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Air pollution tolerance index of some ornamental plants around Rayalaseema

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Abstract
The present study was attempted to know the air pollution tolerance indices of ornamental plants at five different polluted locations in two seasons. The aim of the present study is to determine the variation in physiological and biochemical attributes to establish the susceptibility level of different ornamental plants with reference to their tolerance and performance index which might be very useful in the selection of appropriate species that are expected to perform well for the development of green environment and for landscaping. Air pollution tolerance index was assessed with plant species located at five different locations in and around Tirupathi and kadapa, A.P. India.

Keywords: APTI, air pollution tolerance index, ornamental plants

Introduction

Rapid urbanization and industrial development increase air pollution especially in major developing countries. Urban industrialization has now become place of increased emission of air pollutants into atmosphere. These pollutants are harmful to the human beings; therefore, reducing the air pollutants in the environment is major issue of environmental concern at international, national and local level.

With urban transport development, traffic derived pollutants become an increasing problem and have been linked to respiratory and cardiovascular disease, birth and developmental defects, cancer and so on. The vehicular pollution is considered to be the worst as harmful emissions are discharged at the near-ground point polluting the air we breathe in (Abida and Harikrishna, 2010; Harish, 2012) [2, 17].

Most of the urban areas of the world today have high concentration of air pollutants emanating from different sources like motor vehicles, power plants, industrial setups, residential heating even indoor appliances and materials. These urban air pollutants not only pose a threat to the environment but also a matter of concern for human health. Among the air pollutants, air borne particulates including trace elements and volatile gases are serious concern and required to be monitored and regulated through every possible means. It is well documented that plants play an important role in monitoring the ecological balance and provide psychological push through mood lifting and enhanced alertness as plants differ markedly in their responses to pollutants, some being sensitive and others hardy and tolerant. The sensitivity and tolerance to the pollution in plants depends upon the various biochemical parameters like ascorbic acid content, chlorophyll, relative water content and pH. The response of plants towards air can be assessed by air pollutant tolerance index (APTI) which is being used by landscapers in selecting plant species for a particular area in order of their pollution tolerance. The sensitive species can be used as a bio-indicators of pollution (Rai, 2013) [34].

The air pollution tolerance index (APTI) plays a significant role to determine resistivity and susceptibility of plant species against pollution levels. Raising such tolerant species in polluted habitats will lead to rapid amelioration of habitat to cope up with polluted environment. Such plants are sown to be effectively used as indicators of pollutant scavengers (Joshi and Swami, 2007) [19].

Material and Methods

The present investigation was carried out during the year 2020-2021 at five different locations *viz*., College of Horticulture, Anantharajupeta (Control site, L_1), Mangampeta (Barytes mining area, L_2), Leela Mahal center to Alipiri area Tirupathi (city, main road heavy traffic and fly.

over constructing area including Muncipal park, Tirupati, L_3), Cherlopalle (Tirupati rural, brick kilns area, L_4), Gajulamandyam (Tirupati rural, plastic industrial estate, L_5).

Experimental sites

1. College of Horticulture, Anantharajupeta (control site L_1)

This is an educational institute which was selected as control site because this college area is covered with a huge number of ornamental trees, climbers, shrubs, herbs, palms, ornamental foliage plants and ground covers. Vehicular, anthropogenic activities, gaseous and air pollutants released in the environment from all sides is comparatively less and minimal at the institute.

2. Mangampeta (Barytes mining area and road traffic area L_2)

It is a massive mining area. The roads of this area bear a very heavy traffic load, including large trucks, loaded trucks, mini trucks, private buses, very high number of cars and public buses. Dust accumulation is more due to mining in this area. Lot of dust pollution occurred at core zone and buffer zone area at mining site along with increased levels of traffic pollution due to vehicle movement.

3. Leela Mahal center to Alipiri at Titupathi (city, main road heavy traffic and fly over constructing area including Muncipal Park, Tirupati, L_3)

Tirupati city - main road heavy traffic area experienced a highest level of urbanization wherein tourists flow from all over India round the year will be high with increased transportation and other activities in the region. Since, Tirupati is a gateway for all the activities, apart from the all types of vehicles, this has also experiencing high density of heavy vehicles like trucks especially for the different crop produce marketing throughout the year along with heavy crowd movement. The roads at the town area serve as a connecting link with important tourist areas.

4. Cherlopalle (Tirupati rural, brick kilns area, L_4)

The area is located near many brick manufacturing units exists and having high level of pollution.

5. Gajulamandyam (Tirupati rural, plastic industrial estate, L_5)

It has experienced a highest level of pollution from the plastic manufacturing units and industries in and around the location.

Plant material

Already growing, existing and commonly occurring multiple ornamental plants at five study sites were selected for investigation. In all five study sites, same ornamental plant species were selected uniformly and tagged randomly as per replication and details of plant species selected are given below.

Details of treatments [Ornamental plant (OP)]

S. No	Common name	Botanical name	Family	Plant type
1	Raintree	*Samanea saman*	Leguminosae	Ornamental tree
2	Neem	*Azadiracta indica*	Meliaceae	Ornamental tree
3	Scarlet Bell tree	*Spathodea companulata*	Bignoniaceae	Ornamental tree
4	Rosy trumpet tree	*Tabebuia rosea*	Bignoniaceae	Ornamental tree
5	Yellow gulmohar	*Peltophorum pterocarpum*	Leguminosae	ornamental Tree
6	Button wood	*Conocarpus erectus*	Combretaceae	Tree
7	Pipal tree	*Ficus religiosa*	Moraceae	Ornamental tree
8	Java Fig Tree	*Ficus benjamina*	Moraceae	Tree
9	Yellow oleander	*Thevetia peruviana*	Apocynaceae	Ornamental flowering shrub
10	Eastern white cedar	*Thuja occidentalis*	Cupressaceae	Ornamental tree /shrub
11	Moses in the cradle	*Rhoeo spathacea*	Commelinaceae	Ornamental foliage plant
12	Garden croton	*Codiaeum variegatum*	Euphorbiaceae	Ornamental foliage plant
13	Corn stalk dracaena	*Dracaena fragrans 'Victoria'*	Asparagaceae	Ornamental foliage plant
14	Desert rose	*Adenium obesum*	Apocynaceae	Ornamental succulent/shrub
15	Pedilanthus	*Pedilanthus tithymaloides*	Euphorbiaceae	Ornamental succulent
16	Areca palm/butterfly palm	*Areca lutescens*	Arecaceae	Ornamental Palm

Note: OP-Ornamental plant

Experiment details

In order to conduct the present study, a preliminary survey of all the five locations was done repeatedly to select commonly occurring ornamental plant species in all five study sites. Three plants were selected in each treatment (ornamental plant) at random and labeled properly for recording observations. The study was conducted during two season's *viz*., pre-monsoon and post- monsoon 2020-2021.

Collection of experimental data

To assess the impact of air, vehicular pollution and dust particles from road sides and from control site were collected from fully matured leaves during morning hours (Akilan and Nandhakumar, 2016) [4]. The leaf samples were collected in polythene covers and were carried to the laboratory for analysis in the ice box. Leaf samples were collected during two seasons *i.e.*, pre- Monsoon season and post-monsoon season (2020-2021) for the purpose of analysis. Leaves facing the roadside were plucked mainly on the same day at all the five locations during each season (Tsega and Deviprasad, 2014; Kaur and Nagpal, 2017) [43, 23]. The leaf samples were analyzed for various physiological and biochemical attributes by using standard procedures.

Total Chlorophyll content (mg g^{-1})

The Chlorophyll content was estimated by Arnon, 1949.

Relative water content (RWC, %)

Relative water content of the samples was estimated by using the method proposed by Singh (1977) [39]. After taking the fresh weight of leaves, the leaves were immersed in water over night, blotted dried and then weighted to get turgid weight. The leaves were dried overnight in oven at 70ºC and reweighed to obtain dry weight. Relative water content was computed by using following equation.

$$RWC = \frac{FW-DW}{TW-DW} \times 100$$

Where,

FW=Fresh weight
DW=Dry weight
TW=Turgid weight

Ascorbic acid (mg g^{-1})

Ascorbic acid was estimated by using the methodology of Ranganna (1977) [36] expressed as mg g^{-1}.

Leaf pH

The leaf pH was determined according to protocol of Prasad and Rao (1982) [33]. Leaf samples (0.5g) were homogenized using 50 mL of distilled water and the mixture was filtered, and pH was measured using a digital pH meter.

Air Pollution Tolerance Index (APTI)

The air pollution tolerance index (APTI) was estimated by considering four biochemical parameters *viz*., ascorbic acid, total chlorophyll, leaf extract pH and relative water content and was computed by using the following equation given by Kaur and Nagpal, 2017 [23].

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

Where, A- ascorbic acid (mg g^{-1} FW)
T- total chlorophyll (mg g^{-1} FW)
P- leaf extract pH
R- relative water content (%) of the leaves

Statistical analysis

Seasonal variation of different physiological, biochemical parameters, pattern and their significance level were computed using three-factorial RBD with ornamental plants, different locations and seasons as three factors for analysis. The significance of the analyzed data was tabled at 5 per cent level of significance.

Results and Discussion

Total chlorophyll content (mg g^{-1})

The data pertaining to total chlorophyll content is presented in (table1) was influenced by different landscape ornamental plants, polluted locations, seasons and their interaction during the two seasons (pre-monsoon and post – monsoon).

The present study during 2020-2021, revealed that among ornamentals (OP) total chlorophyll content was found highest with OP_1(3.09 mg g^{-1}). Whereas among the seasons (pre-monsoon and post – monsoon) it was found non-significant. Among different locations L_1 (2.70 mg g^{-1}) was found to be significantly highest. In interaction of ornamentals and seasons studies (OPXS), the total chlorophyll content was recorded significantly highest in OP_1S_1 (3.65 mg g^{-1}), while the lowest was recorded in OP_8S_2 (1.65 mg g^{-1}). Whereas in the interactions of ornamentals and locations studied total chlorophyll content was highest in OP_1L_1 (3.68 mg g^{-1}), which stood at par with OP_9L_1 (3.67 mg g^{-1}), OP_2L_1 (3.56 mg g^{-1})., while the lowest was recorded in OP_5L_2, OP_8L_5(1.46 mg g^{-1}).

In the interactions of ornamentals x seasons x locations (OP X S X L) the total chlorophyll content was found to be highest in $OP_1S_1L_1$ (5.12 mg g^{-1}) which was comparable with $OP_9S_1L_1$ (5.11 mg g^{-1}), followed by $OP_2S_1L_1$ (3.91 mg g^{-1}), while the lowest was recorded in $OP_8S_1L_5$ (1.05 mg g^{-1}).

The results obtained showed that among ornamental plants, *Samanea saman* (OP_1) at control site (L_1-College of Horticulture, Anantharajupeta) recorded highest total chlorophyll content. Whereas, reduction in the total chlorophyll content was observed at L_2, L_3, L_4 and L_5. The air pollutants have an impact on the total chlorophyll content. Apart from that in the current study, a decrease in the amount of total chlorophyll was seen in plants growing in polluted areas. The decrease in chlorophyll content might be due to gaseous contaminants in the surrounding air oxidising the pigment. Chlorophyll degrades when large levels of sulphur dioxide from the surrounding air enter the stomata. This degradation may be brought by the replacement of Mg^{2+} with two hydrogen atoms and the conversion of the chlorophyll molecule into phaeophytin (Rao and Le Blanc, 1966) [37]. Chlorophyll content can either increase or decrease depending on the level of pollution in the area; for example, roadside plants with higher levels of traffic pollution will have lower chlorophyll content. Moreover, the plant's sensitivity makes it more vulnerable to the pollutants found in vehicular exhaust, which can destroy chlorophyll (Jyothi and Jaya, 2010) [20]. The research conducted by Tripathi and Gautam (2007) [42], Joshi *et al.* (2009) [18], Jyothi and Jaya (2010) [20], furnish support for the decrease in the total chlorophyll content in plants growing at polluted areas. Giri *et al.* (2013) [15]. Under conditions of water stress, reactive oxygen species (ROS) develop in the chloroplast, which results in a decrease in the amount of chlorophyll (Prajapati and Tripathi, 2008) [32].

Relative water content (RWC, %)

An inquisition of data regarding to the trait Relative water content (RWC) is presented in table 2, revealed that during the year 2020-2021, among the ornamental plants (OP) studied, RWC varied significantly. OP_5 (77.06%) showed highest RWC which stood at par with OP_3 (73.15%), OP_4 (76.88%), OP_7 (74.35%), OP_8 (73.37%), OP_{11} (76.35%), OP_{12} (74.07%), OP_{13} (75.30%), while the plant OP_9 had least RWC (59.28%). The variation in RWC among different seasons, it was found that post monsoon season S_2 (72.10%) has recorded the highest RWC. In the locations studied, it was found non-significant. The response of ornamental plants X seasons (OPXS), the highest RWC was recorded in OP_5S_2 (77.69%) which was at par with OP_4S_1(76.74%), OP_5S_1(76.42%), OP_6S_1(72.09%), OP_7S_1(77.63%), OP_8S_1(72.36%), OP_1S_1(75.06%), $OP_{12}S_1$(76.31%), $OP_{13}S_1$(74.03%), OP_3S_2(74.52%), OP_4S_2(77.03%), OP_6S_2(72.79%), OP_8S_2(74.38%), $OP_{10}S_2$(73.51%), $OP_{11}S_2$(77.64%) and $OP_{13}S_2$(76.56%) while the lowest was recorded in OP9S1(56.15%). It was found non-significant to RWC, for the interaction response of (OPXL). Whereas in the interactions of (OP×S×L), RWC was recorded highest in $OP_5L_1S_2$(85.03%) which was comparable with $OP_6S_2L_4$(84.80%), $OP_5S_2L_2$(84.48%), $OP_4S_1L_1$(75.27%), $OP_{11}S_1L_1$(75.10%), $OP_6S_1L_2$(73.61%), $OP_12S_1L_2$(75.41%), $OP_6S_1L_2$(79.36%), $OP_1S_1L_3$(73.11%), $OP_4S_1L_4$(73.22%), $OP_7S_1L_4$(72.58%), $OP_{13}S_1L_4$(75.86%), $OP_5S_1L_5$(80.29%) $OP_{11}S_1L_5$(78.66%), $OP_4S_2L_1$(78.92%), $OP_{12}S_2L_1$(74.48%), $OP_4S_2L_2$(79.94%), $OP_5S_1L_1$(73.63%), $OP_{12}S_1L_1$(75.53%), $OP_7S_1L_2$(83.43%), $OP_4S_1L_3$(80.17%), $OP_7S_1L_3$(84.10%),

$OP_{12}S_1L_2$(75.20%), $OP_5S_1L_4$(81.37%), $OP_{11}S_1L_4$(72.80%), $OP_3S_1L_5$(74.80%), $OP_8S_1L_5$(78.46%), $OP_3S_1L_5$(78.00%), $OP_7S_2L_1$(80.45%), $OP_7S_2L_1$(80.45%), $OP_{13}S_2L_1$(79.68%), $OP_5S_1L_2$(84.48%), $OP_7S_1L_1$(76.11%), $OP_3S_1L_2$(73.30%), $OP_{11}S_1L_2$(75.53%), $OP_5S_1L_3$(83.46%), $OP_8S_1L_3$(74.40%), $OP_{13}S_1L_3$(74.28%), $OP_5S_1L_4$(73.61%), $OP_{12}S_1L_4$(76.72%), $OP_4S_1L_5$(82.58%), $OP_{11}S_1L_5$(78.74%), $OP_{12}S_1L_5$(73.52%), $OP_8S_2L_1$(77.29%), $OP_3S_2L_2$(83.04%), $OP_8S_2L_2$(73.19%), $OP_{10}S_2L_2$(74.73%), $OP_{11}S_2L_2$(81.97%), $OP_{13}S_2L_2$(81.61%), $OP_4S_2L_3$(81.39%), $OP_{11}S_2L_3$(82.06%), $OP_{16}S_2L_3$(72.95%), $OP_5S_2L_4$(74.29%), $OP_{11}S_2L_4$(80.87%), $OP_4S_2L_5$(72.57%), $OP_7S_2L_5$(74.01%), $OP_{11}S_2L_5$(79.89%), $OP_{16}S_2L_2$(73.14%), $OP_8S_2L_3$(75.29%), $OP_{13}S_2L_3$(78.97%), $OP_2S_2L_4$(79.83%), $OP_6S_2L_4$(84.80%), $OP_{11}S_2L_4$(82.12%), $OP_5S_2L_5$(72.58%), $OP_8S_2L_5$(72.58%), $OP_{14}S_2L_5$(72.50%), $OP_2S_2L_3$(76.09%), $OP_{10}S_2L_3$(74.62%), $OP_{15}S_2L_3$(74.32%), $OP_3S_2L_4$(72.90%), $OP_8S_2L_4$(73.56%), $OP_{13}S_2L_4$(72.93%), $OP_6S_2L_5$(82.25%) and $OP_{10}S_2L_5$(73.89%), whereas the lowest RWC was observed in $OP_9S_1L_1$ (39.29%).

The results obtained shows that OP_5 (*Peltophorum pterocarpum*) has higher RWC during post monsoon season (S_2). However locations are found non-significant but their interactions have shown the significant difference. The interactions of all the polluted locations have shown the elevation in RWC. Our investigations are in consistent with (Mohammed kuddus *et al.* 2011) [28]. Water condition of leaves in plants is closely related to transpiration, respiration, and growth (Dhankar *et al.*, 2015). It allows for protoplasmic permeability in plants, and water content in plants under stress might increase their tolerance for environmental pollutants (Singh *et al.*, 1991; Jyoti and Jaya, 2010; Krishnaveni *et al.*, 2013) [40, 20, 24]. With an increase in the relative water content of plant species, it has been discovered that the species' capacities for drought resistance also increases. In situations of water scarcity, numerous physiological and biochemical systems are affected. Thus those plants with high relative water content under pollution stress may be regarded most tolerant species to pollution.

Ascorbic acid (mg g^{-1})

A significant variation was noticed in the leaf ascorbic acid content of ornamental plant species, locations and their interactions (table.3) showed that during the year 2020-2021, among the ornamental plants studied, OP_{15} (8.22 mg g^{-1}) has recorded highest ascorbic acid content which was on par with OP_{14} (8.18 mg g^{-1}) and OP_{16} (8.16 mg g^{-1}) while the lowest was recorded in OP_4 (5.90 mg g^{-1}). Whereas in seasons studied it was non-significant. Among locations, present study showed elevation in the concentration of ascorbic acid with respect to L_3 (7.19 mg g^{-1}) which stood at par with L_1 (7.09 mg g^{-1}). Among the interactions of (OPXS) it was observed that OP_{15} S_2(8.63 mg g^{-1}) has recorded highest ascorbic acid content which was on par with $OP_{14}S_1$(8.42 mg g^{-1}), $OP_{16}S_1$(8.32 mg g^{-1}), while the lowest was recorded in OP_4S_1(5.72 mg g^{-1}) which was at par with OP_2S_1(6.05 mg g^{-1}), $OP_{10}S_1$(6.05 mg g^{-1}), OP_4S_2(6.07 mg g^{-1}), OP_5S_2(5.86 mg g^{-1}). While in the interaction response of (OPXL) highest ascorbic acid content was noticed in $OP_{15}L_5$(8.53 mg g^{-1}) which was comparable with $OP_{13}L_1$(8.02 mg g^{-1}),$OP_{14}L_1$(8.23 mg g^{-1}), $OP_{15}L_1$(8.17 mg g^{-1}), $OP_{16}L_1$(8.23 mg g^{-1}), $OP_{14}L_2$(8.39 mg g^{-1}), $OP_{15}L_2$(8.12 mg g^{-1}), $OP_{16}L_2$(8.15 mg g^{-1}), $OP_{14}L_3$(8.16 mg g^{-1}), $OP_{14}L_3$(8.12 mg g^{-1}), $OP_{16}L_3$(8.27 mg g^{-1}), $OP_{12}L_4$(8.19 mg g^{-1}),$OP_{13}L_4$(8.13 mg g^{-1}), $OP_{14}L_4$(8.05 mg g^{-1}), $OP_{15}L_4$(8.19 mg g^{-1}), $OP_{16}L_4$(8.11 mg g^{-1}), $OP_{13}L_5$(8.10 mg g^{-1}), $OP_{14}L_5$(8.05 mg g^{-1}), $OP_{16}L_5$(8.06 mg g^{-1}), while the lowest was recorded in OP_4L_2(5.50 mg g^{-1}).Among the interactions of (OPXSXL) it was found that the highest ascorbic acid content was recorded in $OP_7S_2L_1$(9.31mg g^{-1}) which stood at par with $OP_{15}S_2L_5$(8.71 mg g^{-1}), $OP_{15}S_2L_3$(8.62 mg g^{-1}), $OP_7S_2L_3$(8.99 mg g^{-1}), $OP_{15}S_2L_3$(8.55 mg g^{-1}), $OP_{15}S_2L_2$(8.64 mg g^{-1}), $OP_{15}S_2L_1$(8.61 mg g^{-1}), $OP_{14}S_1L_4$(8.52 mg g^{-1}), $OP_{16}S_1L_3$(8.54 mg g^{-1}), $OP_8S_1L_1$(8.77 mg g^{-1}), $OP_{13}S_1L_1$(8.87 mg g^{-1}) and $OP_{16}S_1L_1$(8.53 mg g^{-1}) while the lowest was recorded in $OP_7L_2S_1$(4.57 mg g^{-1}).

The present investigation revealed that OP_7 (*Ficus religiosa*) has the highest ascorbic acid content during the post monsoon season (S_2). Among the locations L_3, which is one of the polluted areas has recorded the highest ascorbic acid content. Our findings for ascorbic acid content are consistent with Jyothi and Jaya (2010) [20], Palit *et al.* (2013) [30], and Sanghi *et al.* (2015) [38]. By scavenging harmful free radicals and reactive oxygen species, the potent antioxidant ascorbic acid supports plant cell proliferation and membrane stability under stressful conditions. As SO_2 is photooxidized to SO_3, reactive oxygen species are created (Halliwell & Gutteridge, 1989) [16]. It can shield plant tissues from the harmful effects of air pollution, which has a significant impact on plant tolerance by scavenging ROS (Kuddus *et al.*, 2011; Gill and Tuteja, 2010) [25, 14]. Heat stress, high humidity, high temperature are some of the factors that might help plants have high ascorbic acid contents (Bhattacharya *et al.*, 2013) [7].

Leaf pH

The data corresponding to leaf pH responded significantly among plants, seasons and locations. The table.4, showed that among the ornamental plants studied regarding leaf pH during the year 2020-2021, highest pH content was recorded significantly in OP_6(7.77) while the lowest pH content was recorded in OP_{13}(5.34). In the seasons post-monsoon S_2 (6.31) has recorded highest pH content when compared to Pre-monsoon (S_1). While in the locations L_3 (6.37) has recorded maximum pH content which was on par with L_4 (6.29). Among the interactions of OPXS, highest pH content was recorded in OP_6S_2 (8.32) while the significant lowest pH content was recorded in $OP_{13}S_1$ (4.81). Whereas in the interaction response of OPXL highest pH content was recorded in OP_6L_4 (9.01) while the lowest pH content was recorded in OP_{15} L_1 (4.82). While in the interaction response of OPXSXL, highest pH content was recorded in $OP_6S_1L_4$ (9.66) and the lowest pH content was recorded in $OP_{13}S_1L_4$ (4.29).

Leaf extract pH is the pH of the concentrates extracted from the leaves of the plant. It was observed that among ornamental plants investigated for pH, *Conocarpus erectus* (OP_6) and all the polluted sites had the highest pH when compared to the control. Our results are similar with findings of (Bakiyaraj and Ayyappan, 2014; Bora and Joshi, 2014) [5, 8]. Plant sensitivity to pollution can be significantly influenced by pH. (Das and Prasad, 2010) [9]. Acidic pH in cell sap results from cell sap being converted into acid radicals when plants are exposed to gaseous air pollutants (NO_2, CO_2, and SO_2) (Kaiser *et al.*, 1993; Swami *et al.*, 2004; Das and Prasad, 2010) [21, 9]. Hexose sugar conversion to ascorbic acid is less in acidic pH (Escobedo *et al.*, 2008; Jyothi and Jaya, 2010) [12, 20] whereas more in alkaline pH which provide tolerance to plants against air pollution (Bakiyaraj and Ayyappan, 2014; Bora and Joshi, 2014) [5, 8].

APTI (Air pollution tolerance index)

The data pertaining to APTI (Air pollution tolerance index) was furnished in table 5. It showed that during the year 2020-2021, significant highest APTI was recorded in OP_2(15.00), while the lowest in OP_{15}(12.23) among ornamental plants. Whereas in the seasons studied, highest APTI was observed during post- monsoon season S_2 (13.53). Among the locations studied, maximum significant APTI was recorded in L_5(14.31), while the lowest was recorded in L_1(12.46). Among the interactions of OPXS, maximum APTI was recorded in OP_2S_2 (15.13), which stood at par with OP_1S_1 (14.45), OP_2S_1 (15.12), while the lowest was recorded in $OP_{15}S_1$ (12.08). Among the interactions of OPXL, highest APTI was recorded in OP_2L_4 (16.61), which was on par with OP_2L_5 (15.76), OP_7L_5 (15.67), while the lowest was recorded in $OP_{15}L_1$ (11.24). Among the interactions of OPXSXL, maximum APTI was recorded in $OP_2S_2L_3$ (16.99), which was at par with $OP_2S_1L_4$ (16.87), $OP_2S_1L_5$ (16.78), $OP_7S_1L_5$ (16.32) and $OP_2S_2L_4$ (16.35), while the lowest was recorded in $OP_{15}S_1L_1$ (10.40).

Air pollution tolerance index is one of the widely used indices which provide information about the tolerant plant species that can be planted at the roadsides or used for green belt development to mitigate air pollution up to certain level (Singh *et al.*, 1991; Kuddus *et al.*, 2011; Rai and Panda, 2015) [40, 25, 35]. APTI score was calculated for plant species as per suggestions by Kalyani and Singaracharya (1995) [22] and Lakshmi *et al.* (2009) [26], and plants were grouped into sensitive, intermediate and tolerant types. APTI included determination of pH, relative water content, total chlorophyll and ascorbic acid content of leaf samples of plants. In the present study, APTI was calculated by considering different parameters and it ranged from (15.00) to (12.23). Among all the leaf samples, *Azadirachta indica* plant samples showed highest APTI (15.00) while *Pedilanthus tithymeloides* samples showed lowest (12.23). High tolerance level of different roadside plants was also observed in earlier studies by Ogunkunle *et al.* (2015) [29] in *Vitellaria paradoxa*, *Terminalia catappa*, *Acacia nilotica* and *Prosopis africana* collected from University of Ilorin, Nigeria; Pandey *et al.* (2015) in *Ficus benghalensis*, *Cassia fistula*, *F. religiosa*, and *Polyalthia longifolia* sampled from urban areas of Varanasi city, India; Bhattacharya *et al.* (2013) [7] in *P. longifolia*, *Azadirachta indica* and *Mangifera indica* collected from urban sites of Vadodara, city of Gujarat, India; Aarti *et al.* (2012) [1] in *Calotropis gigantea, Dalbergia sissoo, Euginia jambolana, Mangifera indica* collected from Pithampur urban area, Madhya Pradesh, India; Agbaire and Esiefarienrhe (2009) [3] in *Emilia santifolia*, *Manihot esculenta* and *Elaeis guineensis* sampled from Delta State, Nigeria. The plants which exhibited high APTI are tolerant to air pollution, can act as bio-mitigators while low APTI in plants indicate their sensitivity towards pollution and can be utilized as bio-indicators of air pollution (Madan and Chauhan, 2015) [27].

Table 1: Response of ornamental plants (OP), Seasons (S), Locations (L) and their interaction to various pollutants with respect to total

Ornamentalplants (OP)	Pre-monsoon(S_1)					OPXS	Post-monsoon(S_2)					OPXS	Over all mean					OPXL
	L1	L2	L3	L4	L5	Mean	L1	L2	L3	L4	L5	Mean	L1	L2	L3	L4	L5	Mean
OP1	5.12	3.53	3.57	3.14	2.91	3.65	2.23	2.66	2.56	2.83	2.35	2.53	3.68	3.10	3.06	2.98	2.63	3.09
OP2	3.91	1.48	2.10	2.88	2.39	2.55	3.21	2.42	3.14	3.53	2.47	2.95	3.56	1.95	2.62	3.21	2.43	2.75
OP3	2.34	1.85	2.12	1.42	2.87	2.12	3.29	1.64	1.95	1.65	2.40	2.19	2.81	1.75	2.04	1.53	2.64	2.15
OP4	2.35	2.25	2.82	2.14	2.92	2.50	3.29	2.84	2.28	2.73	2.30	2.69	2.82	2.55	2.55	2.44	2.61	2.59
OP5	2.48	1.17	1.28	1.48	2.07	1.70	1.75	1.75	2.73	2.92	2.63	2.36	2.12	1.46	2.01	2.20	2.35	2.03
OP6	2.43	2.05	2.44	2.16	2.28	2.27	3.61	3.41	2.33	1.49	1.56	2.48	3.02	2.73	2.39	1.83	1.92	2.38
OP7	1.26	1.71	2.16	2.41	2.75	2.06	2.66	3.02	2.12	2.17	2.70	2.53	1.96	2.37	2.14	2.29	2.72	2.30
OP8	2.66	2.90	1.92	2.13	1.05	2.13	1.48	1.56	2.24	1.09	1.87	1.65	2.07	2.23	2.08	1.61	1.46	1.89
OP9	5.11	3.52	2.44	3.15	2.93	3.43	2.23	2.64	2.52	2.80	2.41	2.52	3.67	3.08	2.48	2.98	2.67	2.98
OP10	3.88	1.13	2.12	2.79	2.34	2.45	2.99	2.43	3.21	3.49	2.47	2.92	3.44	1.78	2.67	3.14	2.41	2.69
OP11	2.40	1.69	2.23	1.51	2.59	2.08	3.28	1.61	1.68	1.69	2.41	2.13	2.84	1.65	1.95	1.60	2.50	2.11
OP12	2.42	2.25	2.30	2.27	2.64	2.37	2.76	2.45	2.11	2.15	1.92	2.28	2.59	2.35	2.21	2.21	2.28	2.33
OP13	2.36	2.36	1.88	1.80	1.82	2.04	2.02	2.26	2.17	2.32	2.50	2.25	2.19	2.31	2.02	2.06	2.16	2.15
OP14	2.37	2.44	2.52	2.20	2.26	2.36	1.94	2.37	2.29	2.24	1.96	2.16	2.16	2.41	2.40	2.22	2.11	2.26
OP15	1.99	1.95	1.61	2.16	2.37	2.01	2.33	2.52	2.28	2.44	2.31	2.38	2.16	2.23	1.95	2.30	2.34	2.20
OP16	2.21	2.23	2.34	2.34	2.23	2.27	2.11	2.05	2.15	2.17	2.27	2.15	2.16	2.14	2.25	2.26	2.25	2.21
Mean (SXL)	2.83	2.16	2.24	2.25	2.40	2.38	2.57	2.35	2.36	2.36	2.28	2.38	2.70	2.26	2.30	2.30	2.34	2.38
Comparing means of	OP	S	OPxS	L	OPxL	SxL	OPxSxL											
SE(m)	0.041	0.015	0.058	0.023	0.092	0.033	0.13											
CD [P=0.05]	0.115	N/A	0.162	0.064	0.256	0.091	0.362											

Chlorophyll content (mg g^{-1}) during (2020 -2021).

Note: OP-Ornamental plant, S –Season, L- Location

Table 2: Response of ornamental plants (OP), Seasons (S), Locations (L) and their interaction to various pollutants with respect to RWC content (%) during (2020 -2021)

Ornamentalplants (OP)	Pre-monsoon(S_1)				OPXS		Post-monsoon(S_2)					OPXS	Over all mean					OPXL
	L1	L2	L3	L4	L5	Mean	L1	L2	L3	L4	L5	Mean	L1	L2	L3	L4	L5	Mean
OP1	56.97	60.91	58.49	58.19	68.33	60.58	59.25	67.46	63.99	63.35	59.67	62.74	58.11	64.18	61.24	60.77	64.00	61.66
OP2	66.43	65.18	63.78	56.98	53.55	61.18	59.99	72.41	63.20	79.83	72.24	69.53	63.21	68.80	63.49	68.40	62.90	65.36
OP3	72.20	73.30	69.13	69.48	74.80	71.78	70.58	83.04	76.09	72.90	70.02	74.52	71.39	78.17	72.61	71.19	72.41	73.15
OP4	75.27	72.46	80.17	73.22	82.58	76.74	78.92	79.94	81.39	72.31	72.57	77.03	77.10	76.20	80.78	72.77	77.58	76.88
OP5	73.63	63.33	83.46	81.37	80.29	76.42	85.03	84.48	72.09	74.29	72.58	77.69	79.33	73.90	77.78	77.83	76.44	77.06
OP6	66.31	73.61	79.36	73.61	67.58	72.09	69.37	62.46	65.07	84.80	82.25	72.79	67.84	68.04	72.21	79.21	74.92	72.44
OP7	76.11	83.43	84.10	72.58	71.93	77.63	80.45	64.46	68.62	67.82	74.01	71.07	78.28	73.95	76.36	70.20	72.97	74.35
OP8	68.27	71.98	74.40	68.69	78.46	72.36	77.29	73.19	75.29	73.56	72.58	74.38	72.78	72.59	74.85	71.13	75.52	73.37

OP9	39.29	59.72	58.40	65.52	57.81	56.15	58.73	65.95	63.60	62.93	60.83	62.41	49.01	62.83	61.00	64.23	59.32	59.28
OP10	63.55	65.15	64.29	66.35	65.14	64.90	63.46	74.73	74.62	80.87	73.89	73.51	63.51	69.94	69.46	73.61	69.52	69.21
OP11	75.10	75.53	73.11	72.80	78.74	75.06	62.18	81.97	82.06	82.12	79.89	77.64	68.64	78.75	77.59	77.46	79.31	76.35
OP12	75.53	75.41	75.20	76.72	78.66	76.31	74.48	71.74	71.69	71.00	70.26	71.84	75.01	73.58	73.44	73.86	74.46	74.07
OP13	70.83	71.19	74.28	75.86	78.00	74.03	79.68	81.61	78.97	72.93	69.61	76.56	75.26	76.40	76.63	74.39	73.80	75.30
OP14	67.77	68.58	67.37	70.24	66.95	68.18	68.36	69.60	70.33	69.62	72.50	70.08	68.07	69.09	68.85	69.93	69.73	69.13
OP15	72.20	71.46	69.87	66.94	73.52	70.80	70.26	68.75	74.32	68.58	69.14	70.21	71.23	70.11	72.10	67.76	71.33	70.50
OP16	70.16	72.46	67.11	71.90	72.42	70.81	70.06	73.14	72.95	72.13	69.78	71.61	70.11	72.80	70.03	72.02	71.10	71.21
Mean (SXL)	68.10	70.23	71.41	70.03	71.80	70.31	70.50	73.43	72.14	73.07	71.36	72.10	69.30	71.83	71.78	71.55	71.58	71.21
Comparing means of	OP	S	OPxS	L	OPxL	SxL	OPxSxL											
SE(m)	1.424	0.504	2.014	0.796	3.185	1.126	4.504											
CD [*P*=0.05]	3.963	1.401	5.604	N/S	N/s	N/s	12.532											

Note: OP-Ornamental plant, S –Season, L- Location

Table 3: Response of ornamental plants (OP), Seasons (S), Locations (L) and their interaction to various pollutants with respect to Ascorbic acid content (mg g^{-1}) during (2020 -2021).

Ornamental pants (OP)	**Pre-monsoon**					**OPXS**	**Post-monsoon**					**OPXS**	**Over all mean**					**AXC**
	L1	L2	L3	L4	L5	Mean	L1	L2	L3	L4	L5	Mean	L1	L2	L3	L4	L5	Mean
OP1	6.48	7.42	7.07	6.69	7.13	6.96	7.37	7.08	6.40	6.45	6.30	6.72	6.93	7.25	6.74	6.57	6.72	6.84
OP2	6.04	6.72	6.56	5.22	5.69	6.05	6.54	8.00	7.06	7.64	6.66	7.18	6.29	7.36	6.81	6.43	6.18	6.61
OP3	6.63	6.43	6.78	5.06	6.17	6.22	6.65	6.26	6.96	6.73	6.16	6.55	6.64	6.35	6.87	5.90	6.17	6.38
OP4	6.22	5.38	5.73	5.08	6.20	5.72	5.78	5.62	6.17	6.24	6.55	6.07	6.00	5.50	5.95	5.66	6.38	5.90
OP5	6.82	6.45	5.76	6.44	6.22	6.34	5.28	5.56	5.49	6.23	6.72	5.86	6.05	6.01	5.63	6.34	6.47	6.10
OP6	6.90	5.92	7.40	6.57	6.96	6.75	7.50	7.27	7.47	6.49	5.71	6.89	7.20	6.59	7.43	6.53	6.33	6.82
OP7	6.56	4.57	5.97	6.55	8.43	6.42	9.31	7.75	8.99	6.77	6.14	7.79	7.93	6.16	7.48	6.66	7.29	7.10
OP8	8.77	8.78	8.20	7.19	7.08	8.00	6.43	6.09	6.14	6.11	5.82	6.12	7.60	7.44	7.17	6.65	6.45	7.06
OP9	6.49	7.42	7.31	6.55	7.20	6.99	7.41	7.27	6.43	6.40	6.34	6.77	6.95	7.34	6.87	6.48	6.77	6.88
OP10	6.21	6.74	6.52	5.27	5.53	6.05	5.43	7.91	7.27	6.15	6.20	6.59	5.82	7.33	6.89	5.71	5.86	6.32
OP11	6.17	5.90	7.64	5.64	6.10	6.29	6.36	6.16	7.13	6.71	5.52	6.38	6.26	6.03	7.39	6.18	5.81	6.33
OP12	6.45	5.19	8.22	8.33	8.19	7.28	7.79	7.96	7.15	8.05	7.24	7.64	7.12	6.58	7.69	8.19	7.71	7.46
OP13	8.87	7.26	7.78	7.91	7.83	7.93	7.16	7.47	7.37	8.35	8.37	7.74	8.02	7.37	7.58	8.13	8.10	7.84
OP14	8.36	8.38	8.46	8.52	8.37	8.42	8.10	8.40	7.86	7.58	7.72	7.93	8.23	8.39	8.16	8.05	8.05	8.18
OP15	7.72	7.59	7.68	7.75	8.34	7.82	8.61	8.64	8.55	8.62	8.71	8.63	8.17	8.12	8.12	8.19	8.53	8.22
OP16	8.53	8.48	8.54	8.12	7.94	8.32	7.93	7.81	8.01	8.09	8.17	8.00	8.23	8.15	8.27	8.11	8.06	8.16
Mean (SXL)	7.08	6.79	7.23	6.68	7.09	6.97	7.10	7.20	7.15	7.04	6.77	7.05	7.09	7.00	7.19	6.86	6.93	7.01
Comparing means of	OP	S	OPxS	L	OPxL	SxL	OPxSxL											
SE(m)	0.092	0.033	0.3	0.051	0.206	0.073	0.291											
CD [*P*=0.05]	0.256	N/S	0.362	0.143	0.573	0.203	0.81											

Note: OP-Ornamental plant, S –Season, L- Location

Table 4: Response of ornamental plants (OP), Seasons (S), Locations (L) and their interaction to various pollutants with respect to Leaf pH content during (2020 -2021).

Ornamental pants (OP)	**Pre-monsoon(S_1)**					**OPXS**	**Post-monsoon(S_1)**					**OPXS**	**over all mean**					**OPXL**
	L1	L2	L3	L4	L5	Mean	L1	L2	L3	L4	L5	Mean	L1	L2	L3	L4	L5	Mean
OP1	5.41	5.64	5.30	4.52	5.82	5.34	5.59	5.17	5.74	6.28	5.73	5.70	5.50	5.41	5.52	5.40	5.77	5.52
OP2	4.56	6.89	5.60	6.45	6.41	5.98	6.84	5.62	7.59	7.81	6.78	6.93	5.70	6.25	6.59	7.13	6.60	6.45
OP3	6.88	6.57	8.39	7.88	7.37	7.42	7.38	7.46	7.40	7.16	6.41	7.16	7.13	7.02	7.89	7.52	6.89	7.29
OP4	5.74	7.39	5.55	5.46	5.58	5.94	6.35	5.27	5.19	4.74	6.37	5.59	6.05	6.33	5.37	5.10	5.97	5.77
OP5	5.80	5.28	5.54	4.61	4.44	5.13	5.62	5.82	5.66	6.60	8.46	6.43	5.71	5.55	5.60	5.61	6.45	5.78
OP6	5.37	7.63	6.54	9.66	6.91	7.22	8.87	8.58	5.89	8.36	9.88	8.32	7.12	8.10	6.22	9.01	8.40	7.77
OP7	5.35	5.76	6.81	7.61	5.80	6.27	5.54	5.76	5.53	5.73	5.79	5.67	5.45	5.76	6.17	6.67	5.80	5.97
OP8	5.85	6.53	6.35	6.43	6.19	6.27	6.74	6.67	5.92	5.47	5.68	6.10	6.29	6.60	6.14	5.95	5.94	6.18
OP9	6.60	6.78	6.36	5.93	6.89	6.51	6.62	6.39	6.80	7.28	6.79	6.78	6.61	6.58	6.58	6.61	6.84	6.64
OP10	5.72	7.18	6.73	7.56	7.43	6.93	7.77	4.97	6.64	6.86	5.78	6.40	6.75	6.08	6.69	7.21	6.61	6.66
OP11	6.09	5.86	7.37	6.81	6.55	6.53	6.73	6.39	7.05	6.41	6.06	6.53	6.41	6.13	7.21	6.61	6.31	6.53
OP12	5.25	6.56	5.32	5.12	4.76	5.40	5.51	5.35	4.46	5.83	5.40	5.31	5.38	5.95	4.89	5.48	5.08	5.36
OP13	4.71	5.15	5.44	4.29	4.45	4.81	5.36	5.39	5.77	7.38	5.51	5.88	5.03	5.27	5.61	5.84	4.98	5.34
OP14	6.28	5.38	6.11	5.81	7.42	6.20	7.56	7.21	5.34	7.37	8.36	7.17	6.92	6.29	5.73	6.59	7.89	6.68
OP15	4.34	5.76	6.36	5.38	5.40	5.45	5.49	5.29	5.44	5.43	5.27	5.38	4.82	5.60	5.89	5.33	5.33	5.38
OP16	5.59	5.39	5.22	6.31	6.23	5.75	5.57	6.27	5.34	5.57	5.52	5.66	5.58	5.83	5.28	5.94	5.88	5.70
Mean (SXL)	5.60	6.23	6.19	6.24	6.15	6.07	6.47	6.10	5.99	6.52	6.49	6.31	6.03	6.17	6.09	6.37	6.29	6.19
Comparing means of	OP	S	OPxS	L	OPxL	SxL	OPxSxL											
SE(m)	0.043	0.015	0.061	0.024	0.096	0.034	0.36											
CD [*P*=0.05]	0.12	0.042	0.7	0.067	0.268	0.095	0.379											

Note: OP-Ornamental plant, S –Season, L- Location

Table 5: Response of ornamental plants (OP), Seasons (S), Locations (L) and their interaction to various pollutants with respect to APTI content during (2020 -2021).

Ornamental plants (OP)	Pre-monsoon(S_1)					OPXS	Post-monsoon (S_2)					OPXS	OVER ALL MEAN					OPXL
	L1	L2	L3	L4	L5	Mean	L1	L2	L3	L4	L5	Mean	L1	L2	L3	L4	L5	Mean
OP1	11.30	13.96	14.77	14.78	14.30	14.45	12.50	12.86	14.91	14.83	14.50	13.92	13.63	13.41	14.84	14.80	14.40	14.22
OP2	12.24	12.98	13.86	16.87	16.78	15.12	13.25	14.32	16.99	16.35	14.73	15.13	13.56	13.65	15.43	16.61	15.76	15.00
OP3	11.64	14.06	14.64	13.50	14.32	14.13	12.95	13.45	13.47	13.48	14.79	13.63	13.80	13.75	14.06	13.49	14.55	13.93
OP4	11.32	12.27	11.93	13.62	14.79	13.15	13.30	14.61	13.62	13.58	15.07	14.03	12.61	13.44	12.77	13.60	14.93	13.47
OP5	11.84	12.03	12.11	12.92	11.91	12.24	12.83	12.65	13.23	12.79	15.03	13.30	12.47	12.34	12.67	12.86	13.47	12.76
OP6	11.89	12.74	12.56	12.88	12.61	12.70	12.91	13.09	13.08	12.69	14.82	13.32	12.74	12.91	12.82	12.78	13.72	12.99
OP7	11.29	13.01	13.14	14.99	16.32	14.36	12.88	13.26	14.62	13.02	15.01	13.76	13.01	13.13	13.88	14.01	15.67	13.94
OP8	11.12	12.80	12.72	13.18	14.18	13.22	12.40	12.92	13.17	13.16	15.19	13.37	12.56	12.86	12.94	13.17	14.69	13.24
OP9	12.11	12.29	12.30	14.90	14.89	13.59	12.70	12.87	14.36	15.43	14.20	13.91	12.50	12.58	13.33	15.17	14.54	13.62
OP10	11.73	12.53	12.25	13.53	14.14	13.11	11.30	14.32	13.68	13.62	15.38	13.66	11.78	13.43	12.97	13.57	14.76	13.30
OP11	10.90	11.30	11.80	14.90	13.97	12.99	12.31	12.38	14.93	14.90	14.74	13.85	12.05	11.84	13.36	14.90	14.36	13.30
OP12	12.84	12.53	12.34	13.52	13.37	12.94	11.50	12.16	13.24	13.94	14.22	13.01	11.92	12.34	12.79	13.73	13.79	12.92
OP13	11.38	12.15	11.75	13.83	13.01	12.69	11.90	13.21	13.40	13.48	14.65	13.33	11.82	12.68	12.58	13.66	13.83	12.91
OP14	10.93	11.92	11.39	13.46	13.24	12.50	10.96	12.66	13.74	13.67	14.23	13.05	11.18	12.29	12.56	13.56	13.74	12.67
OP15	10.40	12.47	11.12	12.35	12.37	12.08	11.36	12.49	12.05	12.43	14.50	12.57	11.24	12.48	11.59	12.39	13.44	12.23
OP16	11.18	12.78	13.55	12.71	12.49	12.88	11.32	11.84	12.77	12.75	14.32	12.60	12.43	12.31	13.16	12.73	13.41	12.81
MEAN(SXL)	12.64	12.61	12.64	13.87	13.92	13.26	12.27	13.07	13.83	13.76	14.71	13.53	12.46	12.84	13.23	13.81	14.31	13.33
Comparing means of	OP	S	OPxS	L	OPxL	SxL	OPxSxL											
SE(m)	0.175	0.062	0.247	0.098	0.391	0.138	0.553											
CD [*P*=0.05]	0.486	0.172	0.688	0.146	1.087	0.384	1.538											

Note: OP-Ornamental plant, S –Season, L- Location

References

1. Aarti C, Sanjeeda I, Maheshwari RS, Bafna A. Study of air pollution tolerance index of plants growing in Pithampur Industrial area sector 1, 2 and 3. Research Journal of Recent Sciences. 2012;1:172-177.
2. Abida B, Harikrishna S. Evaluation of some tree species to absorb air pollutants in three industrial locations of South Bengaluru, India. E-Journal of Chemistry. 2010;7(S1):51-56.
3. Agbaire PO, Esiefarienrhe E. Air pollution tolerance indices (APTI) of some plants around Otorogun gas plant in Delta state, Nigeria. Journal of Applied Sciences and Environmental Management. 2009;13:11-14.
4. Akilan M, Nandhakumar S. Air pollution tolerance index of selected plants in industrial and urban areas of Vellore district. Agriculture Science Digest. 2016;36:66-68.
5. Bakiyaraj R, Ayyappan D. Air pollution tolerance index of some terrestrial plants around an industrial area. International Journal of Modern Research and Reviews. 2014;2(1):1-7.
6. Barnes JD, Balaguer L, Manrique E, Elvira S, Davison AW. A reappraisal of the use of DMSO for the extraction and determination of chlorophyll a and b in lichens and higher plants. Environment and Experimental Botany. 1992;32:85-100.
7. Bhattacharya T, Kriplani L, Chakraborty S. Seasonal variation in air pollution tolerance index of various plant species of Baroda city. Universal Journal of Environmental Research and Technology. 2013;3:199-208.
8. Bora M, Joshi M. A study on variation in biochemical aspects of different tree species with tolerance and performance index. Ecoscan. 2014;9:59-63.
9. Das S, Prasad P. Seasonal variation in air pollution tolerance indices and selection of plant species for industrial areas of Rourkela. Indian Journal of Environmental Protection. 2010;30:978-988.
10. Dedio W. Water relations in wheat leaves as screening test for drought resistance. Canadian Journal of Plant Sciences. 1975;55:369-378.
11. Dhankhar R, Mor V, Narwal S. Anticipated performance index of selected plant species in university campus area, Rohtak, Haryana, India. International Journal of Advanced Multidisciplinary Research. 2015;2(2):32-41.
12. Escobedo FJ, Wagner JE, Nowak DJ. Analyzing the cost effectiveness of Santiago, Chile's policy of using urban forest to improve air quality. Journal of Environmental Management. 2008;86:148-157.
13. Geravandia M, Farshadfara E, Kahrizi D. Evaluation of some physiological traits as indicators of drought tolerance in bread wheat genotypes. Russian Journal of Plant Physiology. 2011;58:69-75.
14. Gill SS, Tuteja N. Reactive oxygen species and antioxidant machinery in abiotic stress tolerance in crop plants. Plant Physiology and Biochemistry. 2010;48:909-930.
15. Giri S, Shrivastava D, Deshmukh K, Dubey P. Effect of air pollution on chlorophyll content of leaves. Current Agriculture Research Journal. 2013;1:93-98.
16. Halliwell B, Gutteridge JMC. Free radicals in medicine and biology, 2nd edn. Clarendon Press, Oxford, 1989.
17. Harish M. A study on air pollution by automobiles in Bangalore city. Management Research and Practice. 2012;4:25-36.
18. Joshi N, Chauhan A, Joshi PC. Impact of industrial air pollutants on some biochemical parameters and yield in wheat and mustard plants. Environmentalist. 2009;29:398-404.
19. Joshi PC, Swami A. Physiological responses of some tree species under roadside automobile pollution stress around city of Haridwar, India. Ibid: A Student History Journal. 2007;27:365-374.
20. Jyothi SJ, Jaya DS. Evaluation of air pollution tolerance index of selected plant species along roadsides in Thiruvananthapuram, Kerala. Journal of Environmental Biology. 2010;31:379-386.
21. Kaiser WM, Hofler M, Heber U. Can plants exposed to SO_2 excrete sulfuric acid through the roots? Physiologia

Plantarum. 1993;87:61-67.
22. Kalyani Y, Singaracharya MA. Biomonitoring of air pollution in Warangal city, Andhra Pradesh. Acta Botanica India. 1995;23:21-24.
23. Kaur M, Nagpal AK. Evaluation of air pollution tolerance index and anticipated performance index of plants and their application in development of green space along the urban areas. Environmental Science and Pollution Research. 2017;24:18881-18895.
24. Krishnaveni M, Madhaiyan P, Durairaj S, Chandrasekar R, Amsavalli L. Pollution induced changes in plants located at Chinnatirupathi, Salem, Tamil Nadu, India. International Journal of Pharmaceutical Sciences and Research. 2013;4:3192-3195.
25. Kuddus M, Kumari R, Ramteke PW. Studies on air pollution tolerance of selected plants in Allahabad city, India. E3 Journal of Environmental Research and Management. 2011;2:42-46.
26. Lakshmi PS, Sarvanti KL, Srinivas N. Air pollution tolerance index of various plants species growing in industrial areas. An International Biannual Journal of Environmental Sciences. 2009;2:203-206.
27. Madan S, Chauhan S. Air pollution tolerance index and anticipated performance index of selected plant species in Haridwar city, India. Report Opinion. 2015;7:32-37.
28. Mohammed Kuddus, Rashmi Kumari, Pramod W, Ramteke. Studies on air pollution tolerance of selected plants in Allahabad city, India, E3. Journal of Environmental Research and Management. 2011;2(3):042-046.
29. Ogunkunle CO, Suleiman LB, Oyedeji S, Awotoye OO, Fatoba PO. Assessing the air pollution tolerance index and anticipated performance index of some tree species for bio-monitoring environmental health. Agroforestry Systems. 2015;89:447-454.
30. Palit D, Kar D, Misra P, Banerjee A. Assessment of air quality using several bio monitor of selected sites of Duragapur, Burdwan district by air pollution tolerance index approach. Indiana Journal of Science and Research. 2013;4:149-152.
31. Pandey AK, Pandey M, Mishra A, Tiwary SS, Tripathi BD. Air pollution tolerance index and anticipated performance index of some plant species for development of urban forest. Urban for Urban Green. 2015;14:866-871.
32. Prajapati SK, Tripathi BD. Anticipated performance index of some tree species considered for green belt development in and around an urban area: A case study of Varanasi city, India. Journal of Environmental Management. 2008;88:1343-1349.
33. Prasad BJ, Rao DN. Relative sensitivity of a leguminous and a cereal crop to sulphur dioxide pollution. Environmental Pollution. 1982;29:57-70.
34. Rai PK. Environmental magnetic studies of particulates with special reference to biomagnetic monitoring using roadside plant leaves. Atmospheric Environment. 2013;72:113-129.
35. Rai PK, Panda LLS. Roadside plants as bio indicators of air pollution in an industrial region, Rourkela, India. International Journal of Advance Research and Technology. 2015;4:14-36.
36. Ranganna S. Hand book of analysis and quality control for fruit and vegetable products. Tata Mc. Graw Hill publishing Co. Ltd., New Delhi, 1977, 29-31.
37. Rao DN, Leblance F. Effect of sulphur dioxide on lichen alga with special reference to chloroplast. The Bryologist. 1966;69:69-72.
38. Sanghi SB, Sharma C, Sanghi SK. Comparison of APTI values of some medicinal plants of industrial areas and Ratapani wild life sanctuary in Raisen district of Madhya Pradesh. International Journal of Pharmaceutical and Life Science. 2015;6:4157-4160.
39. Singh A. Practical Plant Physiology, Kalyani Publishers, New Delhi. 1977.
40. Singh SK, Rao DN, Agrawal M, Pandey J, Narayan D. Air pollution tolerance index of plants. Journal of Environmental Management. 1991;32:45-55.
41. Swami A, Bhatt D, Joshi PC. Effects of automobile pollution on sal (Shorea robusta) and rohini (Mallotus phillipinensis) at Asarori, Dehradun. Himalayan Journal of Environmental Zoology. 2004;18:57-61.
42. Tripathi AK, Gautam M. Biochemical parameters of plants as indicators of air pollution. Journal of Environmental Biology. 2007;28:127-132.
43. Tsega YC, Prasad AGD. Variation in air pollution tolerance index and anticipated performance index of roadside plants in Mysore, India. Journal of Environmental Biology. 2014;35:185-190.