# Identification of Pollution Tolerant Plant Species in Highly Polluted Area of Lucknow District

**Supriya Shukla[1], Madhu Prakash Srivastava[2]**

**Abstract**

Air pollution has emerged as a major environmental challenge, adversely affecting both plant physiology and ecosystem health. The present study aimed to identify pollution-tolerant plant species in highly polluted areas of Lucknow district, Uttar Pradesh, using the Air Pollution Tolerance Index (APTI) and Anticipated Performance Index (API). Three representative polluted sites—Gomti Nagar, Central School, and Lalbagh—were selected for assessment during 2020–21 and 2021–22. Three tree species, *Ficusbengalensis*, *Ficusreligiosa*, and *Alstoniascholaris*, were evaluated based on biochemical and physiological parameters, including relative water content, leaf extract pH, total chlorophyll content, and ascorbic acid concentration. The results demonstrated significant variation in APTI values among species and study sites. *Alstoniascholaris* exhibited the highest APTI value (13.12), indicating superior tolerance to air pollutants, followed by *Ficusbengalensis* (11.01) and *Ficusreligiosa* (10.59). The findings further revealed that exposure to industrial pollutants reduced chlorophyll content while increasing ascorbic acid concentration in plant leaves, reflecting adaptive physiological responses to pollution stress. API evaluation identified *Alstoniascholaris* as the most suitable species for plantation in highly polluted urban and industrial environments, whereas the remaining species showed moderate tolerance. The study highlights the usefulness of combining APTI and API for selecting appropriate plant species for urban green belt development and environmental pollution mitigation.

[1,2] Maharishi School of Science, Maharishi University of Information Technology, Lucknow
Corresponding Author email id.:supriyatiwari2016@gmail.com

**Keywords:** Air Pollution Tolerance Index (APTI), Anticipated Performance Index (API), *Alstoniascholaris*, *Ficusbengalensis*, *Ficusreligiosa*, Air Pollution, Green Belt Development,

## Introduction

During this era of science, along with technology, the environment is deteriorating quickly. Pollution is an emerging and serious problem due to ecological disturbances, urbanization, and industrialization. Air, water, and soil are important components of the environment. Population explosion is the main crucial reason for environmental pollution. Rapid and uncontrolled growth of population, migration, unrestrained urban development, rise in personal income, economic growth, energy consumption, and transportation using fossil fuels are the root causes of all sorts of environmental pollution throughout the world. According to prescribed characterization, air pollution is 'the presence in the atmosphere of one or more contaminants in such quality and for such duration as is injurious, or tends to be injurious, to human health or welfare, animal or plant life.' It is the pollution of atmospheres as a result of the ejection of destructive material. Air toxic waste, because it causes health-regarding harm. In addition, it can further harm the environment as well as material goods. It has induced a reduction of the defensive ozone layer of the atmosphere, which is most vital toward climate change.

With the quick progress of human being evolution, the number of automobiles has amplified, which leads toward the weakening of air superiority (Sharma et al. 2017a), which influences the morphological changes such as stomata arrangement, stomata amount, leaf quantity, leaf area, etc. Biochemical changes include ascorbic acid content, pigment or color, enzymes, and proteins as well as sugar contents in addition to the physiological properties such as pH of leaf and relative water content, these parameters of the wayside flora (Kaur and Nagpal, 2017). Foliage is usually meant for investigation in view of the fact that it facilitates prime receptors of pollutants.

Air contamination acceptance catalog assessment represents the tolerance point of flora to air contamination; also, it can assist in the choice of the plant species in support of plantations in/in the region of the air-contaminated area. Upper APTI values provide a safeguard, despite the fact that the ones having lesser values can be used as a bio-monitor (Rawal et al. 2001). On the basis of APTI standards, the flora is categorized as tolerant, intermediate, and sensitive as well as the most sensitive plant species. Such information may be used in the planting of plants by the side of special polluted spots to resist air pollutants (Kumari and Deswal, 2017). A study conducted by Enete et al. (2013) shows the opportunity of employing APTI like a tool designed for deciding the decorative vegetation meant for inner-city heat landmass improvement in Enugu City. Consequences resulting from the next grouping of APTI and API can be of huge significance. Moreover, the assessment of a particular biochemical factor possibly will not be perfect for the assessment of plant response regarding various pollutants in favor of the green belt intention (Ogunkunle et al. 2015). The API assessment can offer a rational explanation in favor of green belt enlargement and forestation, along with reforestation, from the time when it integrates APTI next to the natural, in addition to the socio-economic side of the species (Sahu and Sahu, 2015). The permutations of these biochemical restrictions in addition to physiological factors give a further consistent outcome than those of separate factors (Bora and Joshi 2014). APIs are predominantly valuable in the assortment of individuals' plant species; they can carry out functions equally for getting the improved air quality along with offering esthetic and also recreational significance (Sahu and Sahu, 2015). Diverse study has been conducted on APTI, and they concluded that APTI has been used as an instrument for green belt enlargement. (Liu and Ding, 2008) APTI uses towardopt-tolerant species that are fit for the countryside in the location continuously uncovered to air pollutants emanating on or after steel manufacturing within Beijing.

## Material and Methods

Details of material used, techniques adopted and experimental procedures during the course of investigation were presented as:-

**Selection of Study area Lucknow:**

Lucknow falls under the Uttar Pradesh. The geographically Lucknow city fallsstuck between $26.50^0$ N and $80.50^0$ E. Lucknow is positioned at 123 meters above sea level.

**Site selection and sampling:**

District Lucknow purposively selected on the basis of highly polluted area or U.P.In order to collect air and plant samples following three different sites of Lucknow considered for study purposively namely**:-**1. Gomti Nagar,2. Central School and 3. Lalbagh.

**Estimation of APTI:**

Air pollution tolerance index determined with the help ofSingh and Rao(1983) methods.

APTI calculated by:-

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

Here,

A denoted for Ascorbic acid content measured in (mg/g)

Tconnotes for Total chlorophyll measured in (mg/g)

P connotes for leaf extract pH

R connotes for Relative Water Content in leaf measured in (%)

**Estimation of API**

Merging the outcome of APTI standardsbyvariousconnected biological along with socio-economic factors. API can be deliberate for diverse species given by Shannigrahi (2004). On the bases of these factors, given the specialrank (+ or -) are selected to vegetation. Diversevegetation score are count with to their ranks. The criterion used for progression of plant species on the behalf of APTI and further biological as well as socio-economic is specified in following table 3 and table 4.

**Table-1: API ranking (Shannigrahi *et al.*, 2004)**

| Rank | Score cards in (%) | Plant evaluation |
|---|---|---|
| 0 | 0-30 | Not suggested |
| 1 | 30–40 | Very poor category |
| 2 | 40–50 | Poor category |
| 3 | 50–60 | Moderate category |
| 4 | 60–70 | Good category |
| 5 | 70–80 | Very good category |
| 6 | 80–90 | Excellent category |
| 7 | 90–100 | Bed category |

**Selection of flora:**

Three species preferredin support of the present study, they were first ***Ficusbengalensis,*** Second ***Ficusreligiosa and*** third ***Alstoniascholaris***

**Statistical Analysis**

Data recorded regarding to quantitative factor the followthe statistical measuresas described as

**Analysis of Variance**

The observations recorded for different parameters of 3 plants or floras were collected from three different locations with three altitudinal division during the both years2020-21 and 2021-2022 used on behalf of statistical analysis. The significance of differences with treatments was observed at 5 per cent level of significance.

## Result and Discussion

Table 2 depicted the APTI of 3 sites of Lucknow.

**Air Pollution Tolerance Index**

**Air pollution tolerant index of *Ficusbengalensis:***

It was evident from table-2 that in case of *Ficusbengalensis* higher RWC% observed 86.06 % in site 3 Lalbagh followed by site II and Site I while average RWC% 83.50 observed.It was also evident from table-2 that in case of *Ficusbengalensis* higher pH observed 5.7 in Gomti Nagar followed by site II and Site III while average mean observed 3.15.It was also evident from table-2 that in case of *Ficusbengalensis* higherTotal chlorophyll (mg/g) observed 3.30 in Gomti Nagar followed by site II and Site III while average mean observed 3.15.It was also evident from table-2 that in case of *Ficusbengalensis* higher Ascorbic acid (mg/g**)** observed 2.91 in Gomti Nagar followed by site II and Site III while average mean observed 2.82.It was also evident from table-2 that in case of *Ficusbengalensis* higher API observed 11.01 in site 2 Central School followed by site III and Site II while average mean observed 10.73.It also revealed that highest APTI *Ficusbengalensis* 11.01 observed in site 2 Central School.

**Table-2 APTI of three plants**

| **Plant** | ***Ficusbengalensis*** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **RWC%** | | **pH** | | **Overall chlorophyll content (mg/g)** | | **Ascorbic acid Content (mg/g)** | | **API** | |
| | **2020-21** | **2021-22** | **2020-21** | **2021-22** | **2020-21** | **2021-22** | **2020-21** | **2021-22** | **2020-21** | **2021-22** |
| **sites I** | 81.03 ±0.13 | 80.97 ±0.12 | 5.7 ±0.11 | 5.6 ±0.10 | 3.30 ±0.0910 | 3.32 ±0.090 | 2.91 ±0.15 | 2.89 ±0.13 | 10.72 | 10.64 |
| **Site-2 Central School** | 83.42 ±0.17 | 83.13 ±0.14 | 5.3 ±0.14 | 5.2 ±0.12 | 3.12 ±0.094 | 3.13 ±0.092 | 2.86 ±0.12 | 2.82 ±0.12 | 11.01 | 10.69 |
| **Site-3 Lalbagh** | 86.06 ±0.23 | 85.96 ±0.21 | 4.9 ±0.16 | 4.9 ±0.13 | 3.02 ±0.083 | 3.04 ±0.083 | 2.71 ±0.11 | 2.70 ±0.11 | 10.75 | 10.13 |
| Mean | 83.50 ±0.17 | 83.35 ±0.16 | 5.3 ±0.14 | 5.23 ±0.12 | 3.15 ±0.089 | 3.16 ±0.088 | 2.82 ±0.13 | 2.80 ± 0.12 | 10.73 | 10.49 |
| ***Ficusreligiosa*** | | | | | | | | | | |
| **selected sites I** | 87.00 ±0.089 | 86.93 ±0.081 | 7.90 ±0.026 | 7.80 ±0.023 | 9.21 ±0.017 | 9.19 ±0.016 | 0.63 ±0.034 | 0.64 ±0.03 | 9.78 | 9.72 |
| **Site-2 Central School** | 93.00 ±0.062 | 92.86 ±0.063 | 7.14 ±0.016 | 7.23 ±0.014 | 8.43 ±0.025 | 8.40 ±0.023 | 0.67 ±0.06 | 0.68 ±0.06 | 10.34 | 10.31 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Site-3 Lalbagh** | 95.70 ±0.071 | 95.70 ±0.062 | 6.34 ±0.015 | 6.30 ±0.011 | 8.12 ±0.019 | 8.09 ±0.017 | 0.71 ±0.020 | 0.69 ±0.021 | 10.59 | 10.56 |
| Mean | 91.90 ±0.074 | 91.83 ±0.069 | 7.13 ±0.019 | 7.11 ±0.016 | 8.59 ±0.02 | 8.56 ±0.019 | 0.67 ±0.038 | 0.67 ±0.037 | 10.24 | 10.20 |
| ***Alstoniascholaris*** | | | | | | | | | | |
| **selected sites I** | 92.40 ±0.48 | 92.30 ±0.45 | 6.10 ±0.0 | 6.0 ±0.0 | 4.10 ±0.12 | 4.00 ±0.12 | 3.80 ±0.11 | 3.70 ±0.11 | 13.12 | 12.93 |
| **Site-2 Central School** | 86.10 ±0.83 | 86.00 ±0.82 | 5.70 ±0.0 | 5.6 ±0.0 | 2.50 ±0.06 | 2.60 ±0.07 | 3.50 ±0.18 | 3.42 ±0.16 | 11.48 | 11.40 |
| **Site-3 Lalbagh** | 82.10 ±0.62 | 82.00 ±0.57 | 5.30 ±0.07 | 5.33 ±0.06 | 2.10 ±0.04 | 2.20 ±0.05 | 3.10 ±0.10 | 3.07 ±0.11 | 10.50 | 10.52 |
| Mean | 86.67 ±0.64 | 86.77 ±0.61 | 5.70 ±0.02 | 5.64 ±0.02 | 2.90 ±0.07 | 2.93 ±0.08 | 3.47 ±0.13 | 3.40 ±0.13 | 11.65 | 11.62 |

**Air pollution tolerance index:**

It was evident from table-2 that in case of *Ficusreligiosa* higherRWC% observed 95.7 % in site 3 Lalbagh followed by site II and Site I while average RWC% 91.90 observed.It was also evident from table-2 that in case of *Ficusreligiosa* higher pH observed 7.9 in Gomti Nagar followed by site II and Site III while average mean observed 7.13.It was also evident from table-2 that in case of *Ficusreligiosa* higher Total chlorophyll (mg/g) observed 9.21 in Gomti Nagar followed by site II and Site III while average mean observed 8.19. It was also evident from table-2 that in case of *Ficusreligiosa* higher Ascorbic acid (mg/g) observed 0.06 in site 2 followed by site 1 and Site 3 while average mean observed 0.02.It was also evident from table-3 that in case of *Ficusreligiosa higher API observed 10.59 in site 3 followed by site 2 and Site 1 while average mean observed 10.34.*

It revealed that highest APTI *Ficusreligiosa* 10.59. It was evident from table-2 that in case of ***Alstoniascholaris*** higher RWC% observed 92.4 % in site followed by site 2 and Site 3 while average RWC% 86.67 observed.It was also evident from table-2 that in case of ***Alstoniascholaris*** higher pH observed 6.1 in site 1 Gomti Nagar followed by site II and Site III while average mean observed 5.7.It was also evident from table-2 that in case of ***Alstoniascholaris*** higher Total chlorophyll (mg/g) observed 4.1 in Gomti Nagar followed by site II and Site III while average mean observed 2.9.It was also evident from table-2 that in case of ***Alstoniascholaris*** higher Ascorbic acid (mg/g) observed 0.18 in Gomti Nagar followed by site II and Site III while average mean observed 0.13.It was also evident from table-2 that in case of ***Alstoniascholaris*** higher API *observed 13.12 in*site 1 followed by site 2 and Site 3 while average mean observed 11.65.It revealed that highest Air Pollution Tolerance Index ***Alstoniascholaris*** 13.12 observed in site 2 Central School.

Results evidently exposed to industrialized pollutant play a major task in declining the chlorophyll and enhancing the ascorbic acid substance in the preferred plants leaves at highly polluted location of Lucknow

**Summary and Conclusion:**

The present study successfully evaluated the air pollution tolerance of three commonly occurring tree species—*Ficusbengalensis*, *Ficusreligiosa*, and *Alstoniascholaris*—growing in selected highly polluted areas of Lucknow district by employing the Air Pollution Tolerance Index (APTI) and Anticipated Performance Index (API). The findings demonstrated considerable variation in pollution tolerance among the selected species and across different study locations, indicating that plant responses to air pollution are species-specific and influenced by environmental conditions.

Among the three species evaluated, *Alstoniascholaris* exhibited the highest Air Pollution Tolerance Index (APTI) value of 13.12, followed by *Ficusbengalensis* (11.01) and *Ficusreligiosa* (10.59). The superior APTI value of *Alstoniascholaris* suggests that it possesses greater physiological and biochemical adaptability to polluted environments, making it more resilient to the adverse effects of atmospheric pollutants. The observed differences in APTI values indicate that the selected plant species employ different adaptive mechanisms to withstand pollution stress.

The study further revealed that exposure to industrial and urban air pollutants significantly influenced the biochemical characteristics of plant leaves. Air pollution was associated with a decline in chlorophyll content, reflecting impairment of the photosynthetic apparatus, while the concentration of ascorbic acid increased in polluted sites. The elevated ascorbic acid content represents an important protective mechanism that enhances the antioxidant capacity of plants and helps them tolerate oxidative stress induced by atmospheric pollutants. Relative water content and leaf pH also contributed significantly to the overall pollution tolerance of the evaluated species, confirming that these physiological parameters are reliable indicators for assessing plant responses to environmental stress.

The investigation also demonstrated that APTI values varied not only among plant species but also across sampling locations and seasons, emphasizing that pollution tolerance is influenced by both genetic characteristics and prevailing environmental conditions. Therefore, assessment of pollution tolerance should incorporate multiple physiological and biochemical parameters rather than relying on a single indicator.

The Anticipated Performance Index (API), which integrates APTI with biological, ecological, and socio-economic characteristics, provided a more comprehensive evaluation of the suitability of plant species for urban plantation. Based on API assessment, *Alstoniascholaris* was categorized as the most suitable species for plantation in highly polluted industrial and urban areas, whereas *Ficusbengalensis* and *Ficusreligiosa* exhibited moderate performance and can also contribute to pollution mitigation when incorporated into mixed plantations.

Overall, the study highlights the importance of selecting pollution-tolerant plant species for urban environmental management and green belt development. The combined use of APTI and API offers a reliable scientific approach for identifying suitable tree species capable of improving urban air quality, reducing the impact of atmospheric pollutants, and enhancing ecological sustainability. It is recommended that *Alstoniascholaris* be extensively planted along roadsides, industrial zones, commercial areas, and other pollution-prone locations in Lucknow and similar urban environments. Furthermore, long-term monitoring involving a wider range of native plant species and additional environmental parameters is recommended to strengthen urban afforestation strategies and support sustainable environmental planning.

## Reference


1. Agarwal, M.: Plants as Biorrionitors of Air pollution In: Environmental Hazaras-plants and people (Ed. By M. Yunis, P.S. Srivastaba and T.O. Siddiqi). CBS Pub. New Delhi: 404(2000).
2. Babu, G. B., Parveen, S. N., Kumar, N. K., & Reddy, M. S.: Evaluation of air pollution tolerance indices of plant species growing in the vicinity of cement industry and Yogi Vemana University campus. Indian Journal of Advances in Chemical Science, 2(1), 16–20 (2013).
3. Bennett, J.H. and Hill, A.C.: Interactions of air pollutants with canopies of vegetation In: J.B. Mudd and T.T. Kozlowski (Eds.) Responses of plants to air pollution, Academic Free, 273-306(1973).
4. Enete, I. C., Chukwudeluzu, V. U., &Okolie, A. O.: Evaluation of air pollution tolerance index of plants and ornamental shrubs in Enugu City: Implications for urban Heat Island effect. World Environment, 3(3), 108–115(2013).
5. Ganguly, S., Das, M., & Mukherjee, A.: Anticipated performance index (API) of some selected phanerophytes considered for Green Belt development. Research Journal of Pharmaceutical, Biological and Chemical Sciences, 8(3), 525–532(2013).
6. Guderian, R: Air pollution, Phytotoxicity of acidic gasses and its significance in air pollution control, Ecological studies, 277-289(1977).
7. Heck, W.W: The use of plants as indicators of air pollution, Intern. J. air water pollution, 10, 99-111(1964).
8. Hickman, A.J.: The estimation of Air pollution Concentrations from Road Traffic, TRRL Report, 1052 (1982).
9. Kameswaran,S.,Gunavathi,Y. & Gopi, Krishna,P: Dust Pollution and its influence on vegetation a critical analysis, Department of Botany, VikramaSimhapuri University PG Centre, Kavali, AP, India, 5(1),341(2019).
10. Kaur, M., & Nagpal, A. K.: 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, 24, 18881–18895(2017).
11. Krishnaveni, M., & Lavanya, K.: Air pollution tolerance index of plants: A comparative study. International Journal of Pharmacy and Pharmaceutical Sciences, 6(5), 320–324 (2014).
12. Kumari, J., &Deswal, S.: Assessment of air pollution tolerance index of selected plants unveils to traffic roads of Noida, Uttar Pradesh. International Journal on Emerging Technologies, 8(1), 179–184(2017).
13. Liu, Y., & Ding, H. :Variation in air pollution tolerance index of plants near a steel factory: Implications for landscape-plant species selection for industrial areas. WSEAS Transactions on Environment and Development, 4(1), 24–32(2008).
14. Maawali, R. A., &Sulaiman, H. :Trees for air pollution tolerance to develop green belts as an ecological mitigation. World Academy of Science, Engineering and Technology, International Journal of Environmental, Chemical, Ecological, Geological and Geophysical Engineering, 11(2), 106–109(2017).
15. Przybysz, A., Sæbø, A., Hanslin, H.M. &Gawroñski, S.W: Accumulation of particulate matter and traceelements on vegetation as affected by pollution level, rainfall and the passage of time. Sci.Tot. Environ., 481: 360-369(2014).
16. Rai, P.K. Environmental magnetic studies of particulates with special reference to biomagnetic monitoring using roadside plant leaves. Atmos. Environ., 72: 113-129(2013).
17. Rai, P.K.: Particulate matter tolerance of plants (APTIand API) in a biodiversity hotspot located in a tropicalregion: Implications for eco-control Particulate. Sci. Tech.,38: 193-202(2020).
18. Rai, P.K. & Panda, L.L.: Dust capturing potential and airpollution tolerance index (APTI) of some road side tree vegetation in Aizawl, Mizoram, India: an Indo-Burma hotspot region. Air Quality, Atmos Health, 7: 93-101(2014).
19. Sanaeirad, H., Majd, A., Abbaspour, H. &Peyvandi, M.: The effect of air pollution on proline and protein contentand activity of nitrate reductase enzyme in Laurus nobilis L. plants, J. Mol. Biol. Res, 7, 99-105(2017).

20. Sicard, P., De Marco, A., Dalstein-Richier, L., Tagliaferro, F.,Renou, C. &Paoletti, E.: an epidemiological assessment of stomatal ozone flux-based critical levels for visible ozone injury in Southern European forests. Sci. Total Environ. 541: 729-741(2016).
21. Sikarwar, A. & Rani, R.: Assessing the immediate effectof COVID-19 lockdown on air quality: A case study of Delhi, India. J. Environ. Geogr., 13(3-4), 27-33(2020).
22. Trivedi, S. & Agrawal, M.: Air quality status in Varanasicity. J. Environ. Stud. Policy, 6, 75 (2020).
23. Verma, A. & Singh, S. N.: Biochemical and ultra structural changes in plant foliage exposed to auto-pollution. Environ. Monit. Assess.,120, 585-602(2006).
24. Wang, J.X., Sun, X.W., Yang, Y., Huang, H., Lee, Y.C., Tan, O.K.&Vayssieres, L.: Hydrothermally grown oriented ZnOnanorod arrays for gas sensing applications. Nanotechnology, 17, 4995(2006).
25. Xie, X., Semanjski, I., Gautama, S., Tsiligianni, E., Deligiannis, N., Rajan, R.T., Pasveer, F., Philips, W. : A review of urban air pollution monitoring and exposure assessment methods. ISPRS International Journal of Geo-Information, 6, 389 (2017).
26. Xu, Y., Xu, W., Mo, L., Heal, M.R., Xu, X. & Yu, X: Quantifying particulate matter accumulated on leaves by17 species of urban trees in Beijing, China. Environ. Sci.Pollut. Res,25, 12545-56(2018).
27. Zhu, N., Zhang, D., Wang, W., Li, X., Yang, B., Song, J., Zhao, X., Huang, B., Shi, W., Lu, R., Niu, P: A novel corona virus from patients with pneumonia in China, 2019. New England Journal of Medicine, 382, 727-733(2020)
28.