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Integrated Morpho-anatomical and Eco-physiological Responses of Roadside Plants to Air Pollution: A Critical Synthesis of Tolerance Mechanisms

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Abstract

Roadside plants' internal structure, development, and health are all greatly impacted by air pollution from automobile and industrial pollutants. The effects of air pollution on three species such as *Azadirachta indica*, *Bougainvillaea spectabilis*, and *Ficus religiosa* were assessed in this study. Pollution gradients from heavily traveled urban highways to less polluted control areas were represented by the examined research. Particulate matter levels ($PM_{2.5}$ and PM_{10}) and traffic density were used to measure the intensity of pollution. Leaf area, stomatal density, epidermal cell shape, and cuticle thickness were among the morpho-anatomical factors examined. Compared to control plants, plants growing in polluted locations had significantly lower stomatal density (15–30%) and leaf area (20–35%) ($p < 0.05$). Particulate accumulation on leaf surfaces and visible signs like chlorosis were frequently seen. Cuticle thickening, modified epidermal cells, and particulate particles obstructing stomatal apertures were all discovered by anatomical research. These changes, which include stomatal control, cellular structure, and chlorophyll content, show adaptive responses and damage brought on by pollutant-induced oxidative stress. Variations in species tolerance were shown by an eco-physiological assessment utilizing the Air Pollution Tolerance Index (APTI). *B. spectabilis* showed intermediate sensitivity, whilst *A. indica* exhibited the maximum tolerance.

Key Findings: The importance of morpho-anatomical and physiological traits in biomonitoring and urban greenbelt development was highlighted by vehicle and industrial emissions, which decreased leaf area and stomatal density, caused cuticle thickening and stomatal blockage, and revealed species-specific tolerance levels.

Keywords: Air pollution, Ecophysiology, Morpho-anatomy, Particulate matter, Roadside Plants.

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1. Introduction

Air pollution (particularly vehicle pollution in fast-urbanising regions). It is an important abiotic stressor for terrestrial vegetation[1]. Urban air is a mixture of pollutants such as particulate matter (PM), nitrogen oxides (NOx), sulphur dioxide (SO_2), Carbon monoxide (CO) and volatile organic compounds (VOCs) are generally related to transport and industrial activities. These pollutants negatively impact roadside vegetation by obstructing their growth, making them susceptible to pathogen invasion and to premature senescence or death in the most extreme situations[2,3]. Current research has described that airborne pollutants are absorbed by the surfaces of plant vegetation through stomatal openings and cause severe transformation of plant morphology, anatomy and physiology in recent times[4,5,6].

Such changes include a decrease in leaf surface area, chlorosis, modification of stomatal density, morphological transformation of the epidermal cell, decrease in photosynthetic activity. Physiologically, total chlorophyll fraction, relative water content and cell metabolic activities are significantly affected under pollution overload[4,7]. Biochemical responses (e.g.,

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changes in ascorbic acid, phenolics, and soluble sugars) and oxidative stress and response patterns in polluted habitats are also suggested[8,9]. Combined, the morpho-anatomical and eco-physiological responses reveal plant tolerance and functional responses to different types of environmental stress. Plants close to traffic can be excellent bioindicators of air pollution because they are regularly subjected to car emissions and the build-up of pollutants on the leaf surface. Plants possess characteristics, including excellent dust retention efficiency; they have a cuticular modification profile; and stomatal traits, which may afford them the role of natural "sinks" of airborne pollutants[10]. However, excessive particulates could lead to blockage of stomata, reduced gas exchange and slow or no carbon assimilation, degrading the performance of the plant systems and the ecological system[6,7]. Furthermore, the phyllosphere microbial communities are shown in new evidence to mediate the plant responses to pollution, indicating that an interactive component underlies the pollutant tolerance behaviour[11].

However, there remains a lack of both integrative and contrastive approaches capable of assessing morphological, anatomical and eco-physiological responses in different species and pollution gradients simultaneously[4,5]. Current research tends to be site-specific, methodologically inconsistent, and largely descriptive, limiting its application to ecological and urban planning matters[6,7]. Similar variability is seen in experiments and different environmental conditions, where the response reported from the plants does not reflect traditional bioindicator frameworks[9,10].

Therefore, an evaluative summary of the subject is undertaken, based on the recent literature on the morpho-anatomical and eco-physiological responses of roadside plant species to air pollution in order to identify the persistent patterns, appraise methodological constraints, and consider their validity and effectiveness as bioindicators of atmospheric pollution[8]. Unlike previous reviews that are focused on an abstract representation of the phenomenon and the short-term summarise these effects, this study utilises a comprehensive worldwide strategy by linking structural features and physiological and biochemical indices (APTI) toward responses of plant species to pollution stress[3,4]. This work thus reinforces other previously neglected aspects, in particular phyllosphere landscape and standard assessment methodologies, and therefore shows important insights that will help inform the selection of pollution-tolerant species for the facilitation of urban green belt planning and air quality management in cities[9,11].

2. Methods

The current scoping systematic review was carried out following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) to systematically review and analyse the available literature regarding the analysis of air pollution stress in roadside plant species based on morpho-anatomical and eco-physiological studies. A search of the available literature was conducted independently by three authors (AS, PB and AA) through various scientific databases such as Scopus, Web of Science, PubMed, SpringerLink, ScienceDirect, and Google Scholar. This analysis excluded publications published before 2000 and after 2025 with regard to a focus on recent and foundational insights about the topic of the research. The search strategy was made up of a combination of Boolean operators along with relevant keywords including: air pollution stress, roadside plants, urban vegetation, particulate matter ($PM_{2.5}$/PM_{10}), nitrogen oxides (NO_x), sulphur dioxide (SO_2), vehicular emissions, morphological changes, anatomical adaptations, eco-physiological responses, chlorophyll content, ascorbic acid, relative water content, leaf pH, Air Pollution Tolerance Index (APTI) and bioindicator plants.

Such studies could be eligible if they were designed on the interaction of air pollutants on plant species, specifically in the context of roadside (or urban) environments, specifically regarding morpho-anatomical and eco-physiological responses. For comprehensive coverage, all study designs were used, including field studies, controlled experiments, greenhouse studies, modelling studies, etc.

For further elaboration, additional search terms, in particular, were added to the search queries. Studies in the English language were only included.

2.1 Inclusion Criteria (Figure 1)

(i) Studies assessing the effects of one or more air pollutants (PM, NO_x, SO_2, CO, O_3, etc.) on plant species.
(ii) Studies of roadside, urban or traffic-exposed vegetation.
(iii) Studies reporting morpho-anatomical (e.g., leaf structure, stomatal characteristics) and/or eco-

physiological parameters (e.g., chlorophyll content, relative water content, ascorbic acid, leaf pH, APTI).
(iv) Original research articles that were peer-reviewed: experimental, observational and modelling studies.

2.2 Exclusion Criteria

(i) Studies examining only the human or animal health impacts of air pollution.
(ii) Studies carried out either in non-urban or non-roadside ecosystems without reference to the gradients of pollution.
(iii) Purely review articles, editorials, conference abstracts, or any non-peer-reviewed publications.
(iv) Studies without measurable parameters for plant response (morphological, anatomical or physiological).
(v) Publications not available in English.

3. Assessment of Air Pollution Stress: Morpho-anatomical Markers

Morpho-anatomical markers represent some of the earliest and most direct evidence of plant responses to air pollution stress. These markers indicate both visible damage and structural adaptations found in roadside vegetation exposed to airborne pollutants. Their assessment is crucial for evaluating the extent of environmental stress and identifying species-specific tolerance mechanisms.

3.1 Morphological Changes

Air pollutants, particularly particulate matter ($PM_{2.5}$ and PM_{10}), substantially affect plant morphology and are frequently the first visible indicators of stress. Common morphological changes include reduced leaf size, chlorosis, irregular leaf margins, and the accumulation of particulate deposits on leaf surfaces[12]. Such changes have been reported for many plants.

3.1.1 Reduced Growth

Dust and vehicular emissions have been related to lower growth of species like *Zea mays*[13]. The decline in leaf area index in *F. religiosa* in polluted conditions is similar as well, indicating decreased biomass accumulation[14].

3.1.2 Tissue Damage and Necrosis

Tissue damage, such as necrosis and leaf damage, can result from severe exposure to pollution. Increasing necrotic lesions are reported in *Citrus aurantium* species, and structural damage is seen in *Pinus sylvestris* with industrial dust exposure[15,16].

3.1.3 Physiological Dysfunction

Morphological damage is often accompanied by disruption of physiological processes, including increased transpiration and water imbalance[17]. Such damage interferes with vital metabolic functions, leading to cell death in *Taxus baccata*, increased water loss in *Pisum sativum*, and decreased starch synthesis in *Beta vulgaris*[18,19].

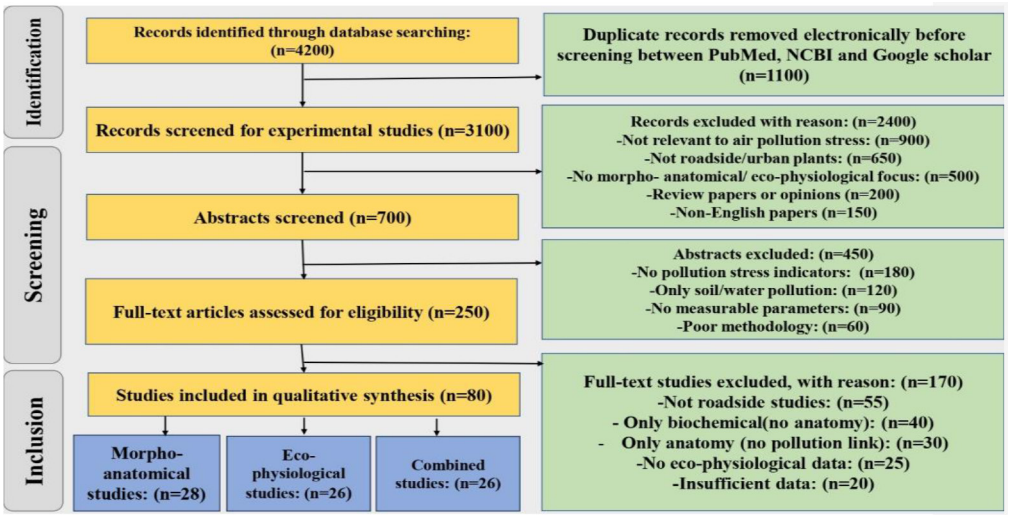


Figure 1. PRISMA flow chart depicting inclusion and exclusion criteria.

3.1.4 Chlorophyll Degradation

The removal of chlorophyll in *Quercus petraea* can be well observed because of the negative stress[20,21]. Together, these morphological changes represent an adverse developmental effect of air pollution on plant growth, plant structure, and general vigour.

3.2 Anatomical Changes

At the microscopic level, air pollution produces extensive anatomical changes in the leaf tissues, indicating both damage and adaptations. These changes are specifically seen in the epidermis, stomata, and internal leaf structure. Chief among them is the build-up of particulate matter in stomatal apertures and on epidermal surfaces that can block gas exchange[12]. The plants often develop protective strategies such as cuticular thickening and modified epidermal cell structure. Distortion of epidermal cells and increased cuticle thickness are both barriers to pollutant penetration but may also affect transpiration and photosynthetic efficiency. Pollution stress has been shown to lead to special sensitivity of stomatal characteristics. Many species are known to suffer such reductions in stomatal density or stomatal index as a protective mechanism by which toxic gaseous pollutants cannot enter their tissues. However, this response can equally stifle CO_2 diffusion and photosynthetic capacity. Pollutant-specific anatomical effects are also documented. Sulphur dioxide (SO_2) exposure may induce interveinal necrosis and damage to epidermal cells among broad-leaved species[22]. In contrast, nitrogen dioxide (NO_2) can cause physiological alterations, including changes in transpiration and stomatal conductance[23]. These distinctions emphasise the fact that the anatomic response depends on pollutant type and exposure intensity. Generally, morphological differences give an important indication of the location and extent of damage brought on by pollution, and are useful to assess plants' tolerance to pollutants[12].

4. Eco-physiological Markers and Tolerance Assessment

Air pollution greatly affects the eco-physiological and biochemical processes in plants, along with structural changes. These indicators are important to study the plant tolerance and the appropriateness of the measures for urban greenbelt development[24]. The result is thus compromised photosynthetic efficiency due to altered chlorophyll metabolism caused by air pollutants. According to Ebrahimi *et al*.,[25] chlorophyll degradation leads to a decrease in chlorophyll content. The overall chlorophyll levels are further reduced by leaf discolouration due to chloroplast damage under polluted conditions, resulting in impaired photosynthesis[26,27]. Carotenoids protect chlorophyll from being damaged by pollution, but can also undergo degradation following environmental damage[28,29]. This decrease weakens the plant's defence system against Reactive Oxygen Species (ROS). Increased ROS levels in polluted media would trigger oxidative stress reactions and lipid peroxidation, resulting in damage to cell membranes and organelles[30]. Normal cellular function has been disturbed, and this process is associated with lowered plant vitality. Chlorophyll profile was recorded under polluted conditions reduced significantly in numerous studies. For instance, reduced chlorophyll content has been well-documented in urban tree species subjected to increased pollution loads that inhibit growth and hence physiological function. According to Neinhuis and Barthlott[27,31], for example, chlorophyll a and b contents decreased in the species of *Ficus benghalensis* and *Dalbergia sissoo* at high levels of pollution. To add to this, significant reductions in chlorophyll pigments up to 35% in chlorophyll a and 60% in chlorophyll b were also reported from industrial fumes for species such as *Shorea robusta, Alstonia scholaris, Peltophorum pterocarpum, Albizia lebbeck, Tectona grandis, Lagerstroemia speciosa* and *Delonix regia*, and would lead to the loss of plant photosynthetic processes and the gradual collapse of plant growth. Moreover, stomatal obstruction by particulate matter accumulating on leaf surfaces restricts gas exchange and carbon assimilation[17,21].

In this way, eco-physiological parameters serve as a functional connection between structural damage and plant performance under pollution stress, which can affect plant tolerance and resilience.

4.1 Physiological Impact and the Air Pollution Tolerance Index (APTI)

The environmental exposure of plants to air pollution has been found to affect many crucial physiological functions that include water balance, photosynthetic potential and metabolism[3,4]. For instance, a measure of stress-induced physiological disturbance has been reported in sensitive species, such as *Pisum sativum*, when transpiration and water loss have increased, which would signal

changes in physiological state[10]. These responses are important indicators of plant adaptation under changing environmental conditions[7].

The Air Pollution Tolerance Index (APTI) is widely used to evaluate plant tolerance by integrating four physiological parameters, as shown in Figure 2: total chlorophyll content (T), ascorbic acid content (A), leaf extract pH (P), and relative water content (R)[9]. It is calculated using the formula:

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

For all four major stress buffers (chlorophyll content, ascorbic acid, leaf pH, and relative water content), pH and relative water content are two important parameters in crop pest avoidance studies[4,8].

These parameters have been used to present a composite assessment of the plant resilience to pollution stress, generally under the category of aggregated features[9,12]. But APTI has various limitations, even for extensive applications. It relies on a small range of physiological factors and does not consider relevant aspects, including anatomical adjustments, molecular responses, or long-term adaptive responses[4,6]. Additionally, APTI can vary according to factors such as seasonal variation, plant growth and developmental stage, and the location-specific aspects of environmental condition at the site, limiting comparisons across studies[7,10]. In contrast, indices like the Anticipated Performance Index (API) have been suggested to offer a more in-depth approach in certain settings with broader criteria including morphology, socio-economic value and ecological importance of plant species[3,9]. As APTI provides a swift and physiology-based assessment, the limited focus might oversimplify complex plant-pollution interactions[4]. Thus, the use of APTI in conjunction with complementary indices, including API and advanced analytical and multivariate methods, is increasingly advocating for a comprehensive evaluation of plant tolerance under urban air pollution scenarios[6,8].

5. Carbon Sequestration Potential

The ability of plants to mitigate air pollution can be evaluated in relation to a plant's ability to provide essential ecosystem services like carbon sequestration. Where species selection in urban areas should not rely solely on tolerance indices such as APTI, but also on their potential to capture and store atmospheric carbon. The species that can not only show high APTI values but also have high carbon sequestration capability are considered best to be optimised for sustainable urban greenbelt development[24]. Combining pollution tolerance with carbon storage capability permits urban planners to have a vegetation system that both mitigates local air pollution and contributes to global climate change mitigation, based

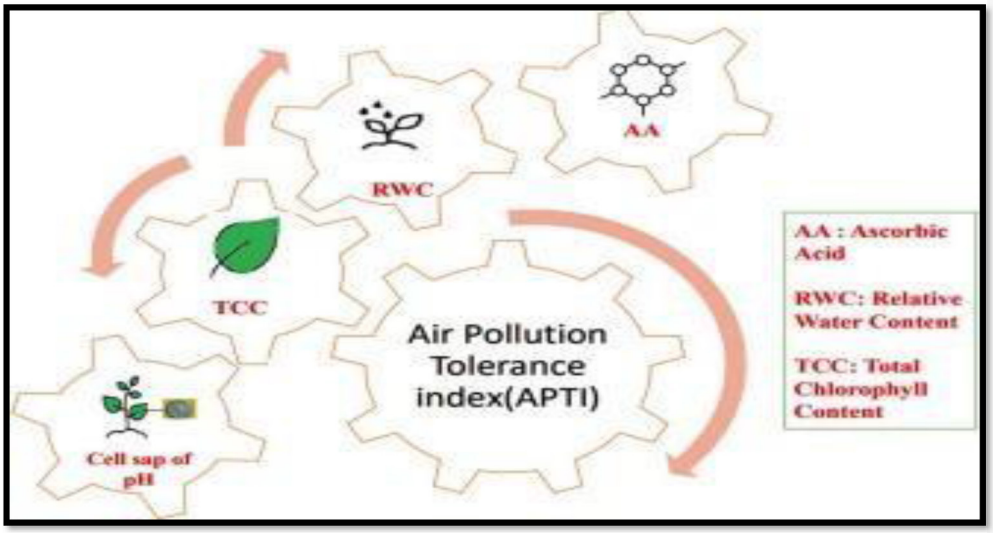


Figure 2. Parameters of the Air Pollution Tolerance Index (APTI)[24].

on the adaptation to local pollution. This approach is a scientific foundation for the selection of resilient species that are able to sustain ecosystem functionality under pollution.

6. Integrated Framework for Bioindicators and Plant Responses

An integrated framework linking pollution exposure, plant responses, measurable indicators, and practical applications is necessary for assessing plant responses to air pollution. Morphological, anatomical and eco-physiological traits constitute bioindicators of environmental stress[12,24]. Morphological traits, for example, leaf discolouration and reduced leaf area, are both quick and readily apparent markers of stress. Anatomical features, including cuticle thickness and stomatal characteristics, show structural responses to exposure to pollutants. Eco-physiological parameters, like chlorophyll content, ascorbic acid levels and relative water content, provide information on metabolic adaptation. Trade-offs govern these responses. Decreased stomatal density, for example, may restrict the uptake of harmful gases including SO_2 and NO_2 but additionally limits the diffusion of CO_2, decreasing photosynthetic efficiency[12,22]. To measure these complex responses quantitatively, these indices (like APTI) are extensively used. APTI compresses several physiological parameters, including antioxidant capacity (ascorbic acid) and buffering ability (leaf pH), into a common value, allowing comparative evaluation of tolerance among species[21]. This joint assessment of APTI and carbon sequestration potential offers a more practical application of bioindicators by relating plant responses to ecosystem services. This integrated strategy contributes to the evidence-based choice of species for pollution mitigation and urban sustainability planning.

7. Integrated Strategies for Urban Green Infrastructure

Effective urban green infrastructure (GI) planning requires a functional awareness of plant tolerance and ecosystem services. Species that gain urban planting require overcoming various stresses (i.e., air pollution, soil degradation, urban microclimatic extremes).

The multilayer approach is implemented:

7.1 Particulate Matter Interception (PMI)

Species characterised by intricate leaf surfaces, trichomes, and coarse surfaces are beneficial for the uptake and retention of $PM_{2.5}$ and $PM_{10,}$ with resulting improvements to local air quality[12].

7.2 Carbon Mitigation (CM)

Species with high APTI values and significant biomass can facilitate long-term carbon sequestration and climate stabilization[24].

7.3 Localised Bioassessment (LB)

Plant structural monitoring and tissue responses allow site-specific analysis of pollution and ecosystem health[32].

These strategies highlight the importance of evidence-based species selection, based on biological properties over aesthetics alone. This holistic approach guarantees the sustainability and functionality of green spaces in the urban context for a long time.

8. Impact of Airborne Particulate Matter on Leaf Surface Microstructures

Airborne $PM_{2.5}$ particles, in particular $PM_{2.5}$ and PM_{10}, significantly alter the morphology and function of leaf surfaces. These continue depositing on leaf surfaces, forming a persistent layer in which light penetration is decreased (and photosynthetic activity is stunted) that can be mineral dust, metal oxides and carbonaceous matter[24,33]. Stomatal apertures can be occluded due to particulate deposition so as to impair gas exchange efficiency and transpiration rates. Reduced transpiration could save a bit of water temporarily; however, prolonged stomatal obstruction can lead to compromised CO_2 uptake as well as reduced photosynthetic performance. Particle deposition may also increase leaf surface temperature, which could contribute to thermal stress. Research on roadside species, including *A. indica* and *M. indica,* shows substantial decreases in stomatal activity and photosynthetic function under heavy particulate load[34]. Ultimately, such structural and functional impairment could diminish the ecological performance of urban vegetation. Thus, species with significant dust tolerance and particulate retention capacity are crucial to urban planning programs.

9. Biochemical Defence Responses in Polluted Environments

Plants exposed to long-term air pollution respond with a variety of biochemical defence mechanisms against oxidative stress. During polluted conditions, increased ROS levels activate antioxidant enzymes, such as catalase (CAT), peroxidase (POD), and superoxide dismutase (SOD). Increased activity of these enzymes has been observed under vehicular emission stress in species including *Calotropis procera* and *Polyalthia longifolia*[34]. Apart from this, the accumulation of proline, phenolics, and flavonoids, the non-enzymatic antioxidants, supports membrane stabilisation and protects against lipid peroxidation. These biochemical responses supplement morphological and anatomical indices by offering mechanistic knowledge of plant tolerance. The inclusion of biochemical markers together with indices, e.g., APTI, improves the accuracy of plant-based air quality monitoring.

10. Long-term Ecological Implications for Urban Vegetation

There are long term impacts of chronic exposure to urban pollution on vegetation. Persistent stress can also hinder reproductive processes such that seed germination is minimised, pollen viability becomes minimal, and population patterns are altered[35]. Those results could eventually decrease species diversity and ecosystem resilience. Furthermore, leaves and shoots are also structurally damaged and susceptible to other stressors such as pathogens, pests and drought. Such cumulative effects demonstrate the urgency of choosing pollution-tolerant species to coexist in urban ecosystems. Longstanding surveillance of plant health (including growth patterns, reproductive success, and leaf structural integrity) is a key to evaluating ecosystem stability in fast-urbanising areas.

11. Cost-effective Biomonitoring Using Plants

Roadside plants serve as an economical and reliable bioindicator of air quality due to their continuous exposure to environmental pollutants. Unlike instrumental monitoring equipment, plants integrate pollution exposure over time, providing cumulative information on environmental conditions. Factors like foliar dust build-up, chlorophyll variation, and stomatal pattern have been effectively employed to evaluate spatial air pollution variations. *M. indica*, *C. fistula*, and *B. spectabilis* are among the most well-represented bio-monitors, well known for their distinct physiological responses and convenient sampling methods[36]. Visual signs (e.g., yellowing of leaves, early senescence, surface dust build-up) can also be interpreted as early warning indicators and facilitate community environment surveillance. Plant biomonitoring offers a sustainable and accessible tool in urban environmental assessment.

12. Discussion

The present study describes the differences in body and plant morphology seen in the two major plant types (leaf and petiole) as one of the most important determinants of plant response to air pollution in a roadside environment with vehicle emissions. Alterations in epithelial physiology, stomatal appearance and vascular pattern are evidence of damage-mediated and adaptive plant adaptation to pollutants (PM, SO_2, NO_x, etc.). The present findings are consistent with a previous investigation, which concluded that chronic exposure to air pollutants is detrimental to plant growth in the form of reduced biomass, increased vulnerability to stress, or catastrophic harm, and death[2,3].

However, smaller leaves may not absorb as many pollutants, but they decrease the efficiency of plants as natural biofilters, indicating a compromise between survival and ecological viability[6,37]. Anatomically, such mechanisms as cuticle roughness/thickening, trichome density level, and mesh-mesh tissue reorganisation are regarded as vigorous barriers to pollution and oxidative destruction[38]. Thickening cuticles, on which gaseous pollution attacks the structure, act as a physical barrier to environmental pollution, and trichomes could accumulate and disseminate particulate matter to the surface of the leaves. However, such adaptations could also affect transpiration and gas exchange, where plant productivity is affected. Besides, palisade parenchyma and mesophyll layers can decrease in high-polluted areas, a sign that the structure is degrading, such that direct impact on photosynthetic efficiency and carbon absorption could be recorded. The stomatal features show complex and opposing patterns in response to the pollution stress.

Others show increased stomatal density and the frequency of epidermal cells, which could be a compensatory response to degraded gases under reduced conditions. Meanwhile, stomatal index decreased, and guard cell size shrank for extremely polluted environments, suggesting that stoma closure or inhibition of development is a factor in the response[10]. These divergent findings indicate that stomatal responses are species-specific and affected by pollutant type, concentration and duration of exposure. Urban roadside plants, besides structural modification, showed improved leaf thickness and increased dust retention capability[3]. The collecting of particulates on the leaf surfaces helps to remove pollutants in the landscape and thus can lead to stomatal obstruction and a decrease in photosynthesis. This duality highlights the complicated interaction between plants and pollutants' protective adaptation, which can reduce toxins can act at the same time as physiological barricades. These trends notwithstanding, interpretations of anatomical responses are limited by heterogeneity in research methodologies as well as species selection and environmental context. Most recent studies were limited to single characteristics and did not incorporate them into a better framework about what was going on functionally, making it hard to determine signals that are invariant for tolerance to pollution.

In addition, other pollutants' simultaneous impacts as well as their climatic effects on the community are often neglected, contributing to its inaccessibility to urban plant responses in the real world. Most of the findings, however, demonstrate morpho-anatomical characteristic have been shown to reveal significant information about how plant-adapted responses to air pollution stress in response to pollution stress are contextual, and highly contextual, but heavily dependent. In order to adequately assess plant tolerance in plants and to select optimal species for urban greening, remediation and pollution prevention measures and protection measures, the integration of anatomical, physiological and biochemical metrics must be combined with other parameters according to more integrative research on plant tolerance.

13. Conclusion

Here, the review integrates recent data on morpho-anatomical and eco-physiological responses of roadside plant species to air pollution stress, demonstrating their potential as bioindicators of urban environmental quality. This study shows that leaf morphology, stomatal features, and physiological and biochemical parameters, all of which are affected by air pollution, can be detected and collectively represent plant adaptability and tolerance mechanisms. Combining these markers, especially in indices such as the APTI (Air Pollution Tolerance Index), provides a practical framework for identifying pollution-tolerant species suitable for urban green belt development. Nevertheless, there are still many research gaps. This work has been mostly site-specific, methodologically inconsistent, and primarily descriptive, limiting cross-comparisons and broader ecological applications. Besides, several studies are limited to subsets of physiological parameters, and integrated responses at anatomical, biochemical, and molecular scales are seldom present. Furthermore, the impact of a multitude of confounding environmental variables (e.g., seasonal variation, soil conditions and multi-pollutant interactions) is not well-researched. Next steps include standardising the methods and using multi-parameter assessment, integrating morpho-anatomical, eco-physiological, and molecular approaches into future research. This can include the use of omics and multivariate modelling to study plant–pollutant interactions and resilience. Further, long-term and multi-species studies in different pollution gradients are required to enhance bioindicator systems. Statistical evaluations of the level of contribution of different pollutants to plant stress reactions and improvements to indices (e.g., APTI using additional functional-level characteristics) will improve their prediction performance. A more integrated and uniform research approach is important to enhance and standardise the selection of resilient plant species that could improve both air pollution risk assessment and the strategic applications of urban vegetation toward air pollution mitigation and sustainable environmental planning.

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Author Contribution

Conceptualization - A.S., P.B. and A.A.; methodology - A.S. and P.B.; software - A.S., P.B. and A.A.; validation - A.S., P.B. and A.A.; formal analysis - A.S. and P.B.; investigation - A.S. and P.B.; resources - A.S., P.B. and A.A.; data curation - A.S. and P.B.; writing-original draft preparation - A.S. and P.B.; writing-review and editing - A.S., P.B. and A.A.; visualization - A.S., P.B. and A.A.; supervision - A.A. All authors have read and agreed to the published version of the manuscript.

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