AES ISSN: 2096-3246
Volume 54, Issue 02, December, 2022 Special Issue

# ASSESSMENT OF AIR POLLUTION TOLERANCE INDEX AND ANTICIPATED PERFORMANCE INDEX OF PLANT SPECIES FOR GREEN BELT DEVELOPMENT

**Pradeep Khyalia**
Maharshi Dayanand University Rohtak,Haryana, India

**Vikram Mor**
vikram_fps@sgtuniversity.org
SGT University, Gurugram, Haryana, India

**Wazir Singh**
SGT University, Gurugram, Haryana, India

**Shivani Bhatnagar**
Babu Banarasi Das University, Lucknow (U.P.), India

**Abstract**
Numerous natural and anthropogenic activities that release hazardous chemicals into the environment have the potential to harm both plants and people.The gradual alteration in the composition of the atmosphere over the past century is caused by increased fossil fuel combustion and industrialization. Heavy metals, respirable particulate matter ($PM_{2.5}$ & $PM_{10}$), volatile organic compounds (VOCs), nitrogen oxides (NOx), ozone (O3), sulphur dioxide (SO2), carbon monoxide (CO), ozone (O3), and other air pollutants all have different chemical compositions, reaction characteristics, emission times, and propensities to diffuse over long or short distances thus effect environment in different proportion. Air pollution also have have adverse effect on the health of living beings. Pollution has disastrous effects on the plants, animals and Human beings. Air pollution damage to plants has been analyzed since 125 years. Injuries to plants can be confused with disease symptoms from fungi, nematodes, termites, bacteria, nutritional deficiencies and toxicities, genetic disorders, temperature, water and salinity. The chapter focused on measuring and monitoring APTI and API in roadside and urban plants. These tools analyse plant pollution tolerance towards air pollution. The plant species which shows higher tolerance towardsair pollution, can be employed as a pollutant sink to control air pollution. High APTI and API plants are used to promote green belts and manage air pollution in cities and developed areas. Many plant species are tolerant of air pollution, making them excellent for industrial areas and roadsides.
**Keywords:** Air pollution, APTI, API, Green-Belt development

## 1. Introduction

Air pollution is one of the most serious issues confronting the entire world. The emission of gases, chemicals, aerosols, or biological materials into the atmosphere that causes harm to living organisms or the environment is called air pollution. Pollutants that are emitted directly from a source and enter the atmosphere are called primary pollutants. About 90% of air pollution is caused by five primary air pollutants. The primary pollutants are as follows:

1) Carbon-based compounds: CO, CO2, CH4, and VOCs.

2) Compounds of sulphur: H2S and SO2.
3) Compounds of nitrogen: NO, N2O, and NH3.
4) Halogens: Chlorides, fluorides, bromides.
5) Particulate matters (PMs): $PM_{10}$, $PM_{2.5}$, $PM_{1.}$

When primary pollutants undergo chemical reactions, they are called secondary pollutants. For Example: sulfuric acid, nitric acid and carbonic acid etc. These pollutants come in the atmosphere mainly through anthropogenic activities (Odilora *et al.,* 2006; Talukdar et al., 2018). Secondary air pollutants are:

1) $HNO_3$ and $NO_2$ from NO
2) $O_3$ from photochemical reactions of NOx and VOCs.
3) Formation of $H_2SO_4$ from the reaction between $SO_2$ and $HN0_3$ from $NO_2$.
4) Formation of organic aerosol from VOCs in gas to particle reaction.

Air pollution originates from industrialization, fortuitous urbanization, disquieting or frightening increase in vehicles fleet and population growth. (Agbaire and Esiefarienrhe*,* 2009; Odilara, 2006; Adamsab *et al*., 2011; Seyyednjad *et al*., 2011). Due to anthropogenic activities, including automotive traffic, road transportation, and factories, the world faces a major and alarming air pollution problem (Johan and Iqbal, 1992; Joshi *et al*., 2009).

## 2. Analysis of Air Pollution Tolerance Index

Plants monitor and maintain the ecological balance by actively cycling gases like $CO_2$, $O_2$, and by providing a large leaf area for impingement, absorption, and accumulation of pollutants to reduce air pollution in the air environment (Escobedo *et al*., 2008). After screening, green belt developers and planners can use pollution-tolerant species as biological indicators or monitors of air pollution to manage urban air pollution (Miria and Khan, 2013). The plants' ability to absorb and store toxins helps in reducing environmental pollution (Liu and Ding, 2008; Nowak et al., 2018). Environmental pollution causes functional weakness and structural simplicity in plants, which harms other biotic groups. Plant physiological and biochemical levels determine their air pollution resistance and susceptibility.

The "Air pollution Tolerance Index" (APTI) is calculated by examining the biochemical properties of leaf components such as pH, ascorbic acid, relative water content (RWC), and total chlorophyll (Pandey and Sharma, 2003). A calibrated digital pH metre can be used to calculate the potential hydrogen ion concentration (pH) and Spectrophotometric for the estimation of total chlorophyll and ascorbic acid in leaf extract. The gravimetric approach can be used to estimate the relative water content by calculating the leaf weight under starting, turgid, and dry weight conditions. The four-factor equation for calculating the "Air Pollution Tolerance Index" (APTI).

$$APTI= A (T+P) +R/10$$

Where P is the leaf extract's potential hydrogen ion concentration (pH), A is the ascorbic acid content (mg/g), T is the total chlorophyll content (mg/g/fresh weight), and R is the leaf extract's relative water content (per cent).

The Air Pollution Tolerance Index, as recommended by Raza and Murthy, has also been used to rate plant species based on their tolerance to air pollution (1988).The tolerance index for air pollution was divided into four categories: Tolerant (T or grade I), Moderately Tolerant (MT or grade II), Intermediate (I or grade III), and Sensitive (S or grade IV). The air pollution tolerance index values are obtained by calculating the mean air pollution tolerance index and its standard deviation for trees (Liu et al, 2008). The biochemical and physiological levels for the evaluation of air pollution tolerance index (APTI) are: total chlorophyll content (TCC), Relative water content (RWC), potential of hydrogen ion concentration, ascorbic acid and proline parameters. On the basis of these biochemical parameters, air pollution tolerance index could be determined for the plant species.

### 2.1 Total chlorophyll content

Chlorophyll a, Chlorophyll b, and other accessory pigments make up the total chlorophyll content. It gives the leaves their green colour and is the primary pigment for capturing sunlight and converting it to chemical energy. Chlorophyll content in plants indicates photosynthetic activity as well as biomass growth and development. It is obvious that the chlorophyll content varies with leaf age, pollution level as well as from species to species. The degradation of photosynthetic pigment can be used as an indicator for higher level of air pollution (Ninave, 2001). Mir et al. (2008) has also reported the reduction in photosynthetic pigment due to high levels of vehicular pollution.

As a result of the air pollution load, stomata close, reducing the amount of available carbon dioxide in leaves and limiting carbon fixation. The net photosynthetic rate is frequently used to demonstrate how increased air pollution affects plant development. Plants absorb, gather, and integrate contaminants into their systems when exposed to air pollution on a regular basis. Depending on their level of sensitivity, plants can exhibit visible changes such as changes in metabolic processes or an accumulation of specific metabolites. When the leaves absorb pollutants, the photosynthetic pigments, namely chlorophyll and carotenoids, decrease, which harms plant productivity because any decrease in chlorophyll content affects plant growth ( Joshi and Swami, 2009).

Traffic density, photosynthetic activity, leaf senescence, total chlorophyll concentration, and stomata conductance all have a relationship (Honour et al., 2009). The gradual loss of chlorophyll, accompanied by leaf yellowing, may reduce photosynthetic ability. When the level of pollution in the environment exceeds the physiologically appropriate tolerable range, the photosynthesis process in exposed plants becomes inactive. The accumulation of dispersed particulate matter on the leaves' surface could cause the  decreased chlorophyll content. This deposition also produces a shadowing effect, which can obstruct gaseous exchange by blocking stomata. As a result, the temperature of the leaf rises, potentially delaying chlorophyll synthesis. Air contaminants enter the tissues via the stomata and partially denature the chloroplasts. As a result, the amount of colour in polluted leaves' cells may decrease. However, Tripathi and Gautam's 2007 study found that the Mangifera indica leaf species increased its chlorophyll content by 12.8% when exposed to air pollution.

### 2.2 Relative water content (RWC)

The relative water content of a plant can act as an measure of its water balance. The enormous amount of water (measured in RWC) in plant tissue helps to maintain its physiological equilibrium when it is under the stress of air pollution. Relative water content tells us about the plant's ability to hold moisture and how hydrated the leaf matrix is. (Dedio, 1975). When the relative water content is low, it indicates a change in the hydration status of the leaf matrix and will lead to more acidic circumstances. More water will dilute acidity. When under stress from air pollution, a sizable amount of water is kept in the plant's body to maintain its physiological equilibrium (Gonzalez et al., 2001). The loss of dissolved nutrients and water caused by cells' protoplasmic permeability, which is related to relative water content, causes leaves to sense earlier (Masuch et al., 1988). High relative water content plant species are consequently more tolerant to pollutants. Calotropis gigantea in the tannery area of the Dindigul town traffic area recorded the highest value of RWC, and Delonix regia exhibits the lowest value of relative water content. In a study at the Madri Industrial Area in Udaipur, Rajasthan, India, Santalum album was shown to have the highest relative water content (Mahecha G.S. et al., 2013).

### 2.3 Potential of hydrogen ion concentration (pH)

A change in the concentration of hydrogen ions in leaf extract due to air pollution may have an effect on stomatal sensitivity. Plants with high sensitivity to sulphur dioxide and nitrogen dioxide closed their stomata more quickly when exposed to pollutants (Swami et al., 2004).Both sensitive and somewhat tolerant plant species can tolerate hydrogen ion concentrations ranging from 4.4 to 8.8 (Lakshmi et al., 2009). Plants are highly resistant to pollution due to the potential for hydrogen ion concentration in alkaline leaf extract (Agarwal and Tiwari, 1988). The efficiency of converting hexose sugar to ascorbic acid increases as the hydrogen ion potential increases (Escobedo, 2008). If the pollutants are acidic, the potential of hydrogen ions in the leaf is reduced, and the drop in the potential of hydrogen ions in sensitive species is greater, lowering the efficiency of converting hexose sugar to ascorbic acid. This suggests that pH and the reducing activity of ascorbic acid are interdependent (Scholtz and Reck, 1977). Air pollution causes changes in hydrogen ion concentration potential, which affects stomata activity (Larcher , 1995). Stomata close more quickly when exposed to air pollutants due to their high sensitivity to sulphur dioxide and nitrogen dioxide. According to Sarala et al., 2012, the potential hydrogen ion concentration of Moringa tinctoria and Calotropis gigantea leaf extracts at the tannery area was 7.20 and 8.52, respectively. In a study of numerous plant species in the vicinity of Nanded City, Maharashtra, India, the greatest potential of hydrogen ion concentration of the leaf extract of Ficus religiosa and Tamarindus indica was determined to be 7.0 and 7.1, respectively (Yannawar et al., 2014).

### 2.4 Ascorbic acid (AA)

Ascorbic acid is regarded as strong reducing agent having a vital role in photosynthesis (carbon fixation). Its ability to concentrate and reduce are inextricably linked. The efficiency of hexose sugar conversion to ascorbic acid is improved by a high hydrogen ion potential related to pollution tolerance (Lui et al., 2008). During the photo-oxidation of $SO_3^{2-}$ to $SO_4^{2-}$, reactive oxygen species (ROS) such as $SO_3^{2-}$, $HSO_3^{2-}$, $OH^-$ and $O_2^-$ are produced, where sulphites are produced from absorbed sulphur dioxide. The free radical produced, depending on the plant's dose and physiological state,

increases the production of free radical scavengers such as ascorbic acid, super oxide dismutase (SOD), and per-oxidase (Cheng et al., 2007). According to Tanee and Albert, the shrub Manihot esculenta had the highest ascorbic acid concentration (2012). Summer had the highest ascorbic acid content in shrub species (Lantana camara), followed by rainy and winter seasons (Das and Prasad, 2010).
The plants Anacardium occidentale (23.20), Pinus spp. (22.35), Mangifera indica (23.37), and Psidium guajava (24.15) were the most tolerant to air pollution, according to Enete et al. (2013). The majority of shrubs had higher air pollution tolerance indices than trees, indicating that shrubs are more tolerant of air pollution than trees. 2014 (Otuu et al.). Landscapers select plant species based on their tolerance to air pollution using the APTI, which has been used to determine plant species tolerance levels. (Yan, 2008).

## 3. Air Pollution Tolerant Plant Species and Bioindicators

Although plants are essential for ecological balance, air pollution can seriously impact them (Kumar and Nandini, 2013). Plants can be used as bio-indicators of air pollutants due to their diverse sensitivities, which include tolerant (no symptoms) and sensitive species (which display the symptoms if the pollutants increase even at tiny concentration). Plant-environment interactions have been studied internationally because plants are far more sensitive to air pollution than other creatures (Abbasi et al., 2004). Trees, shrubs, and herbs exposed to airborne pollution undergo physiological and biochemical changes before displaying obvious leaf damage (Dohmen et al., 1990). An easy method for monitoring how plants react to air pollution can be used, and preventative measures can also be applied. Planting tolerant tree species can have a significant impact on the quality of life and cleanliness of the urban environment (Bamniya et al., 2011). The plants Anacardium occidentale (23.20), Pinus spp. (22.35), Mangifera indica (23.37), and Psidium guajava were the most tolerant to air pollution, according to Enete et al. 2013 (24.15). The majority of shrubs had higher air pollution tolerance indices than trees, indicating that shrubs are more tolerant of air pollution than trees. 2014 (Otuu et al.). Landscapers select plant species based on their tolerance to air pollution using the APTI, which has been used to determine plant species tolerance levels. (Yan, 2008).

## 4. Anticipated Performance Index (API) of Plant Species

When plant species are planted in industrial urban areas, their socioeconomic and biological characteristics, such as the air pollution tolerance index (APTI), canopy structure, plant habit, laminar structure, plant type, and economic value, are examined. These parameters are graded on a scale to assess the expected performance of various plant species (Singh and Rao, 1983). The projected performance index must be evaluated before selecting the appropriate plant species. The plants can be best evaluated and used in green belt plantations in terms of reducing air pollution. Planting trees and plants is an effective and widely accepted method of reducing pollution and improving the environment. The regional extent of pollution load, rainfall, temperature, human interactions, and soil quality will all significantly impact the selection of plant species for the formation of the green belt. Mangiera indica is the best plant for protecting against air pollution, according to Tiwari and co-authors (1991). The monoculture for green belt development is not recommended due to its numerous environmental constraints and other climatic conditions.

## 5. Conclusion

One of the major issues facing the world today is air pollution. In particular, twigs, stems, leaves, and other aerial components can be used by plants to filter the air. The best method for reducing air pollution is to implement a reforestation programme. The ability of trees to reduce pollution issues, which are currently of great concern in metropolitan areas, is known as the air pollution tolerance index (APTI). While trees with a lower APTI can be used as an indicators to determine the level of air pollution, those with a higher APTI are tolerant of air pollution and can be used in green belt development to reduce air pollution. The Anticipated Performance Index is created by combining biochemical and aggregate elements, and it is also useful for the establishment of green belts. To address the issue of air pollution, it is crucial to choose the appropriate plant species. Therefore, the choice should always be based on the plantation's purpose and area. A thorough analysis of a plant species for planting according to the needs of the location can truly resolve many air quality problems specific to that place.

**References:**

Abbasi, S., Chari A., Gajalakshmi, K.B., Ramesh and Ramasamy, E.B., (2004). Approaches to greenbelt design. J. Inst. Pub. Hlth. Engi., 3: 42-49.

Adamsab, M.P., Kousar, H., Shewetha, D.S., Sinajuddin, M.H., and M. Ravichandram, (2011). APTI of some selected plants in Shivamogga city, South Asia. Proceeding of International Conference on Advance Sciences, Engineering and Information Technology, 668-671.

Agbaire, P.O. and Esiefarienrhe, E., (2009). Air pollution tolerance indices of some plants around Otorogun Gas Plant in Delta state, Nigeria. J. Appl. Sci. Environ, 13(1):11–14.

Agrawal, S., and Tiwari, S.L., (1997). Susceptibility level of few plants on the basis of Air Pollution Tolerance Index. Indian Forester, 123: 319-322

Bamniya, B.R., Kapoor, C.S. and Kapoor, K., (2011). Searching for efficient sink for air pollutants: Studies on Mangifera indica L. Clean Tech. Environ. Policy, 14: 107-114.

Cheng, F.Y., Burkey, K.O., Robinson, J.M. and Booker, F.L., (2007). Leaf extracellular Environ. ascorbate in relation to O3 tolerance of two soybeans cultivars. Environ Pollut*,* (150): 355-362.

Das, S. and Prasad, P., (2010). Seasonal variation in Air Pollution Tolerance Indices and selection of the plant species for industrial areas of Rourkela. IJEP, 30(12): 978-988.

Dedio, W., (1975). Water Relations in wheat leaves as Screening Test for Drought Resistance. Can. J. Plant Sci., 55: 369-378.

Dohmen, G.P., Loppers, A. and Langebartels, C., (1990). Biochemical response of Norway spruce (Picea abies (L) Karst) toward 14-month exposure to ozone and acid mist, effect on amino acid, glutathione and polyamine titers. Environ. Pollut, 64, 375-383.

Enete, I.C.; Chukwudluzu, V.U.; Okolie, A.O., (2013). Evaluation of air pollution tolerance index of plants and ornamental shrubs species in Enegu city. Implications for urban heat island effect" world env, 3(3):108-115

Escobedo, F. J., Wagner, J. E. and Nowak, D. J., Maza, De Le, Rodriguez, M. and Crane, D.E.

(2008). Analyzing the cost effectiveness of Santiago, Chile's policy of using urban forest to improve air quality. J. of Environmental Management, (86), 148 – 157.

Gonzalez, L., Gonzalez Vilar, M. and Reigosa, M.J., (2001). Determination of relative water content. Handbook of plant Ecophysiology Techniques Kluwer Academic Publishers. Dordrecht, the Netherlands, 207-212.

Gupta, G. P., Kumar, B., & Kulshrestha, U. C. (2016). Impact and pollution indices of urban dust on selected plant species for green belt development: mitigation of the air pollution in NCR Delhi, India. Arabian Journal of Geosciences, 9(2), 1-15.

Honour, S.L., Bell, J.N., Ashenden, T.W., Cape, J.N. and Power, S.N., (2009). Responses of herbaceous plants to urban air pollution :Effects on growth , phenology and leaf surfaces characteristics.Environ.Pollut.,157:1279-1286.

Johan, S. and Iqbal, Q., (1992). Morphology and anatomical studies on leaves of different plants affected by motor vehicle exhaust. J. Islamic Acad. Sci. 5:21-23.

Joshi, N., Chauhan, A. and Joshi, P.C., (2009). Impacts of industrial air pollutants on some biochemical parameters and yield in wheat and mustard plants. Environmentalist, 29:98-104.

Joshi, P.C. and Swami, A., (2009). Air pollution induced changes in the photosynthetic pigments of selected plant species. J. Environ. Biol., 30:295-298.

Kumar, M., and Nandini, N., (2013). Identification and Evaluation of Air Pollution Tolerance Index of Selected Avenue Tree Species of Urban Bangalore, India", International Journal of Emerging Technologies in Computational and Applied Sciences, 388-390.

Lakshmi, P.S., Sarvanti, K.L. and Srinivas, N., (2009). Air pollution tolerance index of various plants species growing in industrial areas. An Int. Biannua J. of Environ. Sci., 2:203-206.

Larcher W. Physiological Plant Ecology, Berlin, Springer, (1995).

Liu, Y.and Ding, H., (2008). Variation in air pollution tolerance index of plants near a steel factory: Implications for landscape–plant species selection for industrial areas. SEAS Trans.Environ. Develop, 4:24-32.

Mahecha, G.S., Bamniya, B.R., Nair, N. and Saini, D., (2013). "Air Pollution Tolerance Index of Certain Plant Species-A Study of Madri Industrial Area, Udaipur (Raj.), India". IJIRSET, 2(12).

Masuch, G.H., Kicinski, G., Kettrup, A. and Boss, K.S., (1988). Single and combined effects continuous and discontinuous O3 and SO3 emissions on Norway spruce needles. I. Histological and cytological changes, Inter. Jour. of. Envi. Analytial Chemistry, 32:213-241.

Millard, A., (2000).The potential role of natural colonization as a design tool for urban forestry – a pilot study". Landscape and Urban Planning, 5:173–179.

Mir, Q.A., Yazdani, T., Kumar, A., Narain, A and Yunus, Y., (2008). Vehicular population and pigment content of certain avenue trees. Poll. Res., 27: 59-63.

Miria, A. and Khan, A. B., (2013). "Air Pollution Tolerance Index and Carbon Storage of Select Urban Trees- A Comparative Study". International Journal of Applied Research and Studies, 2:1-7.

Ninave, A.S., (2001). Evaluation of air pollution tolerance index of selected Plants. www.jeb.co.in/ paper_26. Pdf.

Nowak, D. J., Hirabayashi, S., Doyle, M., McGovern, M., & Pasher, J. (2018). Air pollution removal by urban forests in Canada and its effect on air quality and human health. Urban Forestry & Urban Greening, 29, 40-48.
Odilara, C.A., Egwaikhide, P.A., Esekheigbe, A., Emua, S.A., (2006). Air pollution Tolerance Indices (APTI) of some plant species around llupeju Industrial Area, Lagos. Journal of Engineering Science and Applications, 4 (2):97-101.
Otuu, F.C., Inya-Agha, S. I., Ani, U. G., Ude, C.M., Inya-Agha, T.O.,(2014)., Air Pollution Tolerance Indices (APTI) of Six Ornamental Plants Commonly Marketed at "Ebano Tunnel" Floral Market, in Enugu Urban, Enugu State, Nigeria. Journal of Environmental Science, Toxicology and Food Technology, vol 8 (1): 51-55.
Pandey, J. and Sharma M.S. (2003). Environmental Science Practical and Field. Yash Pub., Bikaner, India 129.
Raza, S.H., Murthy, M.S.R., (1988). Air pollution tolerance index of certain Plants of Nacharam Industrial area, Hyderabad. Indian J. Bot., 11(1):91-95.
Sarala, Thambavani, D. and Prathipa, V., (2012). "Assessment of Air Quality through Biomonitors of Selected sites of Dindigul Town by Air Pollution Tolerance Index Approach". Journal of research in Biology, 3: 193-199.
Scholtz, F. and Reck, S., (1977). Effects of acids on forest trees as measured by titration *in-vitro* inheri-tance of buffering capacity in Picea – Abies, Water, Air and Soil Pollution, 8:41-4.
Seyyednejad,S.M., Niknejad, M. and Koochak, H.,(2011). A Review of Some Different Effects of Air Pollution on Plants. Research Journal of Environmental Sciences, 5: 302-309.
Singh, S.K., Rao, D.N., (1983). Evaluation of the plants for their tolerance to air pollution Proc. Symp. on Air Pollution control held at IIT, Delhi, 218-224.
Swami, A., Bhatt, D. and Joshi, P. C., (2004). Effects of automobile pollution on sal (Shorea robusta) and rohini (*Mallotus phillipinensis*) at Asarori, Dehradun. Himalayan Journal of Environment and Zoology, 18 (1): 57 – 61.

Talukdar, P., Ghosh, N., Malik, S., & Rahaman, C. H. (2018). Effect of air pollution on plant growth and pollen viability. World Scientific News, 109, 131-142.
Tanee, F. B. G. and Albert, E., (2012). Air pollution tolerance indices of plants growing around Umuebulu Gas Flare Station in Rivers State, Nigeria. African Journal of Environmental Science and Technology, 7(1):1-8.
Tankha, K. and Gupta, R.K., (1992). Effect of water deficit and sulphur dioxide on total soluble protein, nitratre reductase activity and proline content in sunflower leaf. Biol.Planta, 34:305-310.

Tiwari, M. G., Pandey, D. D. and Sinha, C. S., (1991). Impact of coal dust pollution on biomass, chlorophyll and grain characteristics of rice. Journal of Biology, 3: 51-55.
Tripathi, A.K. and Gautam, M., (2007). Biochemical parameter of plants as indicator of air pollution. J.Environ.Bio, 28: 127-132.

Yan-Ju, Hui, D., (2008). Variation in air pollution tolerance index of plants near a steel factory. implications for landscape-plant species selection for industrial areas. Environ. Dev. 1(4): 24 -30.

Yannawar V. B., Bhosle, Arjun B., (2014). Air Pollution Tolerance Index of Various Plant Species around Nanded City, Maharashtra, India. Journal of Applied Phytotechnology in Environmental Sanitation, 3 (1): 23-28.