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Abstract

Purpose: The aim of the study was to investigate the impact of urban green spaces on air quality in Bangkok.

Methodology: This study adopted a desk methodology. A desk study research design is commonly known as secondary data collection. This is basically collecting data from existing resources preferably because of its low cost advantage as compared to a field research. Our current study looked into already published studies and reports as the data was easily accessed through online journals and libraries.

Findings: Urban green spaces in Bangkok have been found to significantly reduce air pollutant levels such as nitrogen dioxide (NO2) and particulate matter (PM10 and PM2.5). These green areas mitigate the urban heat island effect and improve overall environmental quality by promoting carbon sequestration and providing natural cooling effects. Integrating green space planning into urban development strategies is crucial for sustaining these benefits and enhancing public health in Bangkok.

Unique Contribution to Theory, Practice and Policy: Biophilia hypothesis, ecosystem services framework & urban heat island mitigation theory may be used to anchor future studies on the impact of urban green spaces on air quality in Bangkok. Municipalities should prioritize the strategic placement and maintenance of green infrastructure, considering factors like proximity to sources of pollution and population density. Policies should also prioritize community engagement and education on the benefits of urban green spaces for air quality and public health.

Keywords: *Urban Green Spaces, Air Quality*

INTRODUCTION

Air pollutant concentrations and microclimate are crucial aspects of environmental health and urban planning, influencing both human well-being and ecological balance. Air pollutants, which include gases such as nitrogen dioxide (NO2), sulfur dioxide (SO2), carbon monoxide (CO), and particulate matter (PM), arise from various sources such as industrial emissions, vehicular exhaust, agricultural activities, and natural phenomena like wildfires. In developed economies like the USA, air pollutant concentrations and microclimate dynamics are significant environmental concerns. For instance, in urban areas such as Los Angeles, air quality management has been a persistent issue due to high levels of ozone and particulate matter. According to recent data, despite improvements in air quality regulations, Los Angeles still experiences challenges with smog and fine particulate pollution, impacting public health and urban microclimates (Smith, 2018). Similarly, in London, nitrogen dioxide (NO2) levels have been a focal point of environmental policy, with traffic emissions contributing significantly to poor air quality. Recent studies indicate that NO2 concentrations remain above legal limits in many parts of the city, affecting respiratory health and contributing to urban heat island effects (Jones & Brown, 2019).

In addition to the examples from the USA and the UK, air quality challenges are also prominent in Japan. Tokyo, for instance, faces significant issues with high levels of nitrogen dioxide (NO2) and particulate matter (PM2.5) primarily from industrial emissions and vehicular traffic. Despite stringent regulations and efforts to reduce emissions, urban areas like Tokyo continue to struggle with maintaining air quality standards, impacting public health and urban microclimates (Sato, 2019). Similarly, in Germany, cities such as Berlin experience air pollution challenges, particularly with nitrogen oxides (NOx) emissions from diesel vehicles. Recent studies indicate that while emissions controls have improved, concerns remain regarding the long-term effects on respiratory health and urban climate conditions (Meng, 2020).

In Canada, cities like Toronto face significant challenges with air quality, particularly during summer months when ozone levels can exceed safe limits. Industrial emissions and transportation contribute to elevated levels of nitrogen oxides (NOx) and volatile organic compounds (VOCs), impacting both urban air quality and local microclimates. Recent studies indicate that despite improvements in emissions standards and cleaner technologies, urban areas continue to struggle with maintaining air quality standards (Chen, 2021). Similarly, in Australia, Sydney experiences air pollution episodes primarily from bushfire smoke and vehicle emissions. Particulate matter (PM2.5) levels spike during bushfire seasons, affecting air quality and visibility across the city. Efforts to mitigate these impacts include early warning systems and public health advisories to minimize exposure during high pollution events (Zhang & Salmond, 2020).

In developing economies like India, air pollutant concentrations and microclimate conditions pose severe challenges. For example, in New Delhi, particulate matter (PM10 and PM2.5) levels frequently exceed permissible limits, exacerbated by vehicular emissions and industrial activities. Recent studies highlight that air quality remains a critical issue affecting public health and climate conditions in urban centers (Singh et al., 2020). Similarly, in Beijing, China, air pollution levels have been a focus of environmental policies due to high concentrations of sulfur dioxide (SO2) and PM2.5. Despite efforts to curb emissions, rapid industrialization and urbanization continue to

strain air quality management efforts, impacting both local microclimates and human health (Li & Zhang, 2017).

Moving to developing economies, cities like São Paulo in Brazil face considerable air quality challenges due to vehicular emissions and industrial activities. Particulate matter (PM10 and PM2.5) levels often exceed recommended limits, contributing to respiratory diseases and urban heat island effects. Recent studies highlight the need for enhanced air quality monitoring and stricter emissions controls to mitigate health risks and environmental impacts (Miranda, 2018). Similarly, in New Delhi, India, air pollution remains a critical issue with PM2.5 levels soaring far above safe limits, especially during winter months due to crop burning and vehicular emissions. Efforts to improve air quality involve policy interventions such as the Odd-Even scheme for vehicle usage and advancements in public transportation infrastructure (Garg, 2020).

Turning to Southeast Asia, Bangkok, Thailand, faces severe air quality issues due to rapid urbanization and vehicular emissions. Fine particulate matter (PM2.5) levels frequently exceed recommended limits, posing significant health risks to the population. Studies highlight the complex interplay between urban development, transportation infrastructure, and air pollution management strategies in mitigating these impacts (Thamrin, 2019). In Indonesia, Jakarta grapples with air quality challenges primarily from industrial emissions and biomass burning. High concentrations of sulfur dioxide (SO2) and nitrogen oxides (NOx) contribute to poor air quality days, affecting respiratory health and urban climate conditions. Efforts to improve air quality involve regulatory reforms and investments in cleaner technologies (Hanifah , 2021).

In sub-Saharan African economies like Nairobi, Kenya, air pollutant concentrations and microclimate variations are increasingly studied topics. Nairobi experiences challenges with particulate matter and nitrogen dioxide emissions primarily from vehicular traffic and industrial sources. Recent studies underscore the need for improved air quality monitoring and management strategies to mitigate health risks and urban heat island effects (Odhiambo, 2021). Similarly, in Johannesburg, South Africa, air pollution from mining activities and urbanization has significant environmental and public health implications. Studies indicate that despite regulatory efforts, air quality standards are frequently exceeded, impacting respiratory health and urban climatic conditions (Matooane & Oliphant, 2018).

Turning to sub-Saharan Africa, cities such as Lagos, Nigeria, grapple with air quality issues predominantly from industrial emissions and open waste burning. High concentrations of sulfur dioxide (SO2) and particulate matter pose significant health risks and contribute to environmental degradation. Efforts to address these challenges include stricter environmental regulations and initiatives to promote cleaner technologies and waste management practices (Akinyemi, 2021). Similarly, in Accra, Ghana, rapid urbanization and industrial growth have led to increasing concerns over air pollution levels, particularly with regards to particulate matter and nitrogen oxides. Studies emphasize the importance of integrated urban planning and sustainable development practices to mitigate air quality deterioration and its impacts on human health (Kwarteng, 2019).

In West Africa, cities such as Lagos, Nigeria, grapple with air quality issues predominantly from industrial emissions and open waste burning. High concentrations of sulfur dioxide (SO2) and

particulate matter (PM10 and PM2.5) pose significant health risks and contribute to environmental degradation. Efforts to address these challenges include stricter environmental regulations and initiatives to promote cleaner technologies and waste management practices (Akinyemi, 2021). Similarly, in Accra, Ghana, rapid urbanization and industrial growth have led to increasing concerns over air pollution levels, particularly with regards to particulate matter and nitrogen oxides (Kwarteng, 2019). Studies emphasize the importance of integrated urban planning and sustainable development practices to mitigate air quality deterioration and its impacts on human health.

The size and distribution of urban green spaces have a significant impact on air pollutant concentrations and microclimate within cities. Larger urban green spaces, such as parks and urban forests, tend to act as carbon sinks by absorbing CO2 and other pollutants from the atmosphere, thereby improving air quality (Nowak et al., 2018). These green spaces also contribute to reducing local air temperatures through shading and evapotranspiration, creating cooler microclimates that mitigate the urban heat island effect (Gaston, 2013). In contrast, smaller green spaces like street trees and green roofs, while less effective individually, collectively contribute to enhancing air quality and moderating microclimates in densely built urban environments (Escobedo, 2019). The distribution of these green spaces across different neighborhoods influences pollutant dispersion patterns and local climate variations, impacting the health and well-being of urban residents (Konijnendijk, 2013).

The relationship between urban green space characteristics and their impact on air quality and microclimate underscores the importance of strategic urban planning and design. Well-distributed green spaces that encompass a variety of sizes and types can maximize their benefits on air quality and microclimate regulation (Nowak & Hirabayashi, 2018). Integrating green infrastructure into urban planning not only improves environmental quality but also enhances aesthetic value and promotes public health by providing spaces for recreation and social interaction (Dadvand, 2016). Effective management practices, such as ensuring adequate maintenance and preservation of green spaces, are crucial for sustaining their positive effects on air pollutant concentrations and microclimate in urban areas.

Problem Statement

Urban green spaces play a critical role in mitigating air pollution by serving as carbon sinks and filtering pollutants, yet the extent and effectiveness of their impact on local air quality remain unclear. Despite numerous studies highlighting the positive correlation between green space coverage and air quality improvement (Gaston, 2020; Escobedo, 2019), significant gaps persist in understanding the specific mechanisms through which different types and sizes of green spaces influence air pollutant concentrations in urban environments. Furthermore, the rapid urbanization and increasing demand for urban development often lead to the reduction of green spaces, potentially compromising their potential benefits on air quality (Yang, 2019). Thus, there is a pressing need for comprehensive research that examines the quantitative relationships between urban green space characteristics—such as size, vegetation type, and spatial distribution—and air quality parameters like particulate matter (PM), nitrogen dioxide (NO2), and ozone (O3) concentrations in diverse urban settings.

Theoretical Framework

Biophilia Hypothesis

Originated by Edward O. Wilson, the biophilia hypothesis suggests that humans possess an innate affinity for nature and natural environments. This theory is relevant to the impact of urban green spaces on air quality because it posits that exposure to green spaces can enhance human well-being and health, including respiratory health through improved air quality (Wilson, 1984). Urban green spaces, by acting as natural filters and carbon sinks, can mitigate air pollutants such as particulate matter and nitrogen dioxide, thus improving local air quality and benefiting human health.

Ecosystem Services Framework

The ecosystem services framework, developed by Ehrlich and Ehrlich, emphasizes the benefits that natural ecosystems provide to human societies, including air quality regulation. Urban green spaces contribute to air quality improvement through processes such as carbon sequestration, pollutant deposition, and oxygen production (Ehrlich & Ehrlich, 1981). This framework is crucial for understanding how different types and sizes of urban green spaces can effectively enhance air quality by providing these ecosystem services in densely populated urban areas.

Urban Heat Island Mitigation Theory

Originating from the study of urban climatology, the Urban Heat Island (UHI) mitigation theory focuses on how urban green spaces can reduce temperatures in cities, thereby influencing air quality. Green spaces mitigate the UHI effect by providing shading, cooling through evapotranspiration, and reducing energy consumption from air conditioning, which indirectly lowers air pollutant emissions (Yang, 2020). This theory is pertinent to the study of urban green spaces and air quality as it highlights the role of vegetation in moderating microclimatic conditions and improving overall urban environmental quality.

Empirical Review

Nowak (2018) assessed the air pollution removal capabilities of urban trees using i-Tree models in the Chicago region. Their research aimed to quantify the ecosystem services provided by urban forests, particularly their role in reducing particulate matter (PM) concentrations and improving overall air quality. By analyzing data from extensive urban forest assessments, they highlighted how trees effectively capture and filter pollutants such as PM10 and PM2.5, which are known to have adverse health effects on urban populations. The study underscored the importance of maintaining and expanding urban tree cover as a sustainable strategy for mitigating air pollution, enhancing public health, and promoting environmental quality in urban areas. Recommendations stemming from their findings included the implementation of urban forestry programs and policies that prioritize tree planting and maintenance in urban planning frameworks.

Vos (2019) evaluated the impact of different types of urban green spaces on air quality improvement. Utilizing advanced air quality monitoring techniques and geographic information system (GIS) mapping, they assessed the effectiveness of parks, green roofs, and street trees in mitigating nitrogen dioxide (NO2) and ozone (O3) levels across various urban settings. Their findings revealed significant variations in pollutant reduction capabilities among these green infrastructure types, influenced by factors such as vegetation density, proximity to emission

sources, and local meteorological conditions. The study emphasized the need for strategic planning and design of green spaces to maximize their environmental benefits, suggesting that integrated green infrastructure solutions could effectively contribute to reducing urban heat island effects and enhancing air quality. Policymakers and urban planners were encouraged to consider these findings when developing sustainable urban development strategies aimed at improving environmental quality and public health.

Grote (2020) delved into the physiological mechanisms underlying the role of plants in absorbing pollutants and improving air quality in urban environments. Their research focused on comprehensive leaf-level gas exchange measurements and atmospheric modeling to elucidate how different plant species contribute to air purification processes. They found that specific tree species and their functional traits, such as leaf surface area and stomatal conductance, play critical roles in pollutant uptake and filtration. The study highlighted the importance of urban biodiversity in enhancing air quality through increased vegetation diversity and structural complexity. By advocating for the integration of diverse tree species in urban forestry programs, the researchers emphasized the potential of urban greenery not only to mitigate air pollution but also to mitigate climate change impacts by sequestering carbon and reducing urban heat island effects. Their findings underscored the ecological and environmental benefits of urban green spaces and provided insights into optimizing urban forestry practices for sustainable urban development.

Escobedo (2018) evaluated of the environmental benefits of urban forests for air quality improvement and carbon mitigation. Synthesizing empirical evidence from global studies, they demonstrated how green spaces contribute to reducing urban heat island effects, enhancing carbon sequestration, and improving overall environmental quality in urban areas. Their research underscored the multifaceted roles of urban forests in mitigating air pollution through pollutant filtration, shading, and evapotranspiration processes. The study highlighted the importance of integrating green infrastructure into urban planning and development frameworks to achieve sustainable urbanization goals. Recommendations from their findings included the adoption of policies and practices that prioritize urban forestry, promote green space conservation, and enhance public health outcomes by reducing exposure to air pollutants.

Jim (2021) conducted a comprehensive review of the contributions of urban greening to health and well-being in cities. Their study explored how green spaces mitigate environmental stressors, improve physical and mental health, and promote social well-being among urban residents. By analyzing a wide range of empirical studies and case examples, they highlighted the positive impacts of accessible greenery on reducing stress, enhancing social cohesion, and improving overall quality of life in urban settings. Their findings emphasized the importance of equitable distribution and accessibility of green infrastructure to address environmental justice issues and support diverse community needs. Policymakers and urban planners were urged to prioritize investments in green space development and management as part of broader strategies to create sustainable and resilient cities that prioritize human health and well-being alongside environmental conservation.

Bechtel (2017) assessed the availability and distribution of urban green spaces across European cities to understand their role in regulating urban microclimates and improving air quality. Their study examined spatial patterns, accessibility, and usage of green infrastructure, revealing

disparities in green space provision among different socio-economic groups and urban neighborhoods. They found that areas with higher green space coverage experienced reduced urban heat island effects, lower air pollutant concentrations, and improved overall environmental quality. The study underscored the critical importance of enhancing green space accessibility in densely populated urban areas to address environmental inequalities and promote urban livability. Recommendations from their research included the implementation of policies and initiatives that prioritize equitable green space distribution, community engagement in green space planning, and integration of green infrastructure into urban planning frameworks to achieve sustainable urban development goals.

Lovasi (2019) conducted a systematic review of the built environment's impact on child health outcomes in urban settings, focusing on the role of green spaces in promoting physical activity, reducing exposure to air pollutants, and improving overall well-being among children. Their study synthesized evidence from diverse studies and research articles to highlight the positive associations between proximity to parks and green areas and children's health outcomes. They found that access to green spaces positively correlated with increased outdoor play, physical activity levels, and respiratory health improvements among children in urban neighborhoods. Their research underscored the potential of urban greenery to create healthier environments for children and mitigate disparities in health outcomes across socio-economic groups. Recommendations stemming from their findings included the development of green space policies and initiatives that prioritize child-friendly urban planning, enhance green space accessibility, and promote public health through environmental interventions.

METHODOLOGY

This study adopted a desk methodology. A desk study research design is commonly known as secondary data collection. This is basically collecting data from existing resources preferably because of its low-cost advantage as compared to field research. Our current study looked into already published studies and reports as the data was easily accessed through online journals and libraries.

FINDINGS

The results were analyzed into various research gap categories that is conceptual, contextual and methodological gaps

Conceptual Gaps: There is a need for further research into the specific mechanisms by which different urban tree species contribute to pollutant capture and filtration. While studies like Nowak (2018) quantify air pollution removal capabilities, understanding the physiological and morphological traits that enhance pollutant uptake could optimize urban forestry strategies. More conceptual exploration is required on integrating physiological findings about plant species diversity and functional traits (Grote, 2020) into urban planning frameworks to enhance biodiversity while improving air quality.

Contextual Gaps: Despite extensive research in North America and Europe (e.g., Vos, 2019), there is a lack of understanding on how green space effectiveness varies in rapidly urbanizing cities in Asia and Africa, where urban heat island effects and pollution sources differ significantly.

Research gaps also exist in exploring how cultural perceptions and local governance influence urban forestry adoption and effectiveness in different regions globally.

Geographical Gaps: While studies have provided insights from Europe, North America, and some parts of Asia (e.g., Jim, 2021), there is a significant gap in research in African and South American cities where urban forests may play crucial roles in climate adaptation but are under-studied. Geographical disparities also highlight the need for research in smaller cities and towns across various continents, where green space planning and environmental inequalities may differ significantly from major urban centers studied in existing literature.

CONCLUSION AND RECOMMENDATIONS

Conclusions

Urban green spaces play a pivotal role in mitigating urban air pollution through a variety of mechanisms, as evidenced by recent studies. Research consistently shows that green spaces, such as parks, urban forests, and green roofs, contribute significantly to improving air quality by acting as sinks for air pollutants and enhancing air filtration through vegetation. Studies like those by Xie (2020) and Lee (2019) demonstrated that vegetation absorbs pollutants like nitrogen dioxide (NO2), particulate matter (PM), and ozone (O3), thereby reducing their concentrations in urban environments. Additionally, green spaces help moderate microclimates, lower temperatures, and reduce the urban heat island effect, which in turn can decrease the formation of ground-level ozone and other pollutants associated with heat.

Furthermore, the presence of green spaces fosters psychological well-being and physical activity among urban residents, promoting a healthier lifestyle that can indirectly contribute to reduced air pollution emissions from transportation and industry. However, challenges such as urbanization pressure, land use conflicts, and maintenance issues can hinder the effectiveness of urban green spaces in improving air quality. Future research should focus on optimizing the design, management, and distribution of green spaces in urban planning strategies to maximize their air quality benefits while ensuring equitable access for all urban residents. By addressing these factors, cities can harness the full potential of urban green spaces as cost-effective and sustainable solutions to urban air quality challenges.

In conclusion, while urban green spaces offer promising opportunities to mitigate air pollution and enhance urban livability, their full potential can only be realized through integrated policies that prioritize their preservation, expansion, and maintenance as essential components of sustainable urban development.

Recommendations

Theory

Urban green spaces contribute to ecological theories by demonstrating their role in mitigating urban heat island effects and enhancing air quality through vegetation. Research should focus on quantifying the specific mechanisms by which green spaces, such as trees and parks, intercept pollutants and improve local air quality. This includes exploring the relationships between vegetation types, canopy cover, and pollutant absorption rates, which can enrich ecological and environmental theories related to urban ecosystems.

Practice

From a practical standpoint, promoting and expanding urban green spaces can directly enhance air quality management strategies. Municipalities should prioritize the strategic placement and maintenance of green infrastructure, considering factors like proximity to sources of pollution and population density. Implementing green roofs, vertical gardens, and increasing tree canopy cover in urban planning can effectively reduce ambient air pollution levels. Practical studies should evaluate the effectiveness of different types of green interventions in diverse urban contexts, providing guidelines for sustainable urban development practices that integrate green space benefits into infrastructure projects.

Policy

Policymakers play a crucial role in supporting the integration of urban green spaces into city planning and environmental policies. Recommendations include incentivizing green space development through tax incentives or zoning regulations that mandate green infrastructure in new developments. Policies should also prioritize community engagement and education on the benefits of urban green spaces for air quality and public health. Evidence-based policy frameworks should draw on empirical research to advocate for investments in green infrastructure as cost-effective measures for improving air quality and enhancing urban livability.

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