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Assessment of Air Pollution Tolerance Index (APTI) for Selected Ornamental Plants in Urban Metropolis of Northern India

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Present study aims to evaluate the tolerance and sensitivity of some selected common ornamental plants like *Dracaena deremensis*, *Tagetes erecta* and *Dianthus caryophyllus* by the Air Pollution Tolerance Index (APTI) at selected sites in an urban metropolis of Northern India, Delhi city. Air pollutant concentrations were monitored at Site I (nearby traffic intersection with less vegetation) and Site II (far by from traffic intersection with dense vegetation) and selected plant species were examined for their biochemical response during winter months (November 16, 2016 – February17, 2017). Based on the results, *Dracaena deremensis* and *Tagetes erecta* were segregated under tolerant whereas, *Dianthus caryophyllus* was under the sensitive category. Therefore, *Dracaena deremensis* and *Tagetes erecta* can be used as natural air filters or sinks for mitigation of air pollution and *Dianthus caryophyllus* as biomonitors or bioindicators.

Keywords: **Mitigation, Air pollution, Ornamental plants, Air pollution tolerance index, Northern India.**

INTRODUCTION

Air pollution has become a global burden disease and contributing a large number of deaths since few decades [1]. The levels of primary and secondary sir pollutants like nitrogen oxides (NO_x), sulphur dioxide (SO_2), particulate matter (PM) and ozone (O_3) are alarmingly high particularly in Asian countries. The major reasons for such high increase is overpopulation growth, rapid industrialization and urbanization, vehicular pollution and ignorance of people for the environment [2]. The resultant worsened air quality leads to affect the morphological, biochemical and physiological parameters of various plant types [3] and leaves are the main receptors of pollutants, which are further used to evaluate the tolerance and sensitivity for air pollution [4]. Air pollution causes a number of diseases in plants like chlorosis, necrosis, *etc*. Nevertheless, plants can also be used as good air purifiers by adopting the processes like absorption, impingement and adsorption and also add aesthetic value to the environment [5]. Leaves are the most important part of the plant as they act as prominent receptor of air pollutants and show different behaviour of various kinds of air pollutants. Some plants are tolerant to specific kind of air pollutant while others behave as sensitive ones. The tolerant ones are usually selected for greenbelt development and the sensitive plants, as bioindicators or biomonitors [6,7]. Though there are other methods too for monitoring and controlling the rate of air pollution by mechanical means, but it comes out as an expensive method, while urban vegetation has shown a unique direction to scientists and policy makers as the most simple and cost-effective one and suitable in all the landscape areas [8]. Hence, a large mass of various tolerant species can be used as a good and cost-effective measure for mitigation of air pollution.

Large surface area and more in number, are the most significant features of plant leaves which make them more efficient receptors of air pollutants. Apart from them, plants may also accumulate particulate matter through their roots. There are few studies, which reported that plants can decrease the particulate matter air pollution by one-third than to sites with almost no vegetation [9]. Likewise, a number of ornamental plants/ trees are also reported to be used as sinks and bioindicators besides their other applications such as improving the aesthetic value [10]. Ornamental plants are still a less explored area of research in terms of biomonitoring or mitigation of air pollution other than trees or shrubs. Greenbelt development planning with those ornamental plants that offers social, health, environmental, economic and air purification capacity is considered as one of the best practice to achieve sustainability. Right choice of ornamental plant species may improve the air quality of a particular place [11,12]. Based on the above facts, Rao [13] recommended a sustainable tool, Air Pollution Tolerance Index (APTI), used to screen the tolerant and sensitive plant species and further applied in green belt development programs. This tool comprises of four basic biochemical parameters like total chlorophyll, ascorbic acid, pH and relative water content. Most of the studies related with APTI are reported from Asian countries where urban green spaces are used to mitigate air pollution. High APTI values indicate tolerant plant species while low APTI values represent sensitive species and they can be used bioindicators or biomonitors. Based on this index, a scale has been designed which is used to segregate the plants into different categories like very sensitive, sensitive, moderate and tolerant [13]. The present study focused on evaluation of tolerance and sensitivity of some ornamental plants, based on APTI values, in mitigating air pollution. This work not only addresses the sustainable use of ornamental plant species in combating air pollution and also to represent the real conditions of most of polluted areas of the world where urgent action is required.

EXPERIMENTAL

Study area and sampling sites: The study area selected for this study is one of the urban metropolis of Northern India, Delhi (28.61ºN, 77.23ºE). Delhi, capital city of India, situated in Indo-Gangetic plain bordered by the Great Himalayas in the North, due to which, the air pollutants at the onset of crop residue burning (CRB) during post-monsoon months (October-November) transported from adjoining national and international regions around India and during pre-monsoon season (May-June), transferred to Delhi and further carried to east in Indo-Gangetic plain [14,15]. It is also one of the highly populated megacity in the world and has a population of 16.7 million with yearly mean growth rate of 1.92% [16]. The population living in urban areas (93%) than the national mean of 31.16% [17]. It is also among the 5 most polluted cities in the world. It has also the highest number of registered motor vehicles in India. 6.93 million vehicles were registered in 2011 and it will expect to rise by 25.6 million in 2030 in Delhi [18].

Delhi has experienced mainly three seasons like winter, summer and monsoon. The mean temperature in summers remains to be 32 ºC whereas in winters, it's about 15 ºC. The wind speed ranges from 3m/s to 9m/s and are usually higher in summer and monsoon as compared to winter season. The average yearly rainfall is 715 mm and it also act as a cleansing agent which scavenges high concentration of air pollutants [19].

According to the reports published by various Indian Governmental pollution control agencies, NO_x, PM, O_3 and CO are some of the air pollutants, which are still higher than their standard limits even after the execution of stringent control measures in Delhi city. Therefore, there is an urgent need to improve air quality by cost effective ways and look forward for better health status of Delhi city [20]. Greenbelt development is one of the most sustainable methods adopted for air pollution mitigation. The green cover of Delhi generally consists of trees like *Ficus religiosa*, *Morus alba*, *Tectona grandis*, *Azadirachta indica*, *etc*. and common ornamental plant species like *Dracaena deremensis*, *Lantana camara*, *Nerium oleander*, *Bougainvillea*, *Tagetes erecta*, *Dianthus caryophyllus*, *Rosa indica*, *etc.* They are usually planted on the sideways of roads and highways or situated in parks or gardens nearby sectoral emission area.

In this study, common and abundant ornamental plant species were selected like *Dracaena deremensis*, *Tagetes erecta* and *Dianthus caryophyllus*, which are planted in and around the vicinity of selected sites. Sampling sites were differentiated based on their traffic flow and vegetative cover (Table-1): Site I: Vasant Vihar (VV) (nearby traffic intersection with less vegetation) and Site II: Jawaharlal Nehru University (JNU) (far by from traffic intersection with dense vegetation). The sampling was done during winter months in the time period, November 16, 2016 – February17, 2017.

Sampling pattern and analysis of plant samples: Fresh leaves of selected plant species were collected in the morning hours (8:00-9:00 hrs). For specific species, 3 plants were selected and samples were collected from each of them, per week in every month from each site. All leaves were placed in collection bags (paper) from the field/site and then analyzed in a laboratory for analysis after washing the leaves with distilled water and dried on blotting paper. These samples were analyzed in triplicate and to evaluate the tolerance and sensitivity of plant species to air pollution, four biochemical parameters, total chlorophyll content [21], leaf-extract pH [12], ascorbic acid content [22] and relative water content [12] were determined. These parameters are collated together and developed a

TABLE-1
TRAFFIC VOLUME AT SELECTED SITES IN DELHI

Site Name	Site No.	Peak traffic volume/h (pcu)[a]	Average vehicle speed (kmph)[b]
Vasant Vihar (VV)	Site I	8112[c]	40-50
Jawaharlal Nehru University (JNU)	Site II	300[c]	50-60

[a]NDMC (1992); [b]TPA (1994); [c]Traffic volume data are not available for these sites and the values given here are guesstimates made on the basis of traffic volume data available for the near by localities.
pcu (passenger car unit): It is the number of vehicle movement expressed in terms of car (hourly in this case). The value of `pcu' for different vehicles is given below:
Car, Taxi, Van and Matador: 1.0; Trucks and Buses: 3.7; Auto Rickshaw and Vikram: 2.0; Scooter, Motor Cycles and Mopeds: 0.75, *etc.*

formula by Singh & Rao [23] to give rise to an empirical value, APTI of particular species:

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

where, A = ascorbic acid content of leaf (mg/g fresh weight), T = total chlorophyll (mg/g), P = pH of a leaf extract and R = relative water content (%).

On the basis of APTI index, the plants are categorized as Tolerant, Moderate, Sensitive and Very sensitive [24] (Table 2). For checking the authenticity of data, statistical analysis was also performed by using the Statistical Package Software System (SPSS), 19.0 version. Duncan's test and Pearson correlation test was performed for compare means and dependency of variables.

TABLE-2
APTI SCALE BY KALYANI & SINGARACHARYA [Ref. 24]

APTI value	Response
30 to 100	Tolerant
29 to 17	Moderate
16 to 1	Sensitive
< 1	Very sensitive

RESULTS AND DISCUSSION

Air quality parameters assessment: The monthly mean of NO_2 (80.10 ± 7.32 µg/m^3) and O_3 (81.12 ± 9.06 µg/m^3) concentrations were found to be about 20 and 4 times higher at site I (VV) than at site II (JNU) (NO_2 – 9.67 ± 4.81 µg/m^3 and O_3 – 23.82 ± 3.22 µg/m^3) during the selected period (Table-3). This might be due to high traffic volume at site I as compared to site II (Table-1). Moreover, site I also have a number of schools and embassy offices and having narrow roads and due to which traffic jams were the usual feature. These favourable conditions lead to high emissions of air pollutants like NO_2 or O_3 at selected sites. In contrast, site II is relatively less polluted area in terms of air pollutants and covered with a dense vegetation cover and having very less traffic volume. This site is an institutional area with very limited number of vehicles with broad roads and no traffic jams. Therefore, concentrations of NO_2 and O_3 were found to be very less as compared to other sites. In addition to that, the concentrations of NO_2 were crossing the permissible limits set by National Ambient Air Quality Standards (NAAQS), India (80 µg/m^3) in all the months except February, which is an alarmingly call of the population resided in that particular area. Among all the months in the selected period, the concentrations of NO_2 and O_3 were found to be higher in January as compared to other months at both the sites. This was because, low boundary layer and temperature inversions which are responsible for increasing levels of air pollutants, especially during winter months (December-January) [25,26].

Biochemical parameters and APTI assessment: Biochemical parameters *viz.* total chlorophyll, pH, ascorbic acid and relative water content and APTI values of selected plant species, *D. deremensis*, *T. erecta* and *D. caryophyllus* at both the sites are given in Tables 4 and 5. *D. deremensis* was found to have higher levels of average Chl (3.85 ± 0.10 mg/g f.w.), pH (6.76 ± 0.36), AA (71.79 ± 5.71 mg/g f.w.) and RWC (80.96 ± 4.02 %) followed by *T. erecta* (Chl - 3.07 ± 0.04 mg/g, pH - 6.41 ± 0.26, AA - 62.10 ± 2.23 mg/g and RWC - 69.11 ± 4.02 %) and *D. caryophyllus* (Chl - 2.42 ± 0.04 mg/g, pH - 6.15 ± 0.03, AA - 26.76 ± 2.68 mg/g and RWC - 25.02 ± 3.06 %) at site II as compared to site I, where, *D. deremensis* with average Chl (1.8 ± 0.68 mg/g), pH (7.07 ± 0.56), AA (76.86 ± 8.76 mg/g)

TABLE-3
MONTHLY AVERAGE AIR POLLUTANTS CONCENTRATIONS (µg/m^3) AT SELECTED SITES IN DELHI

Months	Site I – NO_2	Site I – O_3	Site II – NO_2	Site II – O_3
November	82.74 ± 7.45	83.34 ± 8.65	4.01 ± 6.32	19.86 ± 5.66
December	83.72 ± 11.23	85.48 ± 13.32	10.08 ± 8.05	25.15 ± 7.86
January	84.60 ± 13.22	85.08 ± 9.65	15.97 ± 4.88	27.40 ± 8.77
February	69.35 ± 10.56	66.60 ± 12.65	8.60 ± 4.23	22.88 ± 7.88

TABLE-4
BIOCHEMICAL PARAMETERS VARIABILITY AT SITE I IN ORNAMENTAL PLANT SPECIES

Plants	CHL	pH	A.A.	RWC	APTI
Dracaena	1.8 ± 0.68^a	7.07 ± 0.56^a	76.86 ± 8.76^a	65.15 ± 6.78^a	74.48 ± 7.65^a
Tagetes	1.28 ± 0.50^a	6.81 ± 0.20^a	67.80 ± 6.78^a	62.90 ± 5.00^a	60.93 ± 6.23^{ab}
Dianthus	0.32 ± 0.17^b	3.96 ± 0.37^b	20.02 ± 1.62^b	20.31 ± 2.69^b	10.74 ± 3.44^b

Each value represents mean of 3 replicates ± standard error. Data followed by different letters in a column are significantly different at $p \le 0.05$. Data followed by same letters in a column are non-significant at $p \le 0.05$.

TABLE-5
BIOCHEMICAL PARAMETERS VARIABILITY AT SITE II IN ORNAMENTAL PLANT SPECIES

Plants	CHL	pH	A.A.	RWC	APTI
Dracaena	3.85 ± 0.10^a	6.76 ± 0.36^a	71.79 ± 5.71^a	80.96 ± 4.02^a	84.38 ± 7.89^a
Tagetes	3.07 ± 0.04^a	6.41 ± 0.26^a	62.10 ± 2.23^a	69.11 ± 4.02^{ab}	65.74 ± 4.21^{ab}
Dianthus	2.42 ± 0.04^b	6.15 ± 0.03^a	26.76 ± 2.68^b	25.02 ± 3.06^b	25.46 ± 6.98^b

Each value represents mean of 3 replicates ± standard error. Data followed by different letters in a column are significantly different at $p \le 0.05$. Data followed by same letters in a column are non-significant at $p \le 0.05$.

and RWC (65.15 ± 6.78 %) followed by *T. erecta* (Chl - 1.28 ± 0.50 mg/g, pH - 6.81 ± 0.20, AA - 67.80 ± 6.78 mg/g and RWC - 62.90 ± 5.00 %) and *D. caryophyllus* (Chl - 0.32 ± 0.17 mg/g, pH - 3.96 ± 0.37, AA - 20.02 ± 1.62 mg/g and RWC - 20.31 ± 2.69 %). APTI values also showed the similar trend as that of biochemical parameters, where *D. deremensis* was reported to have higher APTI (84.38 ± 7.89), followed by *T. erecta* (65.74 ± 4.21) and *D. caryophyllus* (25.46 ± 6.98) at site II (JNU) as compared tosite I (VV), where *D. deremensis* have APTI of 74.48 ± 7.65, followed by *T. erecta* with APTI of 60.93 ± 6.23 and then *D. caryophyllus* with APTI of 10.74 ± 3.44. It was also found from Tables 4 and 5, the selected plant species follows the order: *D. deremensis* > *T. erecta* > *D. caryophyllus* at both the sites in terms biochemical parameters and APTIs. On the basis of APTI index, given by Kalyani & Singaracharya [24], *Dracaena deremensis* and *Tagetes erecta* came under the tolerant category at both the sites whereas *Dianthus caryophyllus* shared two different status at both the sites, *viz.*, sensitive at site I (VV) and moderate at site II (JNU). It was also noted that significant difference was found only in the case of *Dianthus caryophyllus* as compared to *Tagetes erecta* and *Dracaena deremensis* at $p \leq 0.05$.

The higher value of Chl was found at site II (JNU) as compared to site I (VV) in all the selected plant species was because of very low levels of air pollutant concentrations of NO_2 and O_3 (Table-3), which leads to their less exposure and keep the plants more healthy than at polluted area (site I). Moreover, the reduction in the total chlorophyll level was significantly less in *D. deremensis* and *T. erecta* as compared to *D. caryophyllus.* Singh & Verma [27], reported that chlorophyll retention and rise in exposure to atmospheric pollution can indicate plant tolerance and helps in reducing air pollution. Moreover, Kammerbauer & Dick [28] also reported that ability of plants to fight against air pollution may be related to synthesis or reduction of chlorophyll and those possess high chlorophyll level are commonly tolerant to air pollutants. A significant decline in chlorophyll content at site I in *D. caryophyllus* support the statement that chloroplast is the major point of attack by air pollutants and they penetrate into the tissues through stomata and produce incomplete denaturation of the chloroplast and resulted in chlorosis in leaves of affected plants. This has also been supported by Muneer *et al*. [29] who observed that the decline in chlorophyll content due to high vehicular pollution was majorly related to the damage of reactive oxygen species (ROS) to the chloroplast. Therefore, *D. deremensis* and *T. erecta* falls under the tolerant category, while *D. caryophyllus* considered as sensitive one.

No significant change was found in leaf extract pH of *D. deremensis* and *T. erecta* at a polluted site (site I) than very less polluted site (site II). While significant reduction in pH value (acidic pH) was found in *D. caryophyllus* at a polluted site (site I). Leaf extract pH is also an important indicator in assessing the susceptibility of plant species to different pollutants and acidic pH produced a significant decline in metabolic activities [13,30]. Plants possessing a relatively higher leaf pH are more tolerant to air pollutants by converting hexose sugar into AA and increasing the reducing rate of AA [31,32]. Moreover, decrease in leaf extract pH also found to show stomatal susceptibility to pollutants and their immediate closure due to stress [24]. Therefore, higher value of pH at a polluted site (site I) indicates *D. deremensis* and *T. erecta* as tolerant while lower or acidic pH indicates *D. caryophyllus* as sensitive.

Higher levels of AA were found at site I (VV) than at site II (JNU) in *D. deremensis* and *T. erecta,* while lower levels of AA were found in *D. caryophyllus*. Normally, tolerant plant species having high ascorbate than sensitive ones. AA is required to synthesize the cell walls, antioxidant system and cell division process and can improve the tolerance of plant species [4]. Moreover, AA is a low molecular weight, strong antioxidant and contributes in scavenging the ROS and therefore, plants having greater AA helps in defending against air pollutants [33]. Therefore, *D. deremensis* and *T. erecta* are tolerant plants while *D. caryophyllus* is sensitive one.

No significant change in relative water content (RWC) has been found in *D. deremensis* and *T. erecta* at a polluted site (site I) than at a very less polluted site (site II). While, *D. caryophyllus* observed to be very less RWC at both the sites. It has been reported by Agarwal & Tiwari [34], higher RWC responsible for maintaining the physiological balance and increasing stress tolerance of plants. High air pollution also causes high permeability in cells, which leads to water loss and decline in dissolved nutrients and responsible for pre-fall of leaves where plants possess low RWC [35]. Thus, the present study observations are also in sync with the above mentioned studies. Therefore, *D. deremensis* and *T. erecta* was found to be tolerant and *D. caryophyllus* is sensitive one.

Correlation analysis: Correlation analysis was done between air pollutants and biochemical parameters at site I (VV) and site II (JNU) with most tolerant plant species, *D. deremensis* and sensitive one, *D. caryophyllus* (Table-6). In Table 6a, it has been clearly noted that at site I, NO_2 is highly positively significantly correlated with O_3 (r = .955) at $p \leq 0.01$ level. This depicts that NO_2 concentration increases, then O_3 also increases and *vice-versa*. This interpretation also be justified with the observations of our present study, where, NO_2 and O_3 concentrations are simultaneously increasing and decreasing at the same pace. Similar results were also reported by Saxena & Ghosh [13]. Moreover, NO_2 and O_3 were also found to be highly positively significantly correlated with pH at r = 0.791 and r = 0.841 at $p \leq 0.01$ level, respectively. This result is also in sync with Singh & Verma [27], where higher leaf extract pH will make the plant more tolerant against air pollution. Therefore, at site I (more polluted), *D. deremensis* was tolerant against air pollutants like NO_2 and O_3 with higher pH. Chlorophyll content is found to be highly negatively significantly correlated with ascorbic acid at r = 0.-841 and relative water content at r = 0.-756 at $p \leq 0.01$ level, respectively. Moreover, ascorbic acid is found to be highly positively significantly correlated with relative water content at r = 0.899 at $p \leq 0.01$ level. These observations are in sync with Samal & Santra [36], increase in ascorbic acid is considered as the best parameter for a tolerant plant when the plant is exposed to any type of abiotic stress, for example, air pollution stress. Normally, ascorbic acid acts

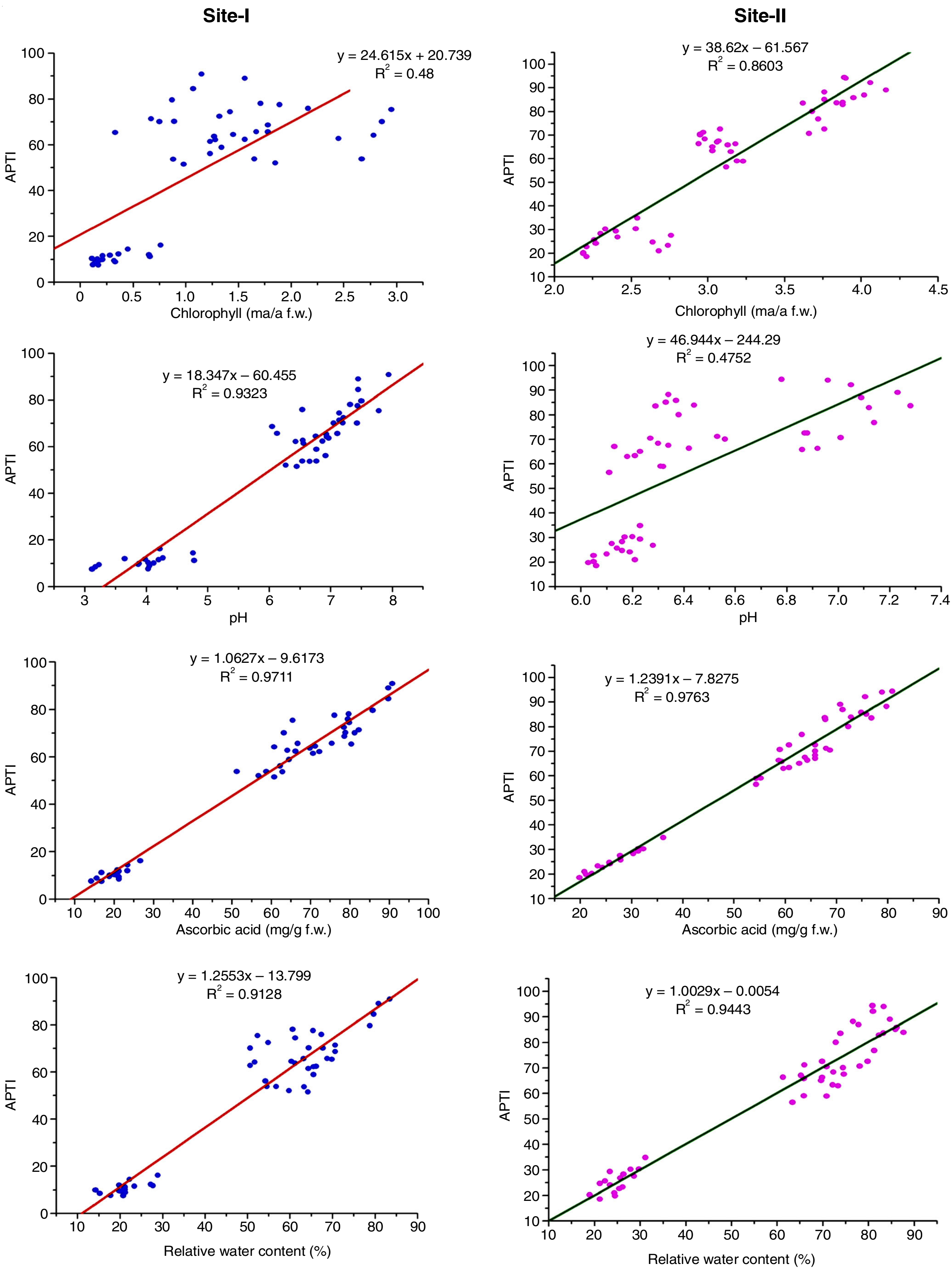

Fig. 1. Linear regression plots of individual biochemical parameter with APTI at Site I and Site II

TABLE-6
(A) AND (B) CORRELATION MATRIX OF AIR POLLUTANTS (NO_2 & O_3) WITH BIOCHEMICAL PARAMETERS AT SELECTED SITES IN *D. deremensis* AND *D. caryophyllus*

	(a)						(b)					
	NO_2	O_3	Chl	pH	AA	RWC	NO_2	O_3	Chl	pH	AA	RWC
Site I												
NO_2	1	.955**	-.042	.791**	.106	-.071	1	.955**	-.101	.227	-.151	.004
O_3	.955**	1	.001	.841**	.095	-.085	.955**	1	-.036	.196	-.248	.061
Chl	-.042	.001	1	-.070	-.841**	-.756**	-.101	-.036	1	.407	.495	.446
pH	.791**	.841**	-.070	1	.280	.153	.227	.196	.407	1	.051	.409
AA	.106	.095	-.841**	.280	1	.899**	-.151	-.248	.495	.051	1	.378
RWC	-.071	-.085	-.756**	.153	.899**	1	.004	.061	.446	.409	.378	1
Site II												
NO_2	1	.922**	-.072	-.386	.367	.391	1	.922**	-.212	.062	-.589*	-.483
O_3	.922**	1	.053	-.182	.270	.334	.922**	1	-.133	-.140	-.698**	-.459
Chl	-.072	.053	1	.448	.237	.417	-.212	-.133	1	.379	.162	.430
pH	-.386	-.182	.448	1	-.402	.172	.062	-.140	.379	1	.634**	.385
AA	.367	.270	.237	-.402	1	.033	-.589*	-.698**	.162	.634**	1	.665**
RWC	.391	.334	.417	.172	.033	1	-.483	-.459	.430	.385	.665**	1

*Significant at $p \leq 0.05$; **Significant at $p \leq 0.01$.

as an antioxidant for the removal of ROS from plant body. In APTI formula, AA has been multiplied with Chl and pH, which played an important role in evaluating the plant's tolerance or sensitivity, nevertheless, the other parameters are even less [37]. Therefore, in the present study, at site I, *D. deremensis* had high AA and RWC and both these parameters are increased under stressed conditions which indicated its high tolerance capability. In case of site II (very less polluted), no biochemical parameter was found to be correlated with same parameters and air pollutants. Only NO_2 was found to be highly positively significantly correlated with O_3 at r = 0.922 at $p \leq 0.01$ level. At site II, NO_2 and O_3 concentrations were found to be in reduced state, due to its distance from traffic intersection area.

In case of *D. caryophyllus*, at site I, no correlation was found between biochemical parameters and air pollutants. At site II, NO_2 was found to be significantly negatively correlated with ascorbic acid at r = 0.-589 at $p \leq 0.05$ level and O_3 were found to be highly negatively significantly correlated with AA at r = 0.-698 at $p \leq 0.01$ level. The concentrations of NO_2 and O_3 were reported to be very less as compared to site I and at low concentrations, normal ascorbic acid levels were found in *D. caryophyllus* and hence, APTI value was found to be in the moderate category as compared to site I where *Dianthus* was in sensitive category. Moreover, the pH was also found to be highly positively significantly correlated with AA at r = 0.634 and AA with RWC at r = 0.665 at $p \leq 0.01$ level.

Fig. 1 shows the linear regression plots of individual biochemical parameter with APTI. At both the sites, site I (Chl vs APTI, r = 0.68; pH *vs.* APTI, r = 0.96; AA *vs.* APTI, r = 0.98 and RWC *vs.* APTI, r = 0.95) and II (Chl *vs.* APTI, r = 0.92; pH *vs.* APTI, r = 0.68; AA *vs.* APTI, r = 0.99 and RWC *vs.* APTI, r = 0.97), all individual parameters were found significantly positive correlation with APTI at $p \leq 0.05$ level. This indicates that all biochemical parameters are important and influencing factors on which APTI depends. These observations are in accordance with Bakiyaraj & Ayyppan [38] and Pathak *et al.* [39], where, it was mentioned that all four parameters of APTI plays an important role in determining the tolerance and sensitivity of plants.

Conclusion

The present study concludes with a sustainable solution to mitigate air pollution in the urban metropolis of Northern India with the help of ornamental plant species. Improvement in the planning of ornamental roadside plants can definitely come with a substantial solution for reducing high levels of air pollutant concentrations in a particular area. Air pollution tolerance index (APTI) can act as a good cost-effective tool for mitigating air pollution in metropolitan cities or urban areas. In this study, *Dracaena deremensis* and *Tagetes erecta* reported high levels of ascorbic acid, pH and relative water content while *Dianthus caryophyllus* had observed low levels of ascorbic acid, pH and relative water content at a polluted site (site I) as compared to very less polluted site (site II). Thus, *D. deremensis* and *T. erecta* can be used in greenbelt development as tolerant species or sinks and *D. caryophyllus* may be used as bioindicator or biomonitor species for the mitigation of high air pollution levels in urban areas.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this article.

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