

## **Air Pollution Tolerance Index for Selected Species of Plants in Roadside Highways at Allahabad, Uttar Pradesh, India**

**Rahul Nishad<sup>1</sup>, Harsh Bodh Paliwal<sup>1</sup>, Makhan Singh Karada<sup>2\*</sup> and Dheer Agnihotri<sup>2</sup>**

<sup>1</sup>College of Forestry, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad- 211007, U.P., India.

<sup>2</sup>Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi-221005, India.

### **Authors' contributions**

*This work was carried out in collaboration among all authors. Author RN designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors HBP and MSK managed the analyses of the study. Author DA managed the literature searches. All authors read and approved the final manuscript.*

### **Article Information**

DOI: 10.9734/IJECC/2020/v10i1230301

#### Editor(s):

(1) Dr. Gamal Abdel-Hafez Mahmoud Bekhet, King Faisal University, Saudi Arabia.

#### Reviewers:

(1) Kareem Ali Jasim, University of Baghdad, Iraq.

(2) Mohamed Sabry Amin El Morsy, Helwan University, Egypt.

(3) Juniastel Rajagukguk, Universitas Negeri Medan, Indonesia.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/63654>

**Original Research Article**

**Received 08 October 2020**

**Accepted 13 December 2020**

**Published 31 December 2020**

### **ABSTRACT**

In recent years air pollution is one of the biggest problems in the world. Owing to the transboundary dispersion of contaminants around the world, air pollution has its own peculiarities. In a much planned urban setup industrial pollution takes a backseat and cooler admission takes the president's as the major cause of urban air pollution in the present investigation your pollution torrents index was calculated for various plant species growing around the Allahabad Highway. Five plants available commonly in all locations were selected for the present research namely *Azadirachta indica* (Neem), *Delonix regia* (Gulmohar), *Saraca asoca* (Ashok), *Ficus benghalensis* (Bargad), *Ficus religiosa* (Pepal). Using normal procedures, ascorbic acid, leaf extract pH, overall chlorophyll, relative water content and air quality tolerance index were analysed. Both plants tested

\*Corresponding author: E-mail: [makhansinghkarada1408@gmail.com](mailto:makhansinghkarada1408@gmail.com);

in both areas have been shown to be pollution-sensitive, varying from 02.29 to 12.53. No pollution tolerant organisms studied were found. The maximum value of pH was 7.8 found in Neem tree spp. (*Azadirachta indica*) in Rewa Road (NH-35) and the minimum value of pH was 5.9 found in Gulmohar tree spp. (*Delonix regia*) in Varanasi Road (NH-19), The maximum value of RWC (89.99 %) found in Ashok tree spp. (*Saraca asoca*) and the minimum value of RWC (58.64 %) found in Neem tree spp. (*Azadirachta indica*) in Mirzapur Road site (NH-76). The maximum value of Total Chlorophyll Content was 1.55 mg/g found in Ashok tree spp. (*Saraca asoca*) in Mirzapur Road (NH-76) and the minimum value of Total Chlorophyll Content was 0.71 mg/g found in Bargad tree spp. (*Ficus benghalensis*) in Control Site and Rewa Road (NH-35). The maximum value of Ascorbic Acid (1.07 mg/g) found in Ashok tree spp. (*Saraca asoca*) in Rewa Road site (NH-35) and the minimum value of Ascorbic Acid (0.39 mg/g) found in Peepal tree spp. (*Ficus religiosa*) in Mirzapur Road site (NH-76) The variance may be due to alternative biochemical parameters being reflected. Plant can filter the air through aerial elements especially through their twigs stem leaves air pollution management is the better manage by the afforestation program. Air pollution tolerance index (APTI) is an intrinsic quality of tree to control air pollution problem which is currently of major concern of local urban locality. The trees having higher tolerance index rate or tolerant towards air pollution and can be used as a major component to reduce air pollution whereas the tree having less tolerance index can be an indicator to know the rate of air pollution. Hence, it is essential to protect the plants.

**Keywords:** pH of leaf extract; relative water content; ascorbic acid; chlorophyll; APTI.

## 1. INTRODUCTION

Although water and land pollution are very dangerous but air pollution burnt out to be a serious problem due to the industrialization and urbanization. Nowadays particulate matter is the biggest concern due to their undesirable impact on plant and animal. The recognition and classification of plants into tolerant and sensitive groups is essential because the sensitive plants can use as an indicator and tolerant as a sink for the pollutants in the city and developed habitats. Plant has a very close relationship with the nature and if any altered conditions occur in the atmosphere it directly affects the physiology and biochemistry of the plant. Naturally plant act as an air purifier which confuse particulate matter and smoke from the atmosphere and cleans the air. Sensitive trees species are suggested as a bio indicators Seyyednjad S.M. et al. [1]. Plant preliminary accept their pollutions does perform like scavengers for pollutants. The trees are being continuously exposed to the environment hence they attract gather and combine pollutants impinging on their leaves surface therefore they show noticeable or slight change depending on their sensitivity level. It is an established fact that vegetation plays an important role in cleaning the atmosphere by absorbing certain toxic air pollutants from its surroundings and also abatement of air pollution [2]. Sometimes physiological change takes place in plant before it visible to the foliage of the plant. Does

air pollution tolerance index is used to choose tolerant species and help in monitoring plant tolerance towards air pollution so assessment of plant on the basis of their level of tolerance to air pollution is essential consequently a APTI based on biochemical parameter is generally employed for recognizing the tolerance level of plants Panda LRL et al. [3].

Air pollution is an inevitable harmful by-product of rapid industrialization and urbanization that is responsible for a variety of deleterious effects on all communities including humans, animals and plants. It has been a major environmental concern since the beginning of industrialization, resulting in a greater release of gaseous and particulate pollutants into the atmosphere [4]. With rapid development of human civilization, the number of automobiles has increased, which ultimately deteriorates the air quality. The use of automobiles is growing fast globally and with much greater pace in developing countries. Road traffic is considered as one of the major sources of air pollution. The combustion of fuel in engines of vehicles gives rise to SO<sub>2</sub>, lead (Pb), NO<sub>x</sub> and CO as well as suspended particulate matter. Emissions from automobiles operating on public roads represent a major portion of the air pollutants included in the emission inventories. In Asian countries increasing urban population growth, industrial activities and automotive traffic have caused serious air pollution The World Bank Report, [5].

Some plant species are susceptible to certain gaseous contaminants and some are tolerant. Any of the gases and toxins found in the atmosphere are phytotoxic and results in various morphological and physiological deformities in plant. In sensitive plants, the degree of such deformities will be high and in resistant ones low. As an early warning measure of emissions, susceptible species are valuable and resilient species help minimise the total pollution load, leaving the air comparatively clean from pollution Rao DN [6].

Singh and Rao have proposed a system for deciding the air Singh SK, Rao DN [7]. APTI by synthesising the values of four distinct biochemical parameters, i.e. leaf extract pH, ascorbic acid, gross chlorophyll and the relative content of water Singh S K [8], Gaikwad US, Ranade CD, Gadgil JM, [9], Jyothi SJ, Jaya DS [10]. Ascorbic acid serves as the first line of protection against the oxidative pressure of the pollutants among four parameters. Ascorbate is found in different organelles such as cytosol, chloroplast, vacuoles, mitochondria, and inside the cell wall Rautenkranz AAF, Li L, Machler F, Martinoia E, Oertli JJ [11], Liso R, De Tullio MC, Ciraci S, Balestrini R, La Rocca N, Bruno L, Chiappetta A, Bitonti MB, Bonfante P, Arrigoni O. [12].

The quality of air has an impact on a human being's quality of life. Air pollution is a result of industrialization and urbanization and is a major problem of cities. Natural factors, such as windstorms, extreme temperature, and dust, add particles and gases to the air; also, human activities, industrial and agricultural plants, and vehicles are factors that result in the presence of such materials into the air Hamraz et al. [13]. Objective of the investigation is to estimate the Relative Water Content, pH of the leaf extract, Ascorbic acid and Chlorophyll contents of the tree species from selected sites along the National Highway of Allahabad, India and to calculate Air Pollution Tolerance Index of selected plant species in different highways of Allahabad, India.

## 2. MATERIALS AND METHODS

The present investigation entitled "Air Pollution Tolerance Index for Selected Species of Plants in Roadside Highways at Allahabad, Uttar Pradesh, India" was conducted at Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, Department of

Environmental Sciences and NRM, and January 2018 – May 2018. The area situated on the national highway of Allahabad from where four different sites were chosen as a study area i.e. Rewa road (NH 35), Mirzapur road (NH 76) and Varanasi road (NH 19) and jhansi control site. Allahabad is located in south eastern part of Uttar Pradesh at an elevation of 98 meters from the mean sea level. Climatic and weather condition during the experimental trial was warm and temperate. The average annual temperature was 25.7 °Celsius. The average rainfall is about 1027 millimeters. The parameter recorded during the investigation was relative water content pH ascorbic acid and chlorophyll content. At each distance, data were collected five commonly occurring plant species, namely *Azadirachta indica* (Neem), *Delonix regia* (Gulmohar), *Saraca asoca* (Ashok), *Ficus benghalensis* (Bargad), *Ficus religiosa* (Pepal). To retain uniformity, care was taken to select the plants of uniform age, size and spread growing at iso-ecological conditions. The observations of selected plant species were recorded during January to May 2018.

### 2.1 pH of Leaf Extract

5 gram of the fresh leaves were homogenized in 10 ml deionized water. This was filtered and the pH of the leaf extract was determined after calibrating pH meter with buffer solution of pH 7 and 9 with the method as described by Singh et al. [14].

### 2.2 Relative Water Content of Leaf (RWC) (%)

The relative water content was estimated by gravimetric method proposed by Singh et al. [15]. The leaf weight under different conditions such as fresh, turgid and dry weight. Fresh weight was obtained by weighing the fresh leaves. The leaves were then immersed in water overnight and then weighed to get turgid weight. Next, the leaves were dried overnight in an oven at 70 °C and reweighed to get the dry weight.

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

FW = Fresh weight

DW = Dry weight

TW = Turgid weight

### 2.3 Total Chlorophyll Content (T) (mg/g)

The total chlorophyll content was analyzed by method described by Arnon [16]. 0.5 gram of

fresh leaves were blended and then extracted with 10 ml of 80 % acetone and left for 15 min. The liquid protein was decanted into another test tube and centrifuged at 2,500 rpm for 15 min. The supernatant was collected and absorbance was measured at 645 nm and 663 nm for chlorophyll a and chlorophyll b using a micro controller based visible spectrophotometer. Calculation were done by using the formula given below:

$$TCH \text{ (mg/g)} = (20.2 \times O.D. \text{ 645 nm}) + (8.02 \times O.D. \text{ 663 nm}) \times 100 \times W$$

$$\text{Total chlorophyll} = \text{chlorophyll a} + \text{chlorophyll b}$$

Where, O.D. 663 and O.D. 645 represent optical densities of respective wavelengths.

V is the volume of extract and

W is the weight of the leaf sample (gm)

## 2.4 Ascorbic Acid Content (A) (mg/g)

The ascorbic acid content was estimated by the A.O.A.C. [17] method. For the estimation of ascorbic acid, fresh leaves (10 g) were homogenized in metaphosphoric acid solution. The volume was made to 50 ml and the solution was titrated against indophenol dye. Appearance of rose pink colour was noted as the end point of the titration. The amount of ascorbic acid in milligrams per 100 g was calculated by using the formula:

$$\text{Ascorbic Acid (mg/100 gm)} = \text{Dye factor} \times \text{Titration reading} \times \text{Volume made} \times 100$$

Weight of leaves taken × Volume taken for estimation

## 2.5 Estimation of Air Pollution Tolerance Index (APTI)

Air Pollution Tolerance Index values were estimated using the method suggested by Singh and Rao [18]. The plant species having APTI values falling in the range of 30 - 100 are regarded as tolerant, between 17 - 29 as intermediately tolerant, between 1 - 16 as sensitive and the plant species having APTI values less than 1 are considered as highly sensitive.

## 3. RESULTS AND DISCUSSION

### 3.1 p<sup>H</sup> of Leaves

pH of tree species at different sites, the table and Fig. 1 shows the pH values of the tree species out different sites. The maximum p<sup>H</sup> (7.18, 6.72, 7.88 and 6.80) was found in Neem at Control site, Mirzapur road, Rewa road and Varanasi road. And minimum p<sup>H</sup> was recorded in Gulmohar at (6.82, 6.22, 6.40, and 5.96) all sites studied in this experiment it may be due to the presence of the acidic pollutants from traffic by emission of harmful gases in environment and settle down on leaf surface. The cells system functions well at optimum p<sup>H</sup> but being exposed to acidic pollutants over a long period will reduce pH levels in fewer tolerant species. It was also found that all plants collected at all locations exhibited lower p<sup>H</sup> values. Similar results were also observed by Miria A. et al. (2013).

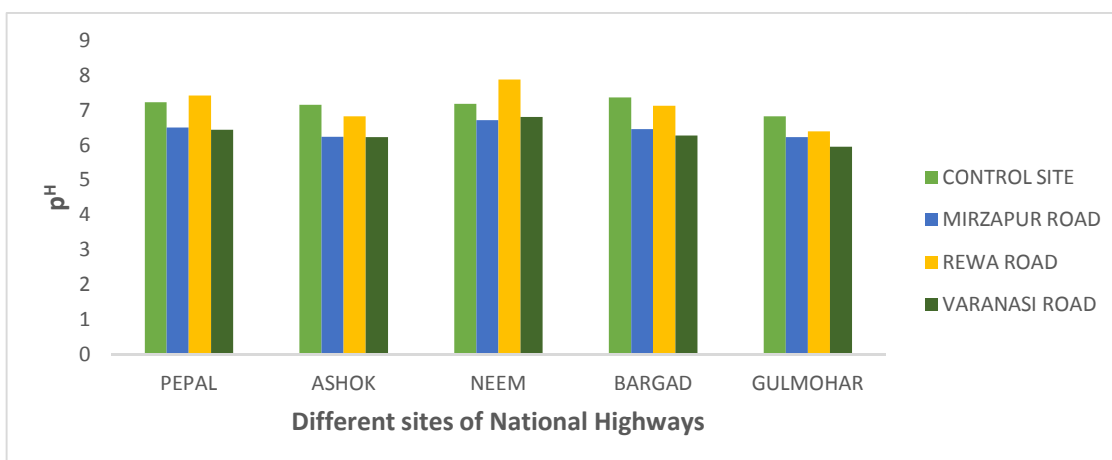


Fig. 1. p<sup>H</sup> of plant leaves at different sites

### 3.2 Relative Water Content (RWC)

RWC of tree species at different sites, the table and Fig. 4 shows the RWC values of the tree species out different sites. The maximum RWC (89.99 %) was found in Ashok tree spp. (*Saraca asoca*) at Mirzapur road. And minimum RWC was recorded in (58.64 %) Neem tree spp. (*Azadirachta indica*). All sites studied in this experiment it may be due to loss of water and dissolved nutrients, resulting in early senescence of leaves Masuch et al. [19]. It is likely therefore that plant with high RWC under polluted conditions may be tolerant to pollutants. It has been reported that air pollutants increases cell permeability Keller, [20].

### 3.3 Total Chlorophyll Content (mg/g) of Plant Leaves at Different Sites

Table and Fig. 4 shows the Total Chlorophyll Content values of the tree species out different sites. The maximum Total Chlorophyll Content (1.55 mg/g) was found in Ashok tree spp. (*Saraca asoca*) at Mirzapur Road. And minimum Total Chlorophyll Content was recorded in (0.71mg/g) Bargad tree spp. at Control Site and Rewa Road. All sites studied in this experiment it may be due to growing in shade contain more chlorophyll content in comparison with open light grown plants on fresh weight basis. High chlorophyll contents and larger leaf size in shade grown plant suggest that it is well adapted to low light intensities and the plants exposed to open light shows decrease in chlorophyll a, b and total

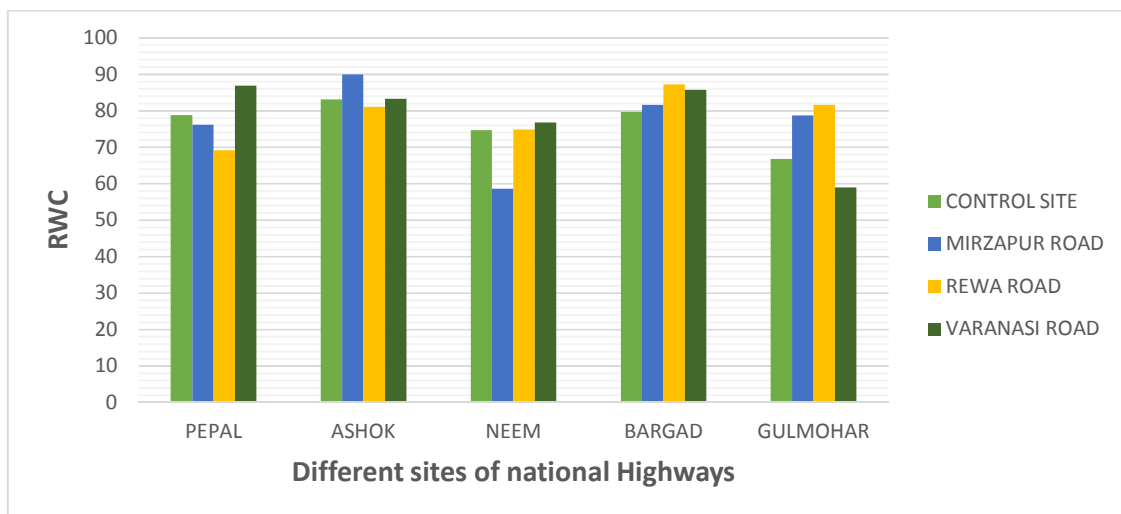
chlorophyll content as compared to plants grown in dark. The increase in chlorophyll content in the leaves of shade grown plant may be attributed to an increase in the number and size of chloroplast

### 3.4 Ascorbic Acid (mg/g) of Plant Leaves at Different Sites

Fig. 4. Shows the Ascorbic Acid values of the tree species out different sites. The maximum Ascorbic Acid (9.74 mg/g) was found in Bargad tree spp. at Control Site. And minimum Ascorbic Acid was recorded (0.39 mg/g) in Peepal tree spp. at Mirzapur Road. All sites studied in this experiment it may be due to increased rate of production of relative oxygen species (ROS), during photo oxidation of SO<sub>2</sub> and SO<sub>3</sub> where sulfites are generated from SO<sub>2</sub> absorption. The opinion that higher ascorbic acid content of plant is a sign of its tolerance against pollution. However its reducing activity is pH dependent, when pH is high at that time concentration of ascorbic acid is low Chaudhary and Rao, [21].

**Table 1. APTI Value Range of Different Trees spp**

Trees species	APTI response
Bargad ( <i>Ficus benghalensis</i> )	Intermediately Tolerant
Ashok ( <i>Saraca asoca</i> )	Sensitive
Neem ( <i>Azadirachta indica</i> )	Sensitive
Peepal ( <i>Ficus religiosa</i> )	Sensitive
GulmoHar ( <i>Delonix regia</i> )	Sensitive



**Fig. 2. Relative Water Content (RWC) of plant leaves at different sites**

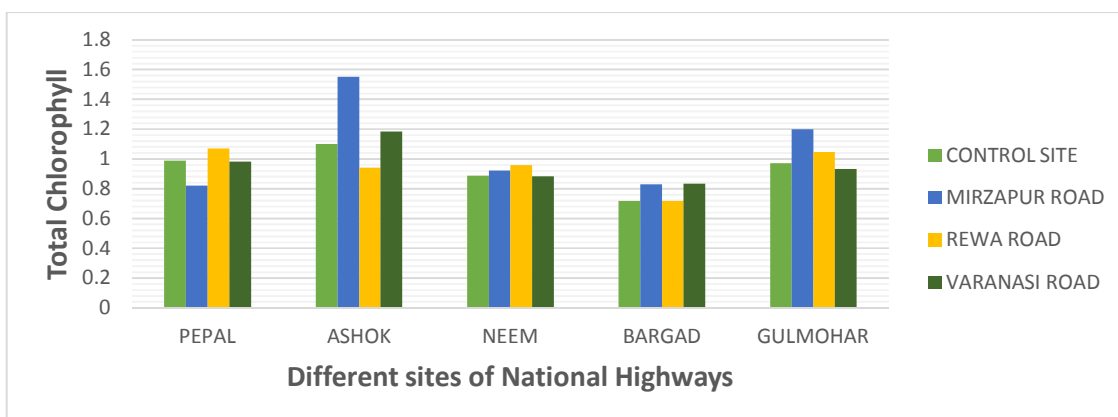


Fig. 3. Total Chlorophyll Content (mg/g) of plant leaves at different sites

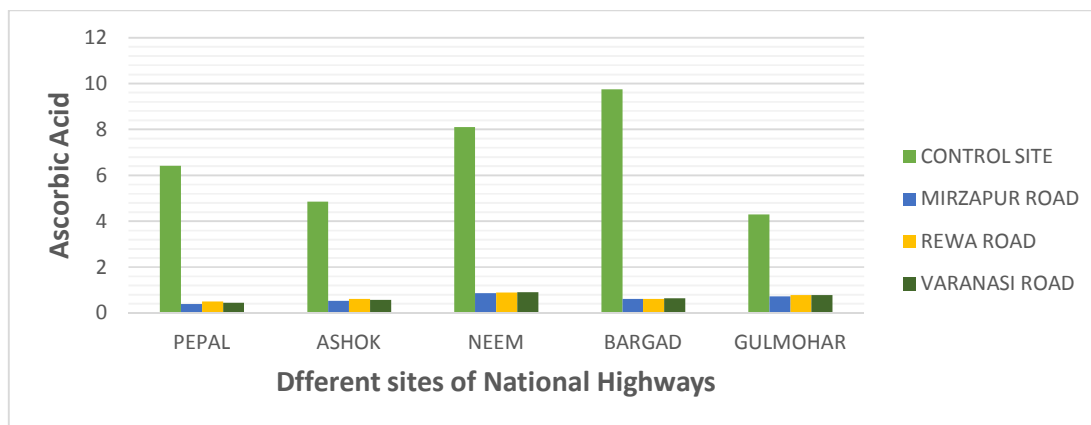


Fig. 4. Ascorbic Acid (mg/g) of plant leaves at different sites

Air pollution tolerance index is an index denotes the capability of a plant to combat against air pollution. Plant which have higher index value are tolerant to air pollution and can be caused as sink to mitigate pollution, while plants with low index value show less tolerance and can be used to indicate levels of air pollution Singh and Rao, [7]. Among the plant species studied the highest tolerance was shown Bargad (*Ficus benghalensis*) (17.22) in Control Site, Ashok (*Saraca asoca*) (11.94) in Mirzapur Road Site, Bargad (*Ficus benghalensis*) (9.70) in Rewa Road Site and Bargad (*Ficus benghalensis*) (9.96) in Varanasi Road site.

And the lowest tolerance was shown in trees species namely Gulmohar (*Delonix regia*) (5.59) in Control Site, Neem (*Azadirachta indica*) (3.66) in Mirzapur Site, Peepal (*Ficus religiosa*) (7.04) in Rewa Site and Gulmohar (*Delonix regia*) (4.02) in Varanasi Site. During the winter season APTI value is higher than the summer season.

Bargad (*Ficus benghalensis*) tree spp. play an important role in purifying the air pollution in the environment. Plantation of these tolerant species is useful for bio monitoring and to develop the green belt among the nature and to reduce industrial air pollution. This is very essential for saving the environment for our future generation to protect the present generation.

#### 4. CONCLUSION

The maximum value of pH was 7.8 found in Neem tree spp. (*Azadirachta indica*) in Rewa Road (NH-35) and the minimum value of pH was 5.9 found in Gulmohar tree spp. (*Delonix regia*) in Varanasi Road (NH-19). The maximum value of RWC (89.99%) found in Ashok tree spp. (*Saraca asoca*) and the minimum value of RWC (58.64%) found in Neem tree spp. (*Azadirachta indica*) in Mirzapur Road site (NH-76). The maximum value of Total Chlorophyll Content was 1.55 mg/g found in Ashok tree spp. (*Saraca*

asoca) in Mirzapur Road (NH-76) and the minimum value of Total Chlorophyll Content was 0.71 mg/g found in Bargad tree spp. (*Ficus benghalensis*) in Control Site and Rewa Road (NH-35). The maximum value of Ascorbic Acid (1.07 mg/g) found in Ashok tree spp. (*Saraca asoca*) in Rewa Road site (NH-35) and the minimum value of Ascorbic Acid (0.39 mg/g) found in Pepal tree spp. (*Ficus religiosa*) in Mirzapur Road site (NH-76). Air pollution tolerance index (APTI) of plants is becoming a vital parameter because it assists the assessment of plants' tolerability to air pollution since the eventual increase of air pollution levels will be detrimental to the health of the existing vegetation. The results from this study provide information for the selection of tolerant species for future planning of the roadside landscape in order to mitigate air pollution and even ultimately reduce pollution. Species in sensitive groups is best to be used as bio-indicators to air quality and species ranked as tolerant is best to be planted around areas with poor air quality since the tolerant species have the ability to absorb air pollutants. With increasing urbanization and industrialization, the air quality is degrading. Plants play a significant role in mitigating the air pollution and maintains ecological balance. APTI determination is of utmost importance because with increase in small scale industries the pollution load rises at a rapid rate. From the results of the present study, this tolerant plant species can be used as indicators of pollution there by acting as a sink to all air pollutants.

### COMPETING INTERESTS

Authors have declared that no competing interests exist.

### REFERENCES

- Seyyednjad SM, Majdian K, Koochak H, Niknejad M. Air pollution tolerance indices of some plants around industrial zone in South of Iran. *Asian J of Biologi. Sci.* 2011;4:300-305.
- Harju L, Saarela KE, Rajanser J, Lill JO, Lindroos A, Heselius SJ. Environmental monitoring of trace elements in bark of Scots pine by thick-target PIXE. *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Minerals and Atoms.* 2002;189:163–167.
- Panda LRL, Aggarwal RK, Bhardwaj DR. A Review on Air Pollution Tolerance Index (APTI) and Anticipated Performance Index (API). *Curr. World Environ.* 2018;13(1).
- Bhatnagar AD, Rao PS, Gaghate DG, Nema P. Inventory of SO<sub>2</sub> and toxic emissions from industrial sources in Greater Mumbai, India. *Atmospheric Environment.* 2005;39:3851–64.
- The World Bank Report. India's Environment: taking stock of plans, programs and priorities. South Asia Regional Office. The World Bank. 2009; 319.
- Rao DN. Sulphur dioxide pollution versus plant injury with special reference to fumigation and precipitation. *Proceedings Symposium on Air Pollution Control.* (Indian Association for Air pollution Control), New Delhi, India. 1983;1:91-96.
- Singh SK, Rao DN. Evaluation of plants for their tolerance to air pollution. In *Proc. Symp. Air pollution control, IIT, Delhi.* 1983;1:218-224.
- Singh SK. Phytomonitoring of Urban-Industrial Pollutants: A New Approach. *Environmental Monitoring and Assessment.* 1993;24:27-34.
- Gaikwad US, Ranade CD, Gadgil JM. Plants as Bioindicators of Automobile Exhaust Pollution- A Case study of Sangli City. *IE(I) Journal-EN.* 2006;86:26-28.
- 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.
- Rautenkranz AAF, Li L, Machler F, Martinoia E, Oertli JJ. Transport of ascorbic and dehydroascorbic acid across protoplast and Vacuole membranes isolated from barley (*Hordeum vulgare* L. cv. Gerbel) leaves. *Plant Physiology.* 1994; 106:187-193.
- Liso R, De Tullio MC, Ciraci S, Balestrini R, La Rocca N, Bruno L, Chiappetta A, Bitonti MB, Bonfante P, Arrigoni O. Localization of ascorbic acid, ascorbic acid oxidase, and glutathione in roots of *Cucurbita maxima* L. *Journal of Experimental Botany.* 2004;55:2589- 2597.
- Hamraz H, Sadeghi-Niaraki A, Omati M Noori N. GIS-Based Air Pollution Monitoring using Static Stations and Mobile Sensor in Tehran/Iran. *Int. J. Sci. Res. In Environ. Sci.* 2014;2(12):435-48.
- Singh SK, Rao DN. Evaluation of plants for their tolerance to air pollution. In:

- Proceeding of Symposium on Air Pollution Control. Ind. Asso. of Air Pollu. Control, New Delhi, 1997;1:218-224.
15. Singh RK, Rao, DN. Evaluation of the plants for their tolerance to air pollution. Proc. Symp. On Air Pollution Control held at IIT, Delhi.1993;218-224.
  16. Arnon DI. Copper enzymes in isolated chloroplasts polyphenol oxidase in Beta vulgaris. Plant Physiol. 1949;24:1-15.
  17. Adams WN, Miescier JJ. Commentary on AOAC method for paralytic shellfish poisoning. J. of the Ass. of Offi. Analytical Chem. 1980;63(6):1336-43.
  18. Singh SK, Rao DN. Evaluation of plants for their tolerance to air pollution, In:Proceedings Symposium on Air Pollution Control, Indian Association for Air Pollution Control. 1983;1:218-224.
  19. Masuch G, Kicinski H, Kettrup. Boss KS. Single and combined effects of continuous and discontinuous O<sub>3</sub> and SO<sub>2</sub> emission on Norway spruce needle Histochemical and cytological changes. Intl. J. Env. Anal. Chem. 1988;32:213-41.
  20. Keller T. The electrical conductivity of Norway spruce needle diffusive as affected by air pollutants. Tree Physiol. 1986;1:85-94.
  21. Choudhary CS, Rao DN. Study on some factors in plants controlling their susceptibility to SO<sub>2</sub> pollution. Proc. Indian National Sci. Acad. 1977;43: 236-41.

© 2020 Nishad et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

*Peer-review history:*

*The peer review history for this paper can be accessed here:  
<http://www.sdiarticle4.com/review-history/63654>*