (2014) who reported high RWC in roadside plants at more polluted site.

Table 4. Relative water content (RWC)of selected samples at different location. [The data were expressed as Mean ±S.D. and statistical analysis using One Way ANOVA for obtaining F and P value. Significance difference between mean value among different pollution level are indicated by different letters (Duncan multiple comparison test, P< 0.05. (n=15)]

Plant species	Location			Mean	F-value	p-value
	Heavily polluted	Moderately polluted	Least Polluted (Control)			
Bougainvillea glabra	86.8±1.01a	85.43±0.98a	84.27±1.82a	85.70± 1.00	1.78	0.082
Lantana camara	79.82±4.23b	79.78±3.23a	73.86±1.23b	77.30± 2.75	21.13	0.003
Duranta repens	84.60±2.12b	85.50±3.11a	78.63±2.21b	82.55±2.75	35.78	0.001
Sambucus hookeri	75.68±3.03a	76.38±2.36b	80.50±3.31c	76.67±3.22	47.34	<0.001
Ricinus communis	75.9±4.31b	76.19±3.23a	74.41±2.34c	77.75±30.25	32.71	<0.001

Table 5. Leaf extract pH of selected samples at different location. [The data were expressed as Mean ±S.D. and statistical analysis using One Way ANOVA for obtaining F and P value. Significance difference between mean value among different pollution level are indicated by different letters (Duncan multiple comparison test, P< 0.05). (n=15)]

Plant species	Location			Mean	F-value	P- value
	Heavily polluted	Moderately polluted	Least Polluted (Control)			
Bougainvillea glabra	5.80±1.01a	6.9±0.98a	6.85±1.82b	6.43	17.89	0.002
Lantana camara	6.10±0.23a	6.13 ±0.13a	6.6±0.23b	6.27±0.20	12.13	0.01
Duranta repens	5.60±0.12a	5.50±0.11a	6.63±0.21b	6.05±0.25	32.78	0.001
Sambucus hookeri	5.68±0.43a	6.38±0.36b	6.50±0.31b	6.17±0.32	21.23	0.03
Ricinus communis	5.5±0.31a	6.10±0.43b	6.11±0.34b	5.94±0.30	16.24	0.04

There was significant variation in leaf extract pH among the plant species. The range of the leaf extract The pH among the selected species was from 5.94 to 6.43 (Table 5). Maximum leaf extract pH was recorded in *Bogainvillea glabra* (6.43) whereas minimum was recorded in *Ricinus communis* (5.94). The order of the leaf extract pH in plant species was *Bougainvillea glabra* (6.43) > *Lantana camara* (6.27) > *Sambucus hookeri* (6.17) > *Duranta repens* (6.05) > *Ricinus communis* (5.94). There was significant difference in leaf extract pH of all

species at different pollution level with significantly higher value at least polluted site (control), followed by those growing at less polluted, moderately polluted and highly polluted sites (Table 5). The lowest value of pH in case of plants growing at highly polluted site may be ascribed due to highest level of vehicular pollution. Similar results were also observed by Singare and Talpade (2013) who also reported that the leaf extract pH tend to decrease with the increase in pollution with respect to control site. The change in leaf extract pH might influence the stomatal sensitivity due to air pollution. The plants with high sensitivity to SO_2 and NO_2 closed the stomata faster when they are exposed to the pollutants. Plants with lower pH are more susceptible to pollutants and reduce the photosynthetic activity (Thakar and Mishra, 2010), while those with pH around 7 are tolerant (Singh and Verma, 2007; Achakzai *et al*., 2017).

Table 6. Ascorbic acid content of selected samples at different location. [The data were expressed as Mean ±S.D. and statistical analysis using One Way ANOVA for obtaining F and P value. Significance difference between mean value among different pollution level are indicated by different letters (Duncan multiple comparison test, P< 0.05) (n=15)]

Plant species	Location			Mean	F-value	p-value
	Heavily polluted	Moderately polluted	Least Polluted (Control)			
Bougainvillea glabra	0.68±0.11b	0.62±0.15a	0.64±0.10ab	0.64±0.11	17.56	<0.001
Lantana camara	0.29±0.08b	0.27±0.09ab	0.24±0.09a	0.24±0.09	13.71	<0.001
Duranta repens	0.83±0.06a	0.86±0.01b	0.82±0.02a	0.84±0.02	19.03	<0.001
Sambucus hookeri	0.69±0.10b	0.65±0.12a	0.63±0.10a	0.66±0.09	12.78	0.003
Ricinus communis	0.47±0.10b	0.43±0.12a	0.45±0.21ab	0.44±0.12	28.34	<0.001

Ascorbic acid plays a significant role in the cell wall synthesis, defense mechanisms of the plants as well as in the process of cell division and carbon fixation during photosynthesis (Conklin, 2001). It is a natural detoxificant protecting the plant tissues from damaging effect of air pollutants (Escobedo *et al*., 2008; Lui and Ding, 2008). According to Zhang *et al.* (2016) ascorbic acid imparts tolerance to air pollution in plants, since it activates many physiological and defense mechanisms. It is an antioxidant, acting as reducing agent and influences resistance to harsh environmental stress, including atmospheric pollution by neutralizing the pollutants that enter the plant system via the stomata. The ascorbic acid in the leaves of selected plants varied significantly among the species (Table 6). A significant variation was also noticed with the location. The variation in the ascorbic acid content among species might be due to their inherent capacity to tolerate stress conditions. The increase in leaf ascorbic acid could also be due to improvement in the defense mechanism of the plants which has been reported to be different for each plant species (Cheng *et al.,* 2007). Increasing ascorbic acid content was noticed with the increasing pollution level in the study location (Table 6). The higher ascorbic acid content in the leaves of plants growing at highly polluted site may be attributed to their tendency to synthesize this biomolecule to overcome stress under highly polluted sites (Klumpp *et al*., 2000). The results are comparable with the findings of the previous researchers who have also recorded higher values of ascorbic acid in plant leaves at polluted sites (Bhattacharya *et al.,* 2012; Yannawar and Bhosle, 2014). Pollution load dependent increase in ascorbic acid content of all species may also be due to the increased rate of production of reactive oxygen species (ROS) during photo-oxidation of SO_2 to SO_3 where sulfites are generated from SO_2 (Jyothi and Jaya, 2010).

Table 7. Air Pollution Tolerant Index (APTI) of selected plant species at different location. [The data were expressed as Mean ±S.D. and statistical analysis using One Way ANOVA for obtaining F and P value. Significance difference between mean value among different pollution level are indicated by different letters (Duncan multiple comparison test, P< 0.05). (n=15)]

Plant Species	Location			Mean	F-value	p-value
	Heavily polluted	Moderately polluted	Least Polluted (Control)			
Bougainvillea glabra	9.60 ±1.09b	9.07 ±2.00a	9.04±2.01a	9.15±1.57	12.43	0.002
Lantana camara	7.20 ±1.0b	7.22 ±0.89b	6.61±1.21a	6.95±1.03	15.78	0.03
Duranta repens	9.57 ±1.34b	9.23±2.01b	8.54±2.10a	9.03±1.61	7.89	0.005
Sambucus hookeri	8.51 ±2.00b	8.20 ±1.98b	8.08 ±1.15a	8.21 ±1.61	9.84	0.02
Ricinus communis	8.29±1.83b	7.96±2.31a	7.86±1.45a	8.02±1.81	6.98	0.032

The APTI value estimated using the four biochemical parameters in plant leaves namely RWC, total chlorophyll content, pH and ascorbic acid value can be used as a predictor of air quality. Plants having higher index value are tolerant to air pollution while plants with lower index value show less tolerance (Singh and Rao, 1983). The selected plant species growing along different pollution levels were found to have significantly different air pollution tolerance index (APTI). The maximum APTI was recorded in *Bougainvillea glabra* (9.15) among the selected plant species whereas, minimum was noticed in *Lantana camera* (6.95). The APTI of selected plant species followed the order *Bougainvillea glabra* (9.15), >*Duranta repens* (9.03) > *Sambucus hookeri* (8.21)> *Ricinus communis* (8.02)> *Lantana camera* (6.95) (Table 7). The ATPI of the plants ranged from 6.61 – 9.60 and varied significantly with location of sample collection (Table 7). The highest ATPI was recorded in *Bougainvillea glabra* at highly polluted site (9.60). Least APTI value (6.61) was recorded in *Lantana camera* at least polluted site. The higher APTI of *Bougainvillea glabra* may be attributed to its higher tendency to synthesize ascorbic acid and maintain high RWC during pollution stress conditions (Kuddus *et al.,* 2011). Susceptibility to air pollution vary from species to species (Chouhan *et al.,* 2012; Radhapriya *et al.,* 2011). All the plants found in heavily polluted sites have higher ATPI value than in less pollutes sites (Table 7). A plant species known to be sensitive or tolerant in one geographical area may behave differently in another area (Raza *et al.,* 1985). The higher APTI of *Bougainvillea glabra* proved it to be one of the most resistant trees, its dominance in polluted site is an indication of its tolerant nature parallel to its higher APTI. The plants with higher APTI were found to be resistant and also act as a bioaccumulator for air pollutants (Prsanna *et al.,* 2005). Being a resistant species *Bougainvillea glabra* can be grown around the roadside and along road sides as avenue trees.

CONCLUSION

The APTI determination provides a reliable method for screening large number of plants with respect to their susceptibility to air pollutants. It is an easy and inexpensive way to bio-monitor urban air pollution for adoption under field conditions without the use of expensive tools or devices. From the results obtained, it has been observed that *Bougainvillea glabra* and *Duranta repens* were the most tolerant species since they have high APTI values. Tolerant plant species can be used in green belt development as they tend to serve as barriers and act as sink for air pollutants. The sensitive species were *Lantana camera, Ricinus communi*s. They can be used as bio-indicators to air quality. Such studies will help in future planning of the roadside landscape in order to reduce pollution.

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