AIR QUALITY EVALUATION: INSIGHTS FROM CASE STUDIES IN BELGRADE

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This paper analyzes air pollution in three locations in the municipality of Voždovac in Belgrade: Lepenička Street, Bulevar Oslobođenja, and Banjička (Bajfordova) forest. Although these areas are in close proximity, they differ significantly in traffic intensity, layout, green infrastructure, and the presence of buildings of varying heights. This study examines the particulate matter ($PM_{2.5}$ and PM_{10}), humidity and carbon dioxide (CO_2) concentrations, as well as air pressure levels in the areas under observation. The results indicate that local air pollution is directly influenced by green spaces and traffic exposure. The study highlights the impact of urban planning and green infrastructure on local air quality, emphasizing the need for targeted environmental policies in urban areas. The importance of site-specific environmental measures is emphasized to achieve optimal results in environmental, economic, and health outcomes for the community

Keywords: air pollution, environmental monitoring, pollution sources, Belgrade

Introduction

Cities are complex systems that are locally and regionally specific, yet they simultaneously have a significant impact on air quality at both the local and regional levels. The quality of air in cities is a significant global issue due to rapid urbanization and population growth, which lead to increased traffic, industrial activities, and energy consumption [1]. Air pollution is a ubiquitous problem in urban environments with consequences for human health and the environment. It is estimated that air pollution has led to 4.2 million premature deaths globally [2]. Urban settlement planning can contribute to reducing air pollution through various strategies and approaches. According to Meteologos [3] and Abhijith [4], research indicates that incorporating green infrastructure is a crucial strategy for enhancing air quality and promoting the sustainability of urban environments. This includes trees along streets, vegetative barriers, green walls, and roofs, which act as filters for air pollution. In addition to reducing pollution, these green elements also bring other benefits such as reducing noise, better temperature regulation, rainwater management, mitigating fog and smog occurrences, ambient cooling and microclimate regulation (leading to reduced local energy consumption and associated emissions), stormwater attenuation, enhanced mental and physical health, biodiversity support, and climate change adaptation [5]. Climate conditions in the city significantly differ from surrounding areas due to less reflection of sunlight and limited absorption of rainwater into the soil, leading to variations in temperature and air humidity. Staying in urban areas with altered climates can have negative health consequences, reduced air circulation, which can increase the risk of air pollution. Certain city features contributing to adverse local climate conditions can be enhanced through effective planning measures during construction or reconstruction. The key elements include adjusting building density and height, street width, building orientation, and material choices [3]. According to Barwise [5], alongside the many political, technological, and cultural shifts needed to directly decrease harmful emissions at their source, addressing existing air pollution to reduce human exposure is also essential. Factors influencing air pollution in urban environments include:

-Traffic: Intensive automotive traffic can be one of the main sources of air pollution, especially if a large amount of gases and particles is emitted from vehicle exhaust systems.

-Industry: Factories and industrial zones can emit various types of air pollutants, including gases, particles, and chemicals, contributing to overall pollution levels.

-Heating: The use of fossil fuels for heating during winter months can be a significant source of air pollution, especially if outdated or inefficient heating sys-

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tems are used.

-Topographic factors: The region's topography, such as the presence of hills or valleys, can affect the concentration of air pollution at specific locations.

-Weather conditions: Meteorological factors such as wind speed, precipitation, and temperature can influence the spread and dilution of pollutants in the air. Air pollution in urban environments typically has multiple sources and may be concentrated in certain locations such as traffic intersections, industrial zones, or densely populated residential areas. Vehicular traffic is often considered an indicator of air quality in cities and surrounding areas along roads, contributes the most to local air pollution in cities and is often used as an indicator of air quality [6]. For example, in Belgrade, the number of registered motor vehicles is 827,146 [7], while the residents of this administrative area make 3,376,991 trips, generating mobility of 2.03 trips per day [8].

Measuring air pollution

Air pollution measurement involves various techniques and instruments to gather accurate data on air quality. The Pollutant Standard Index (PSI) evaluates pollutants like particulate matter (PM), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), and ozone (O_3) in outdoor air, offering insights into air quality and its health effects [6,9]. Some criteria and thresholds for assessing air quality may vary depending on different agencies, organizations, or regulatory bodies. These variations can result from different assessment methods, scientific research, or regulations applied in specific regions or countries (Table 1). Particulate matter (PM) includes microscopic particles from both natural and human-made sources, such as smoke, soot, and dust, formed through atmospheric chemical reactions [10,2]. In the Belgrade agglomeration, the air quality was classified as class III, indicating excessive pollution. This classification was due to the levels of suspended particles PM_{10} and $PM_{2.5}$ surpassing the limit values for the year 2022 [11], despite the implementation of an air quality plan [12]. The highest daily concentrations of PM_{10} in the 2022 were measured on stations Belgrade Ovča 516 μg/m³ and Zaječar 326 μg/m³. The suspended particles were in 2022, as in previous years, the dominant pollutant in the Republic of Serbia [11]. Additionally, measurements consider concentrations of gases like CO_2, SO_2, NO_2, and O_3 [1], emitted from sources such as road traffic, industrial activities, and fossil fuel combustion. For example, Road traffic releases a range of harmful pollutants including particles such as PM_{10} (≤10 μm), $PM_{2.5}$ (≤2.5 μm), and ultrafine particles (UFP; <100 μm), gaseous pollutants like nitrogen oxides (NOx), carbon monoxide (CO), and to a lesser extent sulfur dioxide (SO_2) [4]. CO_2 is mainly emitted as a byproduct of fossil fuel combustion such as coal, oil, and natural gas in processes like driving cars, electricity generation, heating, and cooling, contributing to the greenhouse effect and global warming. While CO_2's role as a greenhouse gas makes it a critical factor in global environmental health, it is not generally considered a "pollutant" in the same way as other air pollutants. In outdoor spaces, it should not exceed 1000 ppm, which was not recorded at the location.

Table 1. Index $PM_{2.5}$ i PM_{10} [24]

Pollutant measurement period	Description of air quality	$PM_{2.5}$ (μg/m³) 1h	PM_{10} (μg/m³) 1h
EXCELLENT	Air quality is satisfactory, and air pollution poses little or no risk.	0 - 15	0 - 25
GOOD	Air quality is acceptable. However, there may be a risk for some people, particularly those who are unusually sensitive to air pollution.	15.01 - 30	25.01 - 50
ACCEPTABLE	The members of sensitive groups may experience health effects. The general public is less likely to be affected.	30.01 μg/m³ - 55	50.01 - 90
POLLUTED	Health alert: The risk of health effects is increased for everyone.	55.01 μg/m³ - 110	90.01 - 180
HIGHLY POLLUTED	Health warning of emergency conditions: everyone is more likely to be affected.	> 110.01	> 180.01

The impact of air pollution on health

Air pollution is a major global risk factor for mortality, linked to 3.3 million to 9 million premature deaths annually [14]. It is a pressing environmental health challenge, particularly in Europe, where 82% to 85% of the urban population was exposed to $PM_{2.5}$ between 2013 and 2015 [11]. Particulate matter ($PM_{2.5}$ and PM_{10}) and gases like NO_2 and O_3 are especially harmful to human health [14], with vulnerable populations such as those with respiratory or cardiovascular conditions, children, and the elderly being most at risk, reduce urban residents quality of life and disrupt outdoor activities. Pollution particles can deposit on plants, reducing their photosynthesis and productivity, harmful chemicals in air pollution can infiltrate aquatic ecosystems, causing water quality problems. Economically, air pollution leads to increased healthcare costs, reduced productivity, lower tourism, and property degradation.

The impact of air pollution on the built environment

The destructive effects of pollution on architectural structures and building materials became evident, particularly during the 20th century. Although interest in this issue intensified in the 1970s, the damage to architecture caused by pollution has persisted for centuries. Harmful gases such as sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) can lead to chemical corrosion, especially when combined with moisture, resulting in the formation of acids that attack stone, concrete, and metal components of buildings. The deposition of soot and other pollutants on facades not only contributes to their physical degradation but also significantly diminishes the aesthetic appearance of buildings, which is particularly problematic for historically and culturally significant structures. In addition to traditional materials, modern buildings, which utilize polymers, glass, and metals, are also susceptible to damage. Contemporary architecture, with its simple lines and dirt-resistant materials, can nonetheless be affected by soot deposition, especially on light-colored surfaces. Continuous exposure to air pollution necessitates more frequent cleaning and restoration of buildings, significantly increasing maintenance costs [15-17].

This study identifies and explains air pollutants at the local level and their impact on the environment. Methodologically, the study describes site characteristics and measurement techniques used to assess air pollution. The findings include tabular representations of pollution levels at the selected sites. The research concludes with insights and recommendations for improving air quality in Belgrade, offering strategies relevant to other urban areas as well. This involves identifying factors contributing to this issue, which should serve as a starting point for further analysis and considerations aimed at improving the quality of life for residents and protecting the environment.

Material and Methods

This study will mention PM, humidity, air pressure, and CO_2 as research findings. In addition, air quality is influenced by air pressure and humidity, which affect pollutant movement and dispersion. For example, high humidity can increase the retention of particles in the air, while low humidity can contribute to faster particle deposition on the ground. Serbia was ranked as the 5th most polluted country in Europe among 37 countries, based on IQAir's 2019 World Air Quality Report. In the capital city of Belgrade, the average $PM_{2.5}$ concentration was 23.3 μg/m^3 in that year, placing it as the 31st most polluted capital city globally out of 85 capitals [18]. The average annual concentration of PM10 at the location is 42.3 μg/m^3 [13] (measurement location: KBC „Dr Dragiša Mišović", Heroja Milana Tepića 1, Belgrade).

Description of the study area

Belgrade is located in a moderately continental climate, with four seasons, hot summers, and cold winters. The average annual air temperature in Belgrade is 11.9 °C. The city's overall warming is attributed to two factors: global warming and the city's expansion, leading to urbanization and the heat island phenomenon [3]. Belgrade stretches over predominantly flat terrain, but there are gently elevated structures that can influence air movement and microclimatic characteristics of certain parts of the city. The complex topography of Belgrade contributes to variations in the types of fog and smog observed across different parts of the city. Moreover, changes in daily fog patterns and air currents suggest the existence of a daily cycle of air pollution [3]. The city is exposed to the influence of various air currents, with winds often coming from the southeast or south, or from the northwest. Wind plays a beneficial role in improving air quality, particularly in large cities, where it acts as a natural cleanser of polluted air generated by vehicle exhaust gases and various combustion processes [19]. The "Košava" wind, also known as the cleaner of Belgrade [20], usually blows for several days (3-21 days). Its average speed is 5–10 m/s. The wind at the location most commonly blows in the direction of Bulevar Oslobođenja and Banjička forest, and crosswise along Lepenička Street. Urbanization has led to increased construction, traffic, and industrial activities. Traffic congestion is common, especially in central parts of the city, further contributing to the emission of harmful gases and particles. Rapidly growing cities, such as Belgrade, face new challenges, requiring further research to improve the quality of life. In recent years, air pollution has become an increasingly relevant topic in Belgrade, as well as in cities worldwide. The largest relative impacts are observed in the central and eastern European countries where the highest concentrations of $PM_{2.5}$ were recorded in 2016. According to the measurements from 2016, the highest concentrations of $PM_{2.5}$ were recorded in Kosovo, Serbia, Bulgaria, Albania, and North Macedonia [21]. In Serbia, the government is aware of the air pollution problem, and a plan has been enacted [12] aimed at addressing this issue. However, this plan does not mention specific changes that could effectively solve the problem. For example, suggestions such as planting green barriers or addressing overcrowding and parking shortages are not explicitly stated. Marjanović [22] emphasizes that the short-term action plan to reduce air pollution has not been implemented as planned. The measures such as the complete ban on traffic for delivery and freight vehicles in cases of episodic air pollution have not been applied, despite being planned. The Department of Transportation believes that such measures are unnecessary, although they were planned. Additionally, a detailed operational plan for implementing measures from the short-term plan has not been made. Although a system for forecasting air pollution for four days in advance has been established, the current system does not accurately determine the location in the city to which the displayed data apply. The medium-term plan does not contain quantitative indicators, making it difficult to assess its implementation accurately. All of this indicates a lack of effective implementation of plans to address air pollution problems in Serbia.

Data collection and the method used

Research methods include empirical observation through fieldwork. To obtain clearer data and information, the research focused on bioclimatic characteristics related to the morphology of the city of Belgrade, environmental pollution, and public health issues. The collected data include bioclimatic characteristics and space properties, dimensions of the location, and traffic activities. Quantitative methods were used to analyze data and determine correlations between the characteristics of different areas and levels of air pollution.

Display of the device characteristics used for measuring air quality

- $PM_{2.5}$ Sensor
- Name: SHARP GP2Y1030AU0F
- Measures particles smaller than 2.5 μm and larger than 2.5 μm
- Sensitivity at particle density of 100 μg/m^3 is typically 1590
- Sensitivity at particle density of 300 μg/m^3 is typically 4300
- Airflow rate required for the sensor: 0.5~3 m/s

Gas, Pressure, Temperature & Humidity Sensor

- Name: Bosch BME680
- Gas precision: 5%
- CO_2 baseline value: 500
- Pressure measurement range: 300-1100 hPa, precision: ±0.6 hPa
- Humidity range: 0-100 %r.H., precision: ±3% (also within the housing).

Results and Discussion

Data analysis (Table 2, Figure 1) demonstrates significant differences in air pollution levels among three different locations - Lepenička Street, Bulevar Oslobođenja, and Banjička Forest. Understanding these factors is crucial for developing effective strategies to improve air quality in various parts of the city. By identifying specific local contributors to air pollution, targeted measures can be implemented to mitigate their impact and enhance the overall health and well-being of the population. In addition, Figure 2 presents air pollution levels recorded at the nearest official monitoring station, showcasing daily variations in air quality. A comparison between measured data (Table 2, Figure 1) and official results (Figure 2) highlights discrepancies, indicating that air pollution levels are not uniformly distributed across the city. However, both data sets consistently demonstrate fluctuations in air quality, emphasizing the dynamic nature of urban air pollution.

Table 2. Air pollution measurement results at locations, 2024

Period	Location average values	$PM_{2.5}$ (μg/m³)	PM_{10} (μg/m³)	∑PM (μg/m³)	Humidity (%)	Air pressure (Pa)	CO_2 (ppm)
March	Lepenička Street	52	233.1	286.2	31	100185	608.9
	Bulevar Oslobođenja	66.7	636.2	706.3	30.6	100186.78	613.3
	Banjička forest	41.8	187.9	230	32.7	100094.89	510
September	Lepenička Street	47.3	123.5	170.8	40.2	99758	500
	Bulevar Oslobođenja	71.8	796.8	869.2	40.8	99758	505
	Banjička forest	12.3	5.8	18.2	40.7	99703	520

The analysis has shown a clear relationship between the characteristics of neighborhoods and the levels of air pollution. For instance, streets with higher traffic intensity tend to have higher air pollution compared to less congested streets. Additionally, the height of buildings and population density can influence the dispersion of pollutants in the air.

Lepenička Street exhibits low average values of $PM_{2.5}$ and PM_{10}, similar to Banjička Forest. This could be due to the street's angular position relative to the wind direction, facilitating the dispersion of pollution beyond its boundaries. On the other hand, Bulevar Oslobođenja

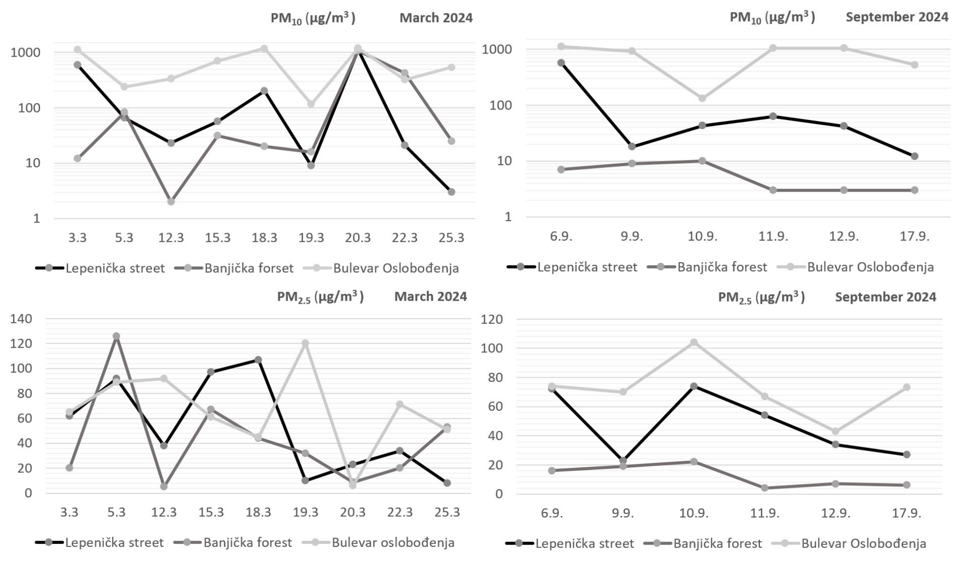

Figure 1. Particulate matter changes by day at different location in the city

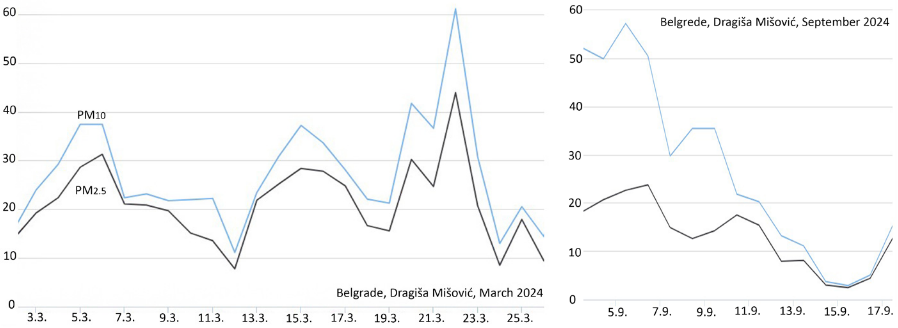

Figure 2. Particulate matter changes by day, measurement location: KBC „Dr Dragiša Mišović", Heroja Milana Tepića 1, Belgrade. [13]

shows higher pollution levels, with average values of $PM_{2.5}$ and PM_{10} (Table 2). This is a result of more intense traffic. Additionally, the boulevard is in the direction of the prevailing wind, which may contribute to the accumulation of pollution along its route. The average values at the locations suggest moderate pollution. Although Banjička Forest is in the wind's direction, adjacent to Bulevar Oslobođenja, potentially exposed to transported pollution, its pollution levels are lower compared to Bulevar Oslobođenja. The CO_2 level was lower in Banjička Forest compared to other locations, possibly due to a higher presence of vegetation that absorbs CO_2 (the minimum value is 500 ppm, and it is considered unhealthy when it exceeds 1000 ppm). Air humidity varied during the measurements,this can affect the particles' ability to disperse in the air and the efficiency of the pollutant deposition process. The average air pressure values remained relatively constant at all locations. Banjička forest exhibits the best quality due to the presence of greenery and absence of traffic.

The research results highlight an important factor that often goes unnoticed in urban environments - air pollution is not uniformly distributed along all streets [4,5,23-26]. This study further confirmed this fact, emphasizing variations in air pollution levels at different locations in the city. These findings are consistent with broader national research (Table 3) which also predicted similar differences in air quality at different locations.

Table 3. Example of air pollutant limit values according to local standards [24]:

Pollutant	Limit value	Measurement period	Legal limit
PM_{10}	50 μg/m³	24 hours	Allowed exceedances: 35 per year
	40 μg/m³	Calendar year	Mandatory compliance
$PM_{2.5}$	25 μg/m³	Calendar year	Mandatory compliance

These studies emphasize that air pollution is a complex problem that requires a differentiated approach. Some streets may be more exposed to pollution due to higher traffic density or the presence of industrial zones, while others may have less pollution due to greater distance from pollution sources or the presence of green areas. Rather than setting universal siting criteria applicable to all urban environments, it would be more effective to rely on expert analysis of local air quality. In some cases, using multiple sensors could be the preferred approach moving forward [14]. Cities already recognize this diversity in air pollution and therefore have multiple monitoring stations distributed throughout the city. This enables more accurate monitoring of air quality and identification of problematic areas, which is significant for developing targeted strategies to reduce pollution. This will allow for more efficient implementation of measures to improve air quality throughout the city. Transportation is a major contributor to urban pollution, and while cities will continue to accommodate cars, prioritizing them in urban planning can harm both human and environmental well-being. Urban planners can promote sustainable transportation modes such as public transit, bike lanes, and pedestrian-friendly areas to reduce car dependency and associated emissions. Many global cities are experiencing a peak in car usage trends [27]. Green spaces and vegetation can also improve air quality by absorbing pollutants and producing oxygen. Proper urban planning, including separating industrial zones from residential areas, can reduce traffic density and its impact on air quality. However, investors often prioritize profit over environmental considerations, which can lead to neglecting ecological sustainability [28]. Approximately 70% [29] of energy consumption is influenced by land use planning decisions [30]. Increased education and cooperation between planners, investors, environmental experts, and local communities are essential for integrating sustainable practices into urban projects. Streets with heavy traffic, such as Bulevar Oslobođenja, typically have higher levels of pollution compared to less congested streets like Lepenička street. These findings underscore the need for an inclusive approach that promotes sustainable transportation, reduces traffic congestion, and expands green spaces.

Potential factors that influenced the results

The air quality measurement results at the location are subject to external factors such as wind speed and direction, traffic intensity, and vegetation condition. For air quality, it is usually more favorable when the wind blows transversely to the street, as it facilitates the dispersion of pollutants in width, rather than blowing along the street and concentrating them in one place. However, this may depend on specific terrain conditions, such as the presence of tall buildings or other obstacles that can affect wind movement and pollution dispersion. In some situations, wind blowing along the street may assist in quicker air cleansing, but transverse wind is considered more favorable for reducing air pollution. Wind transports air contaminants away from their source, facilitating their dispersion. Strong winds can also stir up dust, posing a challenge in dry and windy rural areas [31]. Secondly, traffic intensity has significant potential to contribute to variations in air quality. Since the measurements were conducted during midday hours, factors such as congestion and increased number of vehicles can substantially elevate the emission of harmful gases and particles. During the measurement period in March, vegetation was not in its peak growth phase. The presence and condition of plants can have a significant impact on their ability to absorb certain pollutants from the air. However, the measurements in September yielded the same results as in March, leading to the conclusion that the vegetation in March was dense enough to mitigate pollution. This primarily refers to the vegetation in Banjička forest. Although this is a short-term study, conducted over a limited number of measurement days, the consistent results observed in both March and September indicate that even brief sampling can highlight the stable patterns of air quality across different vegetation and traffic conditions [32,33].

Comparative analysis with related research and literature

Green infrastructure offers localized solutions for reducing pollution exposure, yet actively controlling emissions remains the most effective strategy across various scales [5]. Pedestrian and bicycle paths should be integrated into green areas rather than high-traffic routes [23]. Infrastructure must cater to various populations and consider air pollution implications. A universal sustainable model is less effective than context-specific designs [25]. For instance, Banjička Forest, though near busy Bulevar Oslobođenja, benefits from greenery that mitigates air pollution. This study underscores the need for targeted strategies combining green infrastructure with emission controls. According to Greater London Authority [26], well-placed vegetation can significantly reduce local air pollution.

Based on information from the literature, it can be observed that Lepenička Street appears to be a typical street canyon, where buildings are positioned along both sides (about 12 meters high), shows how such layouts can trap pollutants and heat [4]. Trees are located exclusively in the middle of the widened section of the street (a total of 31 meters). Along the street, there is a single traffic lane and parking space, with narrow sidewalks on both sides. Trees in street canyons can hinder wind, increasing pollution accumulation. Alternative solutions like dense ground-covering hedges or solid barriers might be more effective [4]. In the case of Lepenička Street, the expansion of 31 meters with tall vegetation in the central area can be considered as a potential solution to reduce the heat effect, and provide an opportunity for a different layout, such as underground parking to reduce vehicle circulation and increase the surface area of pedestrian zones.

Bulevar Oslobođenja, which has a width of 30 meters and the presence of residential-commercial buildings (about 15 meters high) on one side and distant objects and forest on the other side, could be considered an open road. [4]. There is a tree-lined median along the entire length of the street between the traffic lanes. The total width is 30 meters, with two traffic lanes in both directions, parking on one side, and wide sidewalks. Vegetation barriers can enhance air quality when dense and tall [4]. Significant reductions exceeding 50% were observed for various pollutants with a 10-meter thick green belt. Vegetation barriers should be placed directly along the road edge, with a minimum height of about 2 meters, to protect the flow of pollutants [5]. Therefore, a proposed solution to improve air quality on streets like Bulevar Oslobođenja could involve organizing traffic lanes so that four traffic lanes are adjacent to each other, with parking along one side. Then, low vegetation should be planted along the road edge, with a height of about 2 meters, to form a vegetation barrier that would help filter pollutants from the air. Subsequently, space for pedestrians and cyclists is recommended, and the tall vegetation currently present in the middle of the boulevard could be removed to make space for these interventions.

Banjička Forest is located along the Bulevar Oslobođenja, with a width of approximately 70 meters, featuring a pedestrian path in the middle. For Banjička forest, which already represents a well-preserved green area, considering its proximity to Bulevar Oslobođenja, where there is heavier traffic and potential for pollution, one option would be to plant evergreen trees along the edge of Banjička forest bordering the boulevard. Evergreen trees have the advantage of retaining their foliage throughout the year, allowing for continuous filtration of pollutants from the air. Alternative paths for cyclists and pedestrians in forest provide people with the opportunity to move without direct exposure to traffic pollution. The linear greenery along these paths enhances air filtration and creates green corridors that support ecological balance and biodiversity. Therefore, Banjička forest not only benefits the local community but also exemplifies sustainable urban planning, serving as a model for improving urban environmental quality.

It should be noted that in most existing urban streets, there is a lack of space for planting greenery. Planting these requires significant space to support root systems, but existing utilities underground and overhead often limit available space. Additionally, safety considerations such as maintaining clear sight lines at road junctions and pedestrian crossings further restrict planting opportunities [26]. Vegetation requires maintenance, the lack of adequate watering and nutrition can limit the growth of trees and hedges, affecting their ability to provide desired ecological and aesthetic benefits. The financial burden of such projects can be significant for local municipalities and administrations as it often requires complete street reconstruction, which may limit the implementation of such initiatives.

Based on literature recommendations and analyzed street characteristics, strategies for improving air quality can be directed towards three key aspects. First, for canyon-like streets, where limited ventilation leads to the accumulation of pollution and heat, effective solutions may include dense, low hedges or solid barriers instead of tall trees. Widening narrow streets could reduce the urban heat island effect, with the potential introduction of underground parking to expand pedestrian zones. Second, for open streets, it is recommended to place vegetative barriers along the road edges to form a continuous filter for pollutants, with traffic lanes organized in the center, followed by green belts and pedestrian and cyclist pathways. Third, the preservation of natural resources and green belts in urban areas may involve planting evergreen trees along busy streets, allowing for year-round pollutant filtration, while alternative pathways for pedestrians and cyclists within green corridors reduce direct exposure to traffic pollution. The proposed strategies are based on proven methods from similar studies [4,5,23,25,26] highlighting the importance of green vegetative barriers in reducing pollution across various urban settings, thereby contributing to a more comprehensive approach to improving air quality.

Conclusion

This study highlights the importance of addressing air pollution issues in urban areas at the local level, as pollution is not evenly distributed across all streets within a city. The connection between the characteristics of locations in Voždovac and pollution levels provides a foundation for further research and policy development aimed at improving air quality. In light of contemporary challenges, the question arises whether street design principles, which have historically focused on aesthetics and functionality, should be revised to reduce pollution. Traditional approaches may lead to the construction of wide streets, tall buildings, and limited green spaces. Strategies for reducing pollution could include more environmentally efficient transportation, increased green spaces, adjustable building heights for better ventilation, and reorientation of streets in alignment with wind direction. Modern approaches can revise traditional street design principles to focus on pollution reduction. This requires a comprehensive approach that includes changes in infrastructure, more green spaces, and collaboration at all levels. The current decision-making mechanisms acknowledge the importance of nature-based solutions in shaping cities. However, the concept of green infrastructure has not yet been established in the legislation of the Republic of Serbia [34]. Additionally, implementing specific policy recommendations, leveraging technological innovations, and ensuring continuous monitoring of air quality will be crucial for effective pollution control. Raising public awareness and addressing financial considerations are also essential for achieving long-term improvements. It is important for cities to share best practices to collectively address this global challenge and create a healthier future for all. This initial research can serve as a foundation for future, more extensive studies on air pollution seasonality in Belgrade and similar urban environments, with an emphasis on extended monitoring periods to gain deeper insights into seasonal variations.

ABBREVIATIONS

CO_2 Carbon dioxide [ppm]
PMxx Particulate matter [μg/m^3]
PSI Pollutant Standard Index
SO_2 Sulfur dioxide [μg/m^3]
NO_2 Nitrogen dioxide [μg/m^3]
CO Carbon monoxide [ppm]
O_3 Ozone [μg/m^3]

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Izvod

PROCENA KVALITETA VAZDUHA U BEOGRADU: UVIDI IZ STUDIJA SLUČAJA

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Ovaj rad analizira aerozagađenje na tri lokacije na opštini Voždovac u Beogradu: Lepenička ulica, Bulevar oslobođenja i Banjička (Bajfordova) šuma. Iako su ove oblasti prostorno blizu, značajno se razlikuju po intenzitetu saobraćaja, urbanističkom rasporedu, zelenoj infrastrukturi i prisustvu zgrada različitih visina. Studija ispituje koncentracije suspendovanih čestica ($PM_{2.5}$ i PM_{10}), vlažnost i koncentraciju ugljen dioksida (CO_2), kao i nivoe vazdušnog pritiska na posmatranim lokacijama. Rezultati pokazuju da lokalno zagađenje vazduha direktno zavisi od prisustva zelenih površina i izloženosti saobraćaju. Studija naglašava uticaj urbanističkog planiranja i zelene infrastrukture na kvalitet vazduha, ističući potrebu za ciljanom ekološkom politikom u urbanim područjima. Takođe se ističe značaj specifičnih ekoloških mera kako bi se postigli optimalni rezultati po životnu sredinu, ekonomiju i zdravlje zajednice.

Ključne reči: zagađenje vazduha, monitoring životne sredine, izvori zagađenja, Beograd

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