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Megha V Majethiya and
Department of Biosciences (UGC-CAS), Saurashtra University, Rajkot, Gujarat, India

Mital J Kaneria
Department of Biosciences (UGC-CAS), Saurashtra University, Rajkot, Gujarat, India

Corresponding Author:
Mital J Kaneria
Department of Biosciences (UGC-CAS), Saurashtra University, Rajkot, Gujarat, India

Air pollution tolerance index of selected plants from the industrial area of Rajkot

Megha V Majethiya and Mital J Kaneria

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Abstract
Air pollution poses a significant threat to urban ecosystems, particularly in rapidly industrializing regions such as Rajkot, India. Plants serve as effective bioindicators and biomitigators of air pollution, and their tolerance can be quantified using the Air Pollution Tolerance Index (APTI). Present study evaluates the APTI of selected plant species growing in the industrial area of Rajkot to assess their potential for urban greening and pollution mitigation. Physiological and biochemical parameters were measured to calculate the APTI values. The results revealed considerable variation in tolerance levels among the studied species, with *Azadirachta indica*, *Cassia siamea*, and *Alstonia scholaris* exhibiting high tolerance, making them suitable candidates for plantation in polluted zones. The findings underscore the importance of selecting appropriate plant species for urban landscaping and ecological restoration in industrially impacted areas. This study contributes valuable data for sustainable urban planning and highlights the critical role of green belts in improving air quality.

Keywords: APTI, Rajkot, pH, industrial area, relative water content, total chlorophyll

Introduction
The industrial region shows significant sources of air polluting agents. The emissions of one or more of these pollutants are evident depending on the raw materials utilized. The decline in air quality primarily stems from human-generated emissions linked to transportation, industry, and household heating, significantly impacting urban populations around the globe. The increasing human population, alongside a diminishing green environment, has led to polluted ambient air. Over the past few decades, air pollution has escalated into a significant issue, primarily driven by urban and industrial growth. There has been a rapid expansion in both the industrial and automotive sectors across all cities and towns. The combination of industrial advancement and a sharp rise in vehicle numbers has resulted in a drastic alteration of the atmosphere. Pollution predominantly arises from human activities such as waste disposal, incomplete burning of fossil fuels and firewood or other detrimental secondary products harmful to living beings. Air pollution stands as one of the critical issues the world faces today due to ongoing fluctuations in the concentration of certain gases and trace metals in the environment caused by human activities like road transportation and vehicle traffic. Clean air is the most vital resource needed for the survival of all life forms, and every organism requires unpolluted air for proper growth and development. However, anthropogenic influences adversely affecting plant life (Karmakar *et al*., 2016) [19]. Clean air is essential for sustaining life, and all organisms require it for their healthy development. Yet, this essential air has now become heavily contaminated.
The presence of both particulate and gaseous pollutants, either individually or together, can significantly hinder the overall physiological processes in plants (Anda, 1986) [4]. Primary pollutants infiltrate the plant body via stomatal openings during gas exchange. Additionally, cement dust can elevate leaf surface alkalinity (up to pH 12), which hydrolyzes lipid and wax components and denatures proteins, ultimately leading to plasmolysis of the leaf (Prajapati, 2012) [25]. The accumulation of limestone dust on lichen thalli damages their photosynthetic apparatus (Arianoutsou *et al*., 1993) [5]. With a high pollution load, the increased content of ascorbic acid results in a higher rate of reactive oxygen species (ROS) production during the photo-oxidation of SO_2 to SO_3 (Jyothi and Jaya, 2010) [17]. The absorption of SO_2 causes both visible and invisible injuries to plants. Under favorable environmental conditions, it promotes stomatal opening, resulting in the deposition of highly water-soluble SO_2 in plants, which ionizes to form hydrogen ions (H^+), SO_3^{2-}, and HSO_3^-ions based on the pH (Giordano *et al*., 2005) [14].

The free radicals generated through oxidation harm key physiological activities, including amino acids, plant hormones (IAA), chlorophyll, and carotenoids, which contribute to stunted plant growth (Arora *et al*., 2002) [7]. In the leaves, NO_2 reacts to form nitrous acid, which is then converted to ammonia and incorporated into the synthesis of amino acids and proteins. The combination of SO_2 and NO_2 has been shown to cause more yield loss than SO_2 alone (Agrawal *et al*., 1991) [2]. Meanwhile, SPM contributes to the encrustation of leaf cuticles, as particulate matter penetrates into the epicuticular wax, potentially reducing incident light intensity and disrupting thermal balance within the leaf. Furthermore, gaseous and particulate fluorides settle on plant surfaces and are absorbed through leaf stomata, traveling along the transpiration stream and accumulating to toxic levels in leaf tips and margins (Emberson *et al*., 2003) [13].

Plants play a crucial role in all ecosystems and are likely to suffer from air pollution as they are among the organisms that are most susceptible to the effects of airborne contaminants. The impacts of pollution are mainly visible on the leaves, which serve as the primary receptors for a wide variety of airborne pollutants. Utilizing plants for bio-monitoring is a valuable method for assessing the influence of air pollution. A greenbelt refers to the extensive planting of trees (both evergreen and deciduous) aimed at effectively reducing air pollution by filtering, intercepting, and absorbing harmful substances (Sharma and Roy 1997) [35]. Trees offer a vast leaf area for the deposition of particulate matter and the removal of gases. Various parts of a tree contribute to the elimination of pollution, Greening through plantation, which utilizes vegetation to eliminate, detoxify, or stabilize persistent pollutants, serves as an environmentally friendly method for achieving a clean environment. Identifying effective plants for capturing particulates is crucial for reducing air pollution in urban settings. The APTI is a key measure that assesses the ability of plants to withstand air pollution, and plants with a higher index value can serve as natural sinks for carbon dioxide sequestration (Bamniya *et al*., 2011) [8]. The sensitivity and tolerance of plants to air pollutants differ based on several fundamental biochemical parameters. The APTI, developed by Singh and Rao (1983) [36], is calculated using these four biochemical parameters. Therefore, the objective of this study was to evaluate the APTI of plants located in the industrial area of Rajkot.

Materials and Methods

Fresh leaves of the randomly selected six plants (Table 1) were collected from the study site, a chosen industrial area in Rajkot, Gujarat, India, and immediately taken to the laboratory for further analysis. The total chlorophyll was estimated principally by the method of Arnon (1949) [6]. Ascorbic acid content was measured by the Titrimetric method using 2, 6, Dichlorophenol indophenols dye (Sadasivam and Balasubraminan, 1987) [31]. The pH of the filtered leaf extract was measured with the help of a digital pH-meter with a glass electrode dip in a homogenized solution of leaf filtrate. The glass electrode was calibrated using the buffer solutions of pH 4 and pH 9 (Singh and Rao, 1983) [36]. Relative water content (RWC) was calculated by using the following formula (Barrs and Weatherley, 1962) [9].

$$RWC = [(FW - DW) / (TW - DW)] \times 100$$

Where

FW=fresh weight, DW=dry weight, TW=turgid weight

The APTI of plant species has been calculated by the following formula proposed by Singh and Rao (1983) [36] to assess the tolerance/resistance power of plants against air pollution.

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

Where,

A=ascorbic acid contents (mg/g), T=total chlorophyll (mg/g), P=pH of leaf extract, R=relative water content (%)

Table 1: List of the selected plant species for the evaluation of air pollution tolerance index from the study site.

Sl. No.	Plant name	Family	Coordinates (Latitude; Longitude)
1	*Ailanthus excelsa* Roxb.	Simaroubaceae	22°264’ N 70°802’ E
2	*Alstonia scholaris* (L.) R.Br.	Apocynaceae	22°266’ N 70°801’ E
3	*Azadirachta indica* A.Juss.	Meliaceae	22°264’ N 70°802’ E
4	*Cassia siamea* Lam.	Fabaceae	22°267’ N 70°803’ E
5	*Dalbergia sissoo* Roxb.	Fabaceae	22°265’ N 70°803’ E
6	*Peltophorum pterocarpum* (DC.) K.Heyne.	Fabaceae	22°264’ N 70°803’ E

Table 2: Total chlorophyll content, Ascorbic acid content, relative water content, pH, and air pollution tolerance index (APTI) of selected plant species from the study site.

SL. No.	Plant name	Total chlorophyll (mg/g)	Ascorbic acid (mg/g)	Relative water content (%)	pH	APTI
1	*Ailanthus excelsa*	1.179	0.061	45.79	5.49	4.62
2	*Alstonia scholaris*	0.24	0.183	49.345	4.65	5.024
3	*Azadirachta indica*	1.164	0.183	63.72	5.15	6.487
4	*Cassia siamea*	0.132	0.122	55.62	3.78	5.609
5	*Dalbergia sissoo*	0.43	0.122	45.075	4.56	4.568
6	*Peltophorum pterocarpum*	0.866	0.183	39.995	5.39	4.114

Results and Discussion

The total chlorophyll content is frequently used to assess how air pollutants impact the photosynthesis rate (Sharma *et al*., 2019) [34]. Total chlorophyll plays a crucial role in plant growth, photosynthetic processes, and biomass production. SO_2 contributes to a decline in chlorophyll levels in plants. When comparing plants in polluted areas to control plants, all species exhibited a reduction in total chlorophyll. Chlorophyll, being the primary pigment for photosynthesis, is indicative of the plant's growth, biomass development, and overall health condition. A reduction in chlorophyll content is proposed as a sign of SO_2 causing damage to chlorophyll, likely through the substitution of Mg^{++} with two hydrogen atoms and the breakdown of chlorophyll molecules into phaeophytin. A significant decrease in total chlorophyll among plants exposed to pollutants reinforces the view that chloroplasts are the main targets of damage by air pollutants, which harm membranes and related molecules including chlorophyll pigments (Allen *et al*., 1987) [3]. The present study revealed that chlorophyll content in all the plants varied with the pollution status of the area. The higher the levels of pollutants, the lower the chlorophyll content as certain pollutants in totality reduce the total chlorophyll content. Among the studied plant species, in study site, the highest total chlorophyll content was found in *Ailanthus excelsa* (1.179 mg/g), followed by *Azadirachta indica* (1.164 mg/g), while the lowest was found in *Cassia siamea* (0.132 mg/g) (Table 2). Chlorophyll content serves as an indicator of photosynthetic activity, which is vital for biomass growth and development (Katiyar and Dubey, 2001) [20].

Ascorbic acid serves as an antioxidant for plants, safeguarding various plant parts against multiple stress factors. Research indicates that ascorbic acid can reduce the amount of ozone that penetrates the cell wall and reaches the plasma membrane (Bellini and Tollio, 2019) [10]. Additionally, ascorbic acid plays a role in the carbon fixation process during photosynthesis by acting as a reducing agent (Wheeler *et al*., 2015) [41]. Tripathi and Gautam (2007) [39] observed that the increased ascorbic acid content in all plant species depends on pollution levels, which may be attributed to a heightened rate of ROS production during the photo-oxidation process. Ascorbic acid serves as a stress-reducing agent and helps in alleviating the effects of sulphur dioxide while acting as an antioxidant. A higher level of ascorbic acid in plant leaves is linked to specific biochemical and physiological traits influenced by the environment (Lima *et al*., 2000) [21] and is found in abundance in all growing parts of the plant, which is vital for resisting adverse environmental conditions, including air pollution. From the study site, highest amount of ascorbic acid found in *Azadirachta indica* (0.183 mg/g), *Alstonia scholaris* (0.183 mg/g) and *Peltophorum pterocarpum* (0.183 mg/g), while lowest was in *Ailanthus excelsa* (0.061 mg/g) (Table 2). The elevated ascorbic acid levels in plants, even after exposure to pollution stress, suggest a significant tolerance to pollution (Manjunath and Reddy, 2019) [24].

Water content plays a crucial role in determining the physiological condition of a plant. The RWC is linked to the permeability of protoplasm within cells. A loss of water and dissolved nutrients can lead to premature leaf aging. The relative water content within a plant assists in sustaining its physiological equilibrium during stressful situations, such as air pollution. A decrease in relative water content signifies an altered physiological condition in the plant due to pollution (Innes and Haron, 2000) [15]. The highest levels of RWC were observed when there was abundant soil moisture and minimal evaporation and transpiration rates. Elevated RWC in leaves aids plants in maintaining physiological balance when faced with stressors (Jabeen 2019) [16]. Consequently, a high RWC value indicates greater resilience to stress in plants (Aghaiee *et al*., 2019) [1]. Increased RWC facilitates the dissolution of airborne pollutants into the cytosol and helps regulate pH levels. Conversely, low relative water content directly influences the cytosolic pH, leading to a drop in pH levels, which reflects the plant's vulnerability to air pollution. The RWC corresponds to the water present when it is fully turgid. In conditions of air pollution, transpiration rates are often elevated, resulting in dryness; thus, a plant's ability to maintain RWC may influence its relative tolerance to pollution. Therefore, the elevated RWC in plant samples from industrial areas may enhance the normal functioning of their biological processes. The increased relative water in samples from industrial sites might contribute to the effective functioning of biological processes in plants. In this study, the highest RWC was observed in *Azadirachta indica* (63.72%) and *Peltophorum pterocarpum* (39.995%) have low RWC (Table 2).

The efficiency of photosynthesis in various plant species is significantly influenced by the pH level of their leaves (Santhanalakshmi *et al*., 2018) [32]. An increase in leaf pH contributes to the conversion of hexose sugars into ascorbic acid (Liu and Ding, 2008) [22] and enhances the reducing capacity of ascorbic acid (Pravin and Madhumita, 2013) [27], thereby improving plants' resistance to pollutants, while lower pH levels are associated with heightened sensitivity to air pollution (Bharti *et al*., 2018) [11]. Reduced pH has been shown to correlate well with sensitivity to air pollution and also hinders the photosynthetic process in plants (Thakar and Mishra, 2010) [38]. When leaves are exposed to acidic pollutants, leaf pH tends to decrease, with more sensitive plant species experiencing a more significant decline compared to tolerant varieties (Rathore *et al*., 2018) [29]. Cells operate optimally at a certain pH level, but prolonged exposure to acidic pollutants can diminish pH levels in less tolerant species, disrupting their biological functions (Saxena and Ghosh, 2013) [33]. pH also serves as an indicator of the type of pollution present at a location; acidic pollutants lead to lower (more acidic) pH values. The plant samples analyzed in this study displayed acidic pH levels, likely due to the presence of specific air pollutants in the environment. The maximum pH was observed in *Ailanthus excelsa* (5.49) which was followed by *Peltophorum pterocarpum* (5.39) and lowest was recorded in *Cassia siamea* (3.78) (Table 2). Changes in the leaf pH may affect the sensitivity of stomata in the presence of air pollutants. Plants exhibited lower pH levels when their leaves were washed to reduce dust accumulation. In contrast, areas with higher dust accumulation have greater dissolution of dust particles in cell sap, leading to an increase in pH (Katiyar and Dubey, 2001) [20]. A high leaf extract pH suggests the presence of SOx, NOx, and other acidic substances. When SO_2 diffuses through stomata, it dissolves in water to create sulphites, bisulphates, and their ionic forms, producing protons that affect cellular pH. Consequently, it is suggested that the observed shift towards acidic pH in most species is attributed to the ingress of SO_2 into the leaf mesophyll (Deepalakshmi *et al*., 2013) [12].

According to Zhang *et al*. (2016) [42], not only do tolerant plants mitigate air pollution, but they also contribute to ecological stability, prevent soil erosion, and enhance the visual appeal of polluted regions. The APTI has been utilized as a more accurate tool for landscapers to identify and choose both tolerant and sensitive plant species in relation to air pollution (Singh *et al*., 1991; Viradiya *et al*., 2020) [2, 37, 40]. Sensitive species can act as biological indicators of air pollution, while tolerant species serve as sinks that can help reduce the levels of pollutants in specific environments (Prajapati and Tripathi, 2008; Maity *et al*., 2017) [26, 23]. Plants subjected to constant pollution exposure accumulate contaminants, integrating them into their biological systems, which changes leaf characteristics, making them more susceptible. This heightened sensitivity is assessed through various biochemical changes, ultimately leading to the calculation of APTI. APTI has been employed to categorize trees, shrubs, and herbs as sensitive or tolerant based on their responses to air pollution in both laboratory and field studies (Singh *et al*., 1991) [2, 37]. Plants with an APTI value of ≤ 1 are deemed very sensitive, while those with values between 16 and 1 are classified as sensitive, values from 29 to 17 are considered intermediate, and those ranging from 30 to 100 are recognized as tolerant (Kalyani and Singaracharya, 1995) [18]. APTI provides a measurable value indicating plant tolerance levels to air pollution. The APTI was evaluated and is displayed in Table 2. The APTI value, determined by four biochemical parameters in plant leaves, namely RWC, total chlorophyll content, pH, and ascorbic acid value, can be used to estimate air quality. Plants with a higher index value are more tolerant to air pollution, whereas those with lower index values show reduced tolerance (Singh and Rao, 1983) [36]. Accordingly, the tolerance index for the studied species in industrial locality was as follows. Species like *Azadirachta indica* (6.487), *Cassia siamea* (5.609) and *Alstonia scholaris* (5.024) and recorded highest APTI value compared to species like *Peltophorum pterocarpum* (4.114) with lowest value in APTI (Table 2). This variation in APTI is primarily due to the different pollutant tolerance levels that specific tree species have adapted. From the aforementioned information, it is evident that all the plants analyzed in the experimental area were sensitive to air pollution. A plant species recognized as sensitive or tolerant in one geographical location may display different behavior in another region (Raza *et al*., 1985) [30].

Conclusion

Determining the APTI is crucial, as increased vehicular movement, urbanization, and the rapid rise of small-scale industries contribute to a growing pollution load. Vegetation plays a vital role in cleansing the atmosphere by absorbing gases and some particulate matter through their leaves. In the present study, six plants were evaluated for their APTI in an industrial area, with *Azadirachta indica* showing the highest recorded value. *Azadirachta indica*, *Cassia siamea*, and *Alstonia scholaris* exhibited the highest APTI values, making them suitable for planting in areas stressed by industrial pollution. The APTI results indicate that the studied species are sensitive to air pollution, suggesting their potential as bioindicators of environmental conditions. Furthermore, these species could be integrated into green belts to support environmental policy and management practices in urban industrial regions. Therefore, continuing this type of research on plants is essential for a better understanding of the interactions and correlations between environmental pollution and various ecological, biochemical, and physiological parameters in urban industrial environments.

References

1. Aghaiee N, Zarei L, Cheghamirza K. Evaluation of some morpho-physiological characteristics in strawberry under different moisture stress regimes. J Berry Res. 2019;9:83-93.
2. Agrawal M, Singh SK, Singh J, Rao DN. Biomonitoring of air pollution around urban and industrial sites. J Environ Biol. 1991;12:211-222.
3. Allen LH, Boote KL, Jones JW, Jones PH, Valle RR, Acock B, *et al*. Response of vegetation to rising carbon dioxide photosynthesis, biomass and seed yield of soybeans. Glob Biogeochem Cycles. 1987;13:1-44.
4. Anda A. Effect of cement kiln dust on the radiation balance and yields of plants. Environ Pollut. 1986;40:249-256.
5. Arianoutsou M, Lanaras T, Zaharopoulou A. Influence of dust from a limestone quarry on chlorophyll degradation of the lichen *Physcia adscendens* (Fr.) Oliv. Bull Environ Contam Toxicol. 1993;50:852-855.
6. Arnon DI. Copper enzyme in isolated chloroplasts, polyphenoloxidase in Beta vulgaris. Plant Physiol. 1949;24:1-15.
7. Arora A, Sairam RK, Srivastava GC. Oxidative stress and antioxidative system in plants. Curr Sci. 2002;82:1227-1238.
8. Bamniya BR, Kapoor CS, Kapoor K, Kapasya V. Harmful effect of air pollution on physiological activities of *Pongamia pinnata* (L.) Pierre. Clean Technol Environ Policy. 2011;14:115-124.
9. Barrs HD, Weatherley PE. A re-examination of the relative turgidity technique for estimating water deficits in leaves. Aust J Biol Sci. 1962;15:413-428.
10. Bellini E, Tullio DMC. Ascorbic acid and ozone: Novel perspectives to explain an elusive relationship. Plants. 2019;8:122.
11. Bharti, Kumar S, Trivedi A, Kumar N. Air pollution tolerance index of plants growing near an industrial site. Urban Clim. 2018;24:820-829.
12. Deepalakshmi AP, Ramakrishnaiah H, Ramachandra YL, Radhika RN. Roadside plants as bio-indicators of urban air pollution. IOSR J Environ Sci Toxicol Food Technol. 2013;3:10-14.
13. Emberson L, Ashmore M, Murray F. Air Pollution Reviews. London: Imperial College Press. 2003;(4):372.
14. Giordano M, Norici A, Hell R. Sulfur and phytoplankton: acquisition, metabolism and impact on the environment. New Phytol. 2005;166:371-382.
15. Innes JL, Haron AH. Air pollution and the forests of developing and rapidly industrializing regions. Report No. 4 of the IUFRO Task Force on Environmental Change. Wallingford: CABI, 2000.
16. Jabeen R. Air pollution tolerance index (APTI) of some plants growing on the roads of Abha, Saudi Arabia. Biosci Biotechnol Res Commun. 2019;12:631-616.
17. Jyothi SJ, Jaya DS. Evaluation of air pollution tolerance index of selected plant species along roadsides in Thiruvananthapuram, Kerala. J Environ Biol. 2009;31:379-386.
18. Kalyani Y, Singaracharya M. Bio monitoring of air pollution in Warangal city, Andhra Pradesh. Acta Bot Indica. 1995;23:21-24.
19. Karmakar D, Malik N, Padhy PK. Effects of industrial air pollution on biochemical parameters of Shorea robusta and Acacia auriculoformis. Res J Recent Sci. 2016;5:29-33.
20. Katiyar V, Dubey PS. Sulphur dioxide sensitivity on two stage of leaf development in a few tropical tree species.

Indian J Environ Toxicol. 2001;11:78-81.
21. Lima JS, Fernandes EB, Fawcett WN. *Mangifera indica* and *Phaseolus vulgaris* in the bio indicator of air pollution in Bahia, Brazil. Ecotoxicol Environ Saf. 2000;46:275-278.
22. Liu YJ, Ding H. Variation in air pollution tolerance index of plants near a steel factory: Implications for landscape-plant species selection for industrial areas. WSEAS Trans Environ Dev. 2008;1:24-32.
23. Maity S, Mondal I, Das B, Mondal AK, Bandyopadhyay J. Pollution tolerance performance index for plant species using geospatial technology: Evidence from Kolaghat Thermal Plant area, West Bengal, India. Spat Inf Res. 2017;25:57-66.
24. Manjunath BT, Reddy J. Comparative evaluation of air pollution tolerance of plants from polluted and non-polluted regions of Bengaluru. J Appl Biol Biotechnol. 2019;7:63-68.
25. Prajapati SK. Ecological effect of airborne particulate matter on plants. Environ Skept Critics. 2012;1(1):12-22.
26. Prajapati SK, Tripathi BD. Seasonal variation of leaf dust accumulation and pigment content in plant species exposed to urban particulates pollution. J Environ Qual. 2008;37:865-870.
27. Pravin US, Madhumita ST. Physiological responses of some plant species as a bio-indicator of roadside automobile pollution stress using the air pollution tolerance index approach. Int J Plant Res. 2013;3:9-16.
28. Rai PK, Panda LLS, Chutia BM, Singh MM. Comparative assessment of air pollution tolerance index (APTI) in the industrial (Rourkela) and non-industrial area (Aizawl) of India: An eco-management approach. Afr J Environ Sci Technol. 2013;7:944-948.
29. Rathore DS, Kain T, Gothalkar P. A study of air pollution status by estimation of APTI of certain plant species around Pratapnagar circle in Udaipur city. Int J Agric Environ Biotechnol. 2018;11:33-38.
30. Raza SN, Vijaykumari N, Murthy MS. Air pollution tolerance index of certain plants of Hyderabad. In: Symp Biomonitoring State of Environment. New Delhi: Indian National Science Academy; 1985. p. 243-245.
31. Sadasivam S, Balasubraminan T. Practical Manual in Biochemistry. Coimbatore: Tamil Nadu Agricultural University, 1987, p. 14.
32. Santhanalakshmi P, Teresita VM, Sathyabama S, Josephine BA. Evaluation of air pollution tolerance index of selected plants in south Chennai. Int J Recent Sci Res. 2018;9:25444-25447.
33. Saxena P, Ghosh C. Ornamental plants as sinks and bioindicators. Environ Technol. 2013;34:3059-3067.
34. Sharma ML, Pandey AC, Goswami N. Chemical estimation of air pollutants and its impact on the total chlorophyll contents a and b of Adhatoda vasica and Aloe vera plants. Asian J Res Chem. 2019;12:75-78.
35. Sharma SC, Roy RK. Green belt an effective means of mitigating industrial pollution. Indian J Environ Prot. 1997;17:724-727.
36. Singh SK, Rao DN. Evaluation of plants for their tolerance to air pollution. In: Proc Symp Air Pollution Control. New Delhi: Indian Assoc Air Pollut Control. 1983;1:218-224.
37. Singh SK, Rao DN, Agrawal M, Pandey J, Narayan D. Air pollution tolerance index of plants. J Environ Manag. 1991;32:45-55.
38. Thakar BK, Mishra PC. Dust collection potential and air pollution tolerance index of tree vegetation around Vedanta Aluminium Limited, Jharsuguda. Environ Sci. 2010;3:603-612.
39. Tripathi AK, Gautam M. Biochemical parameters of plants as indicators of air pollution. J Environ Biol. 2007;28:127-132.
40. Viradiya S, Misan V, Kaneria M. Comparative assessment of air pollution tolerance index (APTI) of selected plants from two different industrial sites of Rajkot. Proc Natl Conf Innov Biol Sci (NCIBS). 2020;SSRN, Elsevier:109-117.
41. Wheeler G, Ishikawa T, Pornsaksit V, Smirnoff N. Evolution of alternative biosynthetic pathways for vitamin C following plastid acquisition in photosynthetic eukaryotes. eLife. 2015;4:e06369.
42. Zhang P, Liu Y, Chen X, Yang Z, Zhu M, Li Y. Pollution resistance assessment of existing landscape plants on Beijing streets based on air pollution tolerance index method. Ecotoxicol Environ Saf. 2016;132:212-223.