Eco. Env. & Cons. 30 (January Suppl. Issue) : 2024; pp. (S154-S158)
Copyright@ EM International
ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2024.v30i01s.029

Assessment of the Air pollution tolerance capacity of trees for development of greenery around the industrial area

Shivam Dinkar[1], Brijendra Pratap Singh[1], Kamesh[1]*, Shailly Misra[2], Chandresh Kumar Singh[1], Tulika Johri[3], Ramesh[1] and Rajesh Kumar[1]

[1]Department of Forestry, Wildlife and Environmental Sciences, Guru Ghasidas (A Central University) Vishwavidyalaya, Bilaspur 495 009, Chhattisgarh, India
[2]Department of Botany, University of Lucknow, Lucknow 226 026, U.P., India
[3]Department of Botany, Shri Jai Narain Mishra P.G. Collage, Lucknow 226 001 U.P., India

(Received 19 June, 2023; Accepted 19 August, 2023)

ABSTRACT

The effectiveness of trees for reducing air pollution has been widely recognized. To mitigate the threat of pollution, it is essential to increase tree planting in industrial areas. It is essential for selecting plants that can withstand air pollution while developing a green belt. The present study is on evaluation of air pollution tolerance index for fifteen dominated tree species around the industrial area Sirgitti, Bilaspur. The leaves samples were collected for analysis of several biochemical parameters such as leaf pH, ascorbic acid, total chlorophyll, and relative water content and APTI. The highest APTI value was recorded in *Moringa oleifera* (13.83) and lowest in *Butea monosperma* (7.81) followed by *Neolamarckia cadamba* (11.27), *Peltophorum petrocarpum* (11.01), *Ficus benghalensis* (10.89), *Saraca asoca* (10.85), *Ficus religiosa* (10.29), *Melia azedarach* (9.98), *Acacia nilotica* (9.71), *Azadirachta indica* (9.62), *Eculaptus alba* (8.91), *Millettia pinnata* (8.82), *Tectona grandis* (8.61), *Ziziphus mauritiana* (8.22), and *Syzygium cumini* (8.08) were estimated for tolerance trees in industrial area. High APTI value tree species are tolerant to air pollution and also best suited for the green belt development in industrial area.

Key words: *Tree, Plantation, Industrial areas, APTI, Green belt, Air pollution, Leaf, Biochemical.*

Introduction

Humanity profited from the industrialization in terms of both social and material progress. Additionally, it has brought about a number of undesirable chemicals and societal issues. The deterioration of the environment is one of the aforementioned problems. The environment upon which humanity's way of life depends most has been harmed by pollution that man brought about by irrational, unscientific development and mineral extraction (Bhardwaj *et al.*, 2023a; Rai *et al.*, 2013; Singh and Tandon, 2009). Rapid industrialization and urbanization are inevitable dangerous outcomes that have a range of negative consequences on both plant and human societies. Since the rise of industrialization, it has been a significant environmental problem, leading to a larger discharge of gaseous and particle pollution into the atmosphere (Bhardwaj *et al.*, 2023b; Singh and Tandon, 2010). In recent years, our atmosphere has become overburdened with air pollutants of all types due to the considerable industrialization and urbanization that has occurred in all Indian cities and small towns. As a consequence of the accelerated development over the past three decades, when newly industrialized nations underwent unmatched economic growth with an increase in urban population, resulted in high levels of emissions from transportation, manufacturing, and refuse combustion. Many developing countries, including India there have been a progressive degradation in air quality. In Asian nations, the general health of the environment, especially air quality, has significantly deteriorated due to growing urban populations, industrial activity, and automated traffic (Anonymous. 2006; Chandra *et al.,* 2021; Skrynetska *et al*., 2018). The combined effects of the particle and gaseous contaminants may severely damage the entire physiology of plants (Chandra and Kumar, 2023). Every ecosystem hinge on plants, and they are also those which are most prone to be harmed by air pollution. Moreover, the impacts are frequently visible on leaves, which are typically the most numerous and visible primary receivers of several air contaminants. Trees can be implemented as a bioindicator to track air pollution since they are exceptionally sensitive to both gaseous and particle contaminants (Rao, 1983). Due to their large leaf surface area, plants reduce the amount of air pollutants in the environment by impinging, absorbing, and accumulating (Darro *et al.,* 2022; Escobedo *et al*., 2008) them. An effective method for assessing the effects of air pollution is through the bio monitoring of plants (Bakiyaraj and Ayyappan, 2014; Kamesh *et al*., 2023). Although leaves are the most vulnerable portion of plants to air pollution, they undergo physiological changes before showing obvious harm to their leaves. As a way to study the negative effects of air pollution, certain parameters were used, including ascorbic acid, chlorophyll, the pH of leaf extract, and relative water content. The air pollution tolerance index (APTI) of plants is generated based on these morphological and biochemical characteristics to assess their susceptibility and tolerance to air pollution (Chauhan and Joshi, 2010). The awareness regarding plant's tolerance and sensitivity to various contaminants allowed us to determine the reaction of plant to air pollution.

Materials and Methods

Study site: The present study was conducted during June 2022 to September 2022 in Sirgitti, the industrial site of Bilaspur, Chhattisgarh. Large number of major and minor industries (steel, thermal power plant and other industries) is situated in Sirgitti area.

Tree species

Fifteen tree species were selected for the studies which were frequently occurring in surrounding of Sirgitti area (Table 1).

Table 1. Shows the list of selected tree species.

Tree species	Common name	Family
Ficus religiosa	Peepal	Moraceae
Ficus benghalensis	Banyan	Moraceae
Saraca asoca	Ashoke	Fabaceae
Peltophorum petrocarpum	Gulmohar	Fabaceae
Neolamarckia cadamba	Kadamb	Rubiaceae
Moringa olifera	Moringa	Moringaceae
Ziziphus mauritiana	Ber	Rhamnaceae
Melia azedarach	Mahaneem	Meliaceae
Eculaptus alba	Nilgiri	Myrtaceae
Millettia pinnata	Karanj	Fabaceae
Butea monosperma	Palash	Fabaceae
Tectona grandis	Teak	Lamiaceae
Azadirachta indica	Neem	Meliaceae
Acacia nilotica	Babool	Fabaceae
Syzygium cumini	Jamun	Myrtaceae

Sample collection: Fresh leaf samples of different tree species were collected at height 2.4 m above ground level and were bagged and transferred to the laboratory, Department of Forestry, Wildlife and Environmental Science, GGV, Bilapsur for further analysis.

Analysis of sample: The biochemical parameters (total chlorophyll content, pH, ascorbic acid, and relative water content) of selected tree species were analyzed for APTI calculation. Leaf extract pH (Sharma *et al.,* 2019), total chlorophyll content (Singare and More, 2020), ascorbic acid (Roy *et al.,* 2020) and relative water content (Sahu *et al.,* 2020) were determined. APTI as demonstrated through (Govindaraju *et al.,* 2012) following equation:

$$\text{APTI} = \frac{\text{Ascorbic acid (total chlorophyll content + leaf pH) + relative water content}}{10}$$

APTI has different categories according to their APTI values Yadav and Pandey (2020):

< 6.0 = very sensitive

6.1 -7.0 = sensitive

7.1-8.0 = intermediate

8.1-9.0 = tolerant
>9.1 = very tolerant

Results and Discussion

Changes in leaf extracts pH: The data revealed the highest leaf extract pH of *Ficus benghalensis* 8.04 and lowest of *Syzygium cumini* 4.35 (Figure 1). While the leaf pH of other tree species *Ficus religiosa, Butea monosperma, Millettia pinnata, Ziziphus Mauritiana, Melia azedarach, Moringa oleifera, Azadirachta indica, Saraca asoca, Tectona grandis, Eculaptus alba, Peltophorum petrocarpum, Neolamarckia cadamba* and *Acacia nilotica* recorded were 7.0, 6.6, 6.45, 6.27, 6.12, 5.98, 5.87, 5.78, 5.67, 5.58, 5.47, and 4.77, respectively (Table 2). Similar leaf extract pH response was recorded in industrial areas (Ahmad *et al.*, 2019; Patel and Kumar, 2018; Sahu *et al.*, 2020). Hence, higher pH ranges in the leaf extract make plants more tolerant to the pollutants. Even in polluted environments, plants may be more tolerant when their leaf extract pH is lower (Balasubramanian *et al.*, 2018).

Changes in relative water content: The highest RWC was recorded in *Moringa oleifera* (135.71%) and lowest in *Syzygium cumini* (64.71 %) (Table 2, Figure 1). RWC (%) of other tree species were recorded *Peltophorum petrocarpum* (94.44), *Neolamarckia cadamba* (92.86), *Ficus religiosa* (92.31), *Saraca asoca* (92.31), *Ficus benghalensis* (86.67), *Acacia nilotica* (85.71), *Eculaptus alba* (81.82), *Millettia pinnata* (81.85), *Azadirachta indica* (77.78), *Tectona grandis* (77.78), *Melia azedarach* (76.7), *Ziziphus mauritiana* (70.00) and *Butea monosperma* (66.67). Almost same result was observed for relative water content in different tree species in industrial sites (Balasubramanian *et al.*, 2018; Banerjee *et al.*, 2016; Govindaraju *et al.*, 2012). A plant body containing a lot of water might help it to retain its physiological balance and the transpiration rates are often high when facing stress (such as expossure to air pollution) (Balasubramanian *et al.*, 2018).

Changes in total chlorophyll content of leaf: The maximum total chlorophyll reported in 1.158 mg/g for *Neolamarckia cadamba* and minimum 0.442 mg/g for *Millettia pinnata* (Figure 1). The total chlorophyll content (mg/g) in *Azadirachta indica, Melia azedarach, Peltophorum petrocarpum, Acacia nilotica, Saraca asoca, Ficus religiosa, Moringa olifera, Tectona grandis, Syzygium cumini, Ziziphus Mauritiana, Ficus benghalensis, Butea monosperma, Eculaptus alba,* and *Millettia pinnata* were 0.815, 0.745, 0.684, 0.644, 0.613, 0.575, 0.568, 0.559, 0.543, 0.522, 0.512, 0.495, and 0.463, respectively (Table 2). Similar findings on total chlorophyll of leaves have been reported by previous researchers in different industrial sites (Chauhan and Joshi, 2010; Roy *et al.*, 2020). Plants with increased chlorophyll content were more tolerant to air pollution. Water stress causes the chloroplast to produce reactive oxygen species (ROS), which lowers the chlorophyll level in the leaves (Balasubramanian *et al.*, 2018).

Changes in ascorbic acid content: *Melia azedarach* (3.4 mg/g) showed highest ascorbic acid and *Moringa olifera* (0.4 mg/g) showed lowest ascorbic

Table 2. The leaf extract pH, total chlorophyll, ascorbic acid content, relative water content, APTI and tree response of selected trees.

Trees	pH	RWC (%)	TCC (mg/g)	AA (mg/g)	APTI Value	APTIresponse
Ficus religiosa	7.0	92.31	0.575	1.4	10.29	Very Tolerant
Ficus Benghalensis	8.04	86.67	0.512	2.6	10.89	Very Tolerant
Saraca asoca	5.87	92.31	0.613	2.5	10.85	Very Tolerant
Peltophorum petrocarpum	5.58	94.44	0.684	2.5	11.01	Very Tolerant
Neolamarckia cadamba	5.47	92.86	1.158	3	11.27	Very Tolerant
Moringa olifera	5.98	135.71	0.568	0.4	13.83	Very Tolerant
Ziziphus mauritiana	6.27	70.00	0.522	1.8	8.22	Tolerant
Melia azedarach	6.12	76.47	0.745	3.4	9.98	Very Tolerant
Eculaptus alba	5.67	81.82	0.463	1.2	8.91	Tolerant
Millettia pinnata	6.45	81.25	0.442	1	8.81	Tolerant
Butea monosperma	6.6	66.67	0.495	1.6	7.81	Intermidiate
Tectona grandis	5.78	77.78	0.559	1.3	8.61	Tolerant
Azadirachta indica	5.98	77.78	0.815	2.7	9.62	Very Tolerant
Acacia nilotica	4.77	85.71	0.644	2.1	9.71	Very Tolerant
Syzygium cumini	4.35	64.71	0.543	3.3	8.06	Tolerant

acid (Figure 1). Other trees showed ascorbic acid content (mg/g) *Syzygium cumini* (3.3), *Neolamarckia cadamba* (3), *Azadirachta indica* (2.7), *Ficus benghalensis* (2.6), *Peltophorum petrocarpum* (2.5), *Saraca asoca* (2.5), *Acacia nilotica* (2.1), *Ziziphus mauritiana* (1.8), *Butea monosperma* (1.6), *Ficus religiosa* (1.4), *Tectona grandis* (1.3), *Eculaptus alba* (1.2), and *Millettia pinnata* (1.0) (Table 2). Similar results was reported of ascorbic acid content in trees (Chauhan and Joshi, 2010; Patel and Kumar, 2018; Sahu *et al*., 2020). Ascorbic acid is an effective anti-oxidant that inhibits the buildup of H_2O_2, O_2, and OH in chloroplasts caused by SO_2 and prevents the in-activation of chlorophyll and enzymes of the CO_2 fixation cycle. It is crucial to understand the sensitivity of plants to SO_2 in addition to leaf pH. Therefore, plants that retain high ascorbic acid content in polluted sites are thought to be tolerant to air pollution stress (Swami and Chauhan, 2015).

Air pollution tolerance index (APTI): The *Moringa oleifera* revealed highest APTI value for 13.83 and *Butea monosperma* showed lowest APTI value for 7.81 (Figure 1). Similar result of air pollution tolerance index was reported (Gupta *et al.,* 2020; Kaur and Nagpal, 2017; Patel *et al.,* 2023). Almost all the tree species showed tolerance response against the air pollution in industrial sites while the *Butea monosperma* was found to be sensitive to air pollution (Table 2).

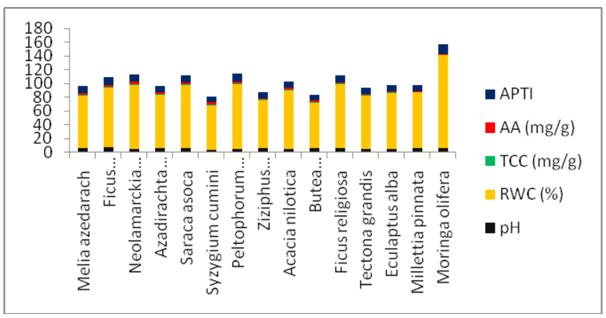

Fig. 1. Graphical representation of trees with different biochemical parameters.

Conclusion

Air pollution in industrial area of Sirgitti, Bilaspur city could be mitigated by developing forest in the city by choosing air pollution tolerant trees. To fulfill this aim air pollution tolerance index (APTI) for 15 commonly found tree species were estimated. *Moringa oleifera* showed highest APTI value and *Butea monosperma* with lowest value. While the four trees such as *Ziziphus mauritiana, Eculaptus alba, Millettia pinnata, Tectona grandis, Syzygium cumini showed* tolerant against industrial pollution site and *Butea monosperma* was showed intermediate response. This work is significant in demonstrating trees the selection of most suitable trees for green belt development in industrial and urban area.

References

Ahmad, I., Abdullah, B., Dole, J. M., Shahid, M. and Ziaf, K. 2019. Evaluation of the air pollution tolerance index of ornamentals growing in an industrial area compared to a less polluted area. *Horticulture, Environment, and Biotechnology.* 60: 595-601.

Anonymous, 2006. Annual report. CPCB 4: 80-99.

Bakiyaraj, R. and Ayyappan, D. 2014. Air pollution tolerance index of some terrestrial plants around an industrial area. *International Journal of Modern Research and Reviews.* 2(1): 1-7.

Balasubramanian, A., Prasath, C.N., Gobalakrishnan, K. and Radhakrishnan, S. 2018. Air pollution tolerance index (APTI) assessment in tree species of Coimbatore urban city, Tamil Nadu, India. *International Journal of Environment and Climate Change.* 8(1): 27-38.

Banerjee, S., Palit, D. and Banerjee, A. 2016. Changing strategies of biochemical physiological features of selected plant species on effect of air pollution in Eastern Steel City, Durgapur, India. *International Journal of Current Microbiology and Applied Sciences*. 5(9): 733-741.

Bhardwaj, A.K., Chandra K.K. and Kumar, R., 2023a. Mycorrhizal inoculation under water stress conditions and its influence on the benefit of host microbe symbiosis of *Terminalia arjuna* species. *Bulletin of the National Research Centre.* 47(89): 1-13. https://doi.org/10.1186/s42269-023-01048-3

Bhardwaj, A.K., Chandra, K.K., and Kumar, R. 2023b. Water stress changes on AMF colonization, stomatal conductance and photosynthesis of *Dalbergia sissoo* seedlings grown in entisol soil under nursery condition. *Forest Science Technology*. 1(19): 47-58 https://doi.org/10.1080/21580103.2023.2167873.

Chandra, K.K. and Kumar R. 2023. *Forestry Practicals*. Scientific publisher, Jodhpur, India.

Chandra, K.K., Bhardwaj, A. K., Singh, A. and Kumar, R. 2021. Impact of drought on tropical forests and plant mechanisms to mitigate drought stress. *Tropical Dry Forest: Emerging Features and Ecology Perspectives*. (Eds. Chaturvedi RK, Singh R., Bhadouria R.), Nova Science Publisher, New York, USA.

Chauhan, A. and Joshi, P.C. 2010. Effect of ambient air pollutants on wheat and mustard crops growing in the vicinity of urban and industrial areas. *New York Science Journal.* 3(2): 52-58.

Darro, H., Swamy, S. L., Kumar, R. and Bhardwaj, A.K. 2022. Comparison of Physico-chemical Properties of Soils under Different Forest Types in Dry Tropical Forest Ecosystem in Achanakmar-Amarkantak Biosphere Reserve, India. *Eco. Env. & Cons.* 28 : S163-S169.

Escobedo, F.J., Wagner, J.E. and Nowak, D.J. 2008. Analyzing the cost effectiveness of Santiago, Chile's policy of using urban forest to improve air quality. *Journal of Environmental Management.* 86: 148-157.

Govindaraju, M., Ganeshkumar, R.S., Muthukumaran, V.R. and Visvanathan, P. 2012. Identification and evaluation of air-pollution-tolerant plants around lignite-based thermal power station for greenbelt development. *Environmental Science and Pollution Research.* 19: 1210-1223.

Gupta, A. Kumar, M. Chauhan, A. Kumar, A. and Tripathi, A. 2020. Assessment of air pollution tolerance index and evaluation of air pollution anticipated performance index of various plants and their application in planning of Moradabad city, India. *Poll Res.* 39(4): 463-473.

Kamesh, Singh, B.P., Misra, S., Verma, K.K., Singh, C.K. and Kumar, R. 2023. An emerging adsorption technology and its applicability on trees as an adsorbent for the remediation of water pollution: A review. *Eco. Env. & Cons.* 29 (2): 627-640. http://doi.org/10.53550/EEC.2023.v29i02.014

Kaur, M., and Nagpal, A. K. 2017. 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.

Patel, D. and Kumar, J. N. 2018. An evaluation of air pollution tolerance index and anticipated performance index of some tree species considered for green belt development: a case study of Nandesari industrial area, Vadodara, Gujarat, India.

Patel, K., Chaurasia, M. and Rao, K. S. 2023. Urban dust pollution tolerance indices of selected plant species for development of urban greenery in Delhi. *Environmental Monitoring and Assessment*. 195(1): 16.

Rai, P.K., Pandaa, L.L.S., Chutia, B.M. and Singh, M.M. 2013. Comparative assessment of Air Pollution Tolerance Index (APTI) in the industrial (Rorkela) and non-industrial area (Aizawal) of India: An eco management approach. *African Journal of Environment Science* and *Technology.* 7(10): 944-948.

Rao, D.N. 1983. Sulphur dioxide pollution versus plant injury with special reference to fumigation and precipitation, In: *Proceedings of the Symposium on Air Pollution Control. Indian Association for Air Pollution Control*, New Delhi, India. 1: 91-96.

Roy, A., Bhattacharya, T. and Kumari, M. 2020. Air pollution tolerance, metal accumulation and dust capturing capacity of common tropical trees in commercial and industrial sites. *Science of The Total Environment.* 722: 137622.

Sahu, C., Basti, S. and Sahu, S.K. 2020. Air pollution tolerance index (APTI) and expected performance index (EPI) of trees in sambalpur town of India. *SN Applied Sciences*. 2: 1-14.

Sharma, B., Bhardwaj, S.K., Sharma, S., Nautiyal, R., Kaur, L. and Alam, N.M. 2019. Pollution tolerance assessment of temperate woody vegetation growing along the National Highway-5 in Himachal Pradesh, India. *Environmental Monitoring and Assessment*. 191: 1-14.

Singare, P.U. and More, S.N. 2020. Identification of the most tolerant plant species along the Chembur industrial area of Mumbai: a key step to mitigate global air pollution. *SN Applied Sciences.* 2(10): 1663.

Singh, B.P. and Tandon P.K. 2009. Effect of river water pollution on hematological parameters of fish, Wallagoattu. *Res Environ Life Sci.* 2(4): 211-214.

Singh, B. P. and Tandon, P.K. 2010. Assessment of water quality of river Suheli and Gomti. *Research in Environment and Life Sciences.* 3 (2): 93-103

Skrynetska, I., Ciepa³, R., Kandziora-Ciupa, M., Barczyk, G., and Nadgórska-Socha, A. 2018. Ecophysiological responses to environmental pollution of selected plant species in an industrial urban area. *International Journal of Environmental Research.* 12: 255-267.

Swami, A., and Chauhan, D. 2015. Impact of air pollution induced by automobile exhaust pollution on air pollution tolerance index (APTI) on few species of plants. *Science*. 4(3): 342-343.

Yadav, R. and Pandey, P. 2020. Assessment of Air Pollution Tolerance Index (APTI) and Anticipated Performance Index (API) of roadside plants for the development of greenbelt in urban area of Bathinda City, Punjab, India. *Bulletin of Environmental Contamination and Toxicology.* 105: 906-914.