Journal of the Serbian Chemical Society
JSCS-info@shd.org.rs • www.shd.org.rs/JSCS
*J. Serb. Chem. Soc. 89* (5) 743–755 (2024)
*JSCS–5753*
*Original scientific paper*
Published 9 May 2024

# Effects of urban vegetation on PM mitigation: The case of a street in Novi Sad, Serbia

MILJAN ŠUNJEVIĆ[1], DEJANA NEDUČIN[1]*, RUŽICA BOŽOVIĆ[2], MAJA SREMAČKI[1], BORIS OBROVSKI[1] and IRINA SUBOTIĆ[1]

[1]*Faculty of Technical Sciences, University of Novi Sad, Trg Dositeja Obradovića 6, Novi Sad, Serbia and* [2]*Faculty of Technical Sciences, University of Priština, Knjaza Miloša 7, Kosovska Mitrovica, Serbia*

(Received 17 January, revised 2 February, accepted 7 March 2024)

*Abstract*: Experiencing rapid development and growth, cities worldwide face a surge in air pollution, primarily driven by the increased concentrations of the particulate matter (PM) originating from various anthropogenic sources, such as traffic, household fuel combustion, and industrial and construction activities. Urban green spaces can naturally filter PM through physicochemical processes, serving as effective urban planning instruments for the improvement of the air quality. Focusing on a street in Novi Sad, the second-largest city in Serbia, this study investigates the efficiency of vegetation in mitigating air pollution, specifically $PM_{10}$ emissions from traffic and construction activities. Using the contemporary monitoring and modelling techniques for measuring and predicting $PM_{10}$ concentrations, the focus of this research is to evaluate the efficacy of vegetation in affecting and minimizing detected PM concentrations. The results indicate a significant reduction in the monitored $PM_{10}$ concentrations behind the green barrier compared to the modelled concentrations near the pollution source (on the road) for both traffic and construction-related emissions. The paper highlights the capacity of green elements to act as natural air pollution mitigators and suggests better integration of strategic environmental management into urban planning to foster the development of healthier and more sustainable cities, providing recommendations to facilitate this objective.

*Keywords*: air pollution; particulate matter (PM); mitigation; urban green spaces; urban design.

## INTRODUCTION

Developing and growing at an almost unprecedented pace, the cities worldwide are grappling with an upsurge in air pollution, primarily attributed to the elevated concentrations of the urban particulate matter (PM). The term refers to a

* Corresponding author. E-mail: d.neducin@uns.ac.rs
https://doi.org/10.2298/JSC240117028S

mixture of minute liquid droplets, solid fragments, and solid cores with liquid coatings suspended in the air and dispersed within urban environments. The particles vary in size, shape,and chemical composition and are classified based on the diameter, with a distinction between fraction $PM_{10}$ (≤ 10 μm) and $PM_{2.5}$ (≤ 2.5 μm). Among diverse sources of PM emission in urban areas, which are mainly related to anthropogenic activities, traffic emerges as a primary contributor.[1–3] According to the calculations, it is responsible for 25 % of urban ambient air pollution from $PM_{2.5}$ and $PM_{10}$, followed by household fuel combustion and industrial activities.[4,5] Additionally, traffic releases various gaseous pollutants, including carbon monoxide, nitrogen oxides ($NO_X$) and sulphur dioxide.[6] Construction activities, including road construction or reconstruction, as well as building projects, are also recognized as significant sources of air pollution in urban environments, releasing a substantial quantity of PM into the air.[7–9] Due to their minute size, $PM_{10}$ and $PM_{2.5}$ are inhalable and can thus induce adverse health effects, including severe acute and chronic diseases.[2,10] With over half of the world's population residing in cities (a proportion expected to increase to 68 % by 2050 according to the UN),[11] urban air quality represents a paramount health concern. Therefore, monitoring and regulating urban PM levels are crucial for mitigating air pollution and safeguarding public health.

A large body of literature has explored the positive environmental impacts of urban green spaces (UGS) in terms of their ability to mitigate the effects of the ambient air pollution by naturally filtering PM, CO, $NO_X$ and $SO_2$.[12–14] UGS thus serve as an effective urban planning tool for improving air quality, especially in urban areas with moderate to heavy traffic, while also contributing to the regulation of temperature, humidity, and air circulation, thereby improving microclimate conditions. In addition, they can reduce the urban heat island effect and offset greenhouse gas emissions by absorbing $CO_2$, contributing to the efforts to address the impacts of climate change.[15,16] Owing to the array of positive impacts on the urban environment they provide, which turn into benefits for public health, UGS can be considered a public good.[17] They are regarded as one of the most valuable urban planning solutions for enhancing the sustainability and resilience of cities.

Novi Sad, the second-largest city in Serbia, was formerly recognized as the green city due to the abundance of lush vegetation that adorned its urban landscape. In alignment with global urbanization trends, it has recently experienced rapid urban development and growth, resulting in a significant increase in both vehicular traffic and construction activities. As outlined in the city's Strategy for the Development of the Green Spaces System 2015–2030, the novel urban development patterns that favour land-use conversion for new constructions have largely overlooked the development of UGS and diminished their share in many city neighbourhoods and along numerous streets.[18] This type of transformation has brought about significant environmental implications, contributing to the elevated concentrations of urban PM and thus exerting a notable impact on air quality in many city neighbourhoods, especially those that underwent extensive regeneration. However, in the neighbourhoods unaffected by extensive regeneration projects, UGS were preserved, although they were often inadequately maintained, because of the increased traffic pollution.

The paper investigates the efficacy of UGS in mitigating air pollution in a street in Novi Sad, focusing on $PM_{10}$ emissions from two different sources – traffic and construction activities. Employing monitoring and modelling techniques, it measures and predicts $PM_{10}$ concentrations and assesses the capacity of vegetation to reduce them. The monitoring involves measuring PM concentrations behind the green barrier using a sensor, while modelling uses COPERT v.5.7 software for the traffic emissions and the EPA tier 1 prediction model for the construction-related emissions near the source (on the road). Additionally, the paper describes the physicochemical interactions between urban PM and vegetation, and addresses current challenges in maintaining and developing UGS in Novi Sad. It underscores the potential of green elements to acts as natural air pollution mitigators and suggests the integration of strategic environmental management into urban planning, in order to create healthier and more sustainable cities, offering recommendations that would aid in achieving this goal.

*Physicochemical interactions mechanisms between urban PM and vegetation*

Vegetation mitigates air pollution by capturing and interacting with urban PM through physicochemical processes. Leaves of trees and hedges act as physical barriers to PM through both adsorption and absorption mechanisms.[19] Their surface properties influence the adsorption of PM, while their microscopic structures and chemical components facilitate the absorption of soluble components from PM into leaf tissues.[20] Upon the contact with leaves, the chemical composition of urban PM undergoes transformations. The reactive oxygen species (ROS), released by leaves during photosynthesis, may oxidize certain PM components, altering their toxicity and reactivity, while enzymatic activities within leaves contribute to the breaking of organic compounds present in PM.

Adsorption predominantly involves the physical adherence of particles to a surface, whereas absorption entails their uptake into the body of the absorbing material. Biochemical adsorption is a process in which particles adhere to a surface, playing a fundamental role in the interaction between urban PM and leaves (trichomes, cuticles and stomata are integral to this process). Trichomes, the hair-like structures on leaf surfaces, significantly contribute to the PM adsorption through their unique morphology enhancing the surface, acting as physical barriers, effectively trapping airborne particles and preventing their dispersion into the atmosphere.[21] Cuticles, the waxy layers covering the leaf epidermis (hydrophobic barrier), and stomata, microscopic pores facilitating the gas exchange, are also integral to the process of PM adsorption.[22] The absorption process involves the penetration of PM components through the cuticles and stomata, entering the leaf tissues, after which they may undergo chemical transformations.[23] ROS released during photosynthesis and enzymatic activities within leaves contribute to the PM transformations within the interaction with UGS. ROS-mediated oxidation can modify the chemical structure and the toxicity of PM components, potentially rendering them less harmful.[24] Furthermore, the enzymatic activities within tree leaves play a crucial role in breaking down organic compounds present in PM. This enzymatic degradation is a crucial step in the transformation of complex organic pollutants into potentially less harmful forms.

*UGS in Novi Sad*

According to the European Environment Agency (EEA) report, green infrastructure covers 18.7 % of Novi Sad's core area and 29.8 % of its commuting zone, both figures falling below the average of 42 % for urban areas in 38 EEA member and cooperating countries.[25] The UGS provision, also referred to as the UGS ratio, quantifies the total green space area within a city's administrative boundaries, expressed as $m^2$ per inhabitant (inhab), and various scientific papers and public policies commonly cite a minimum ranging between 9 and 11 $m^2$/inhab.[26–28] Novi Sad slightly exceeds this minimum, boasting 12 $m^2$/inhab. The data obtained from the newly developed GIS of green areas reveals that grasslands cover 30 % of the city area, while shrubs make up 14 %. The EEA report further notes that urban tree cover, defined as the urban area "covered by tree crowns when seen from above", is 23 % in Novi Sad, which is lower than the average in cities of EEA member and cooperating countries, standing at 30 %.[25] UGS-related issues have also been outlined in local documents. In the UGS SWOT analysis presented in the city's Strategy for the Development of the Green Spaces System 2015–2030 identified weaknesses include inadequate maintenance, a lack of adequate UGS-related regulations (standards and norms), violations of planning documentation, shortages of greenery in some city neighbourhoods, inadequacy of certain UGS categories, and an incomplete UGS network.[18] The main threats to UGS include the risk of land use conversion that may jeopardize the existing green areas and insufficient financial resources for both maintaining existing and creating new UGS. Similarly, the city's Sustainable Development Strategy identifies a lack of UGS as one of the main weaknesses in the urban development SWOT analysis.[29] The results from a 2021 survey, based on a sample of 1,500 residents, reveal that the public is well-aware of all these problems – 38.1 % of respondents rated UGS with a grade 3 (out of 5), while 39.1 % assigned them a grade of 1 or 2 – suggesting that the level of satisfaction with UGS in Novi Sad is generally low.[30] However, in the neighbourhoods that were unaffected by urban regeneration projects and land-use conversions, which often diminished the share of UGS, the satisfaction is much higher than in the regenerated ones.

## MATERIALS AND METHODS

The examination of the impact of vegetation on mitigating air pollution in a street in Novi Sad comprised two phases – monitoring and modelling of $PM_{10}$ emissions from two different sources – traffic and construction activities. The monitoring focused on determining the $PM_{10}$ concentration behind the green barrier, away from the source, while the modelling predicted the concentration values at the source (on the road).

*The monitoring and modeling location*

The examination took place in the Novo Naselje neighbourhood, which was predominantly developed in the late 1970s and during the 1980s (Figs. 1 and 2). This neighbourhood was chosen for two reasons: 1) it stands out as one of the few city districts that largely preserved its green infrastructure, *i.e.*, it remained relatively unaffected by the recent land-use conversion trends, which brought new residential, commercial, and mixed-use developments and typically resulted in a significant reduction of vegetation; 2) in the aforementioned public survey, the residents of Novo Naselje expressed much higher satisfaction with the quality of green spaces, compared to the residents of other city neighbourhoods. A segment of Jovana Dučića Blvd. was chosen as the monitoring and modelling location for three reasons (Figs. 2 and 3): 1) it represents the main and busiest street of this neighbourhood, characterized by moderate traffic, with heavy traffic peaks and frequent congestions during rush hours; 2) the selected segment features lush vegetation along both sides; 3) it underwent comprehensive road reconstruction that began in November 2022, enabling the measurement of both traffic and construction activities-related $PM_{10}$ emissions.

Fig. 1. The position of Novo Naselje within Novi Sad. Source: GIS of Green Areas in Novi Sad (https://gis.zelenilo.com/Map).

Fig. 2. Jovana Dučića Blvd. within Novo Naselje and the analyzed segment. Source: GIS of Green Areas in Novi Sad (https://gis.zelenilo.com/Map).

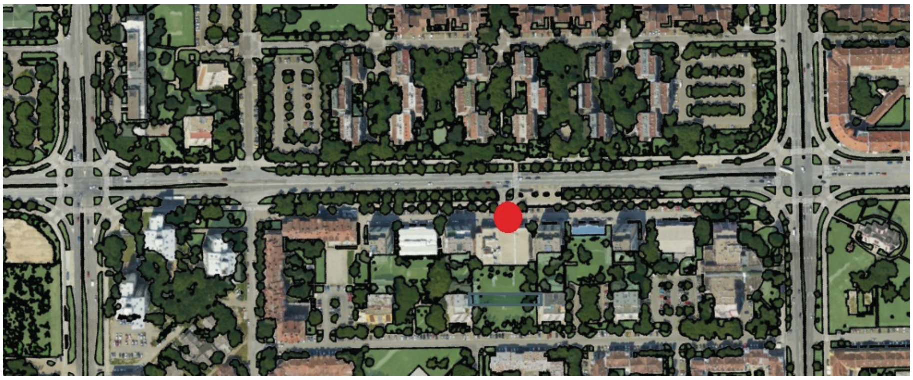

Fig. 3. The monitoring and modeling location and its green infrastructure, with the position of the monitoring sensor. Source: GIS of Green Areas in Novi Sad (https://gis.zelenilo.com/Map).

*The monitoring phase*

The monitoring of $PM_{10}$ emissions was conducted in two different urban circumstances – road reconstruction (no traffic) and rush hour (morning and afternoon – heavy traffic). The monitoring for road reconstruction emissions was performed on the 2$^{nd}$ and 3$^{rd}$ of November 2022, coinciding with the road removal activities that generate higher $PM_{10}$ emission levels. The morning and afternoon rush hour emissions (07:00–09:00 and 15:00–17:00) were measured before the reconstruction began, from the 24$^{th}$ to the 28$^{th}$ of October 2022, capturing baseline levels. A custom-designed PM monitoring sensor based on the optical particle counter OPC-N2 (produced by Alphasense) was used, positioned on the building facade (behind the green barrier) in the middle section of the street, distanced approximately 25 m from the road (Figs. 3 and 4).

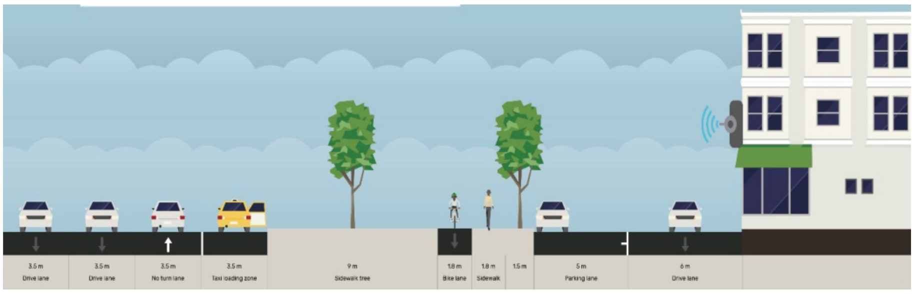


Fig. 4. Street section of the monitoring and modeling location, with the position of the monitoring sensor.

*The modeling phase*

Traffic-related $PM_{10}$ emissions were modelled using COPERT v5.7 software (computer program to calculate emissions from road transport), used in EU member states for the official submission of road transport inventories. The spatial scale of the applied COPERT model can range from a street to a continental level. The modelling followed the COPERT methodology outlined in the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019 for the calculation of air pollutant emissions, which aligns with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.[31,32] The modelling using COPERT v5.7 software required specific data. According to the National Traffic Safety Strategy 2023–2030, the average age of vehicles in Serbia is 17 years, with a petrol- and diesel-fuelled car ratio of 1:2.[33] The local meteorological data, including average wind speeds, humidity and temperatures necessary for the modelling process, were sourced from the website of the Republic Hydrometeorological Institute of Serbia (available at https://www.hidmet.gov.rs/), while the local traffic-related data were collected from the Traffic Study of the City of Novi Sad.[34] For $PM_{10}$ emissions from the construction activities, the calculations relied on the EPA tier 1 prediction model, previously applied and tested in a study involving five construction sites in Novi Sad, which included a direct comparison of modelled and sensor-measured data, confirming the high efficiency of the prediction model.[35] Given that the location C1 in this study was undergoing road reconstruction, the silt content value of 35.4 $\mu g\ m^{-3}$ has been adopted for the purpose of this research.

The limitations of this research relate to $PM_{2.5}$ concentrations, arising from insufficient data necessary for accurate modelling.

## RESULTS AND DISCUSSION

The average $PM_{10}$ concentrations obtained through the monitoring and modelling of pollutant emissions attributed to traffic and construction activities on Jovana Dučića Blvd. in Novi Sad are presented in Table I.

The data reveal a substantial reduction in $PM_{10}$ concentrations behind the green barrier compared to those modelled at the source (on the road) for both traffic and construction-related emissions. Specifically, the $PM_{10}$ concentration from traffic emissions decreased from 98.45 to 26.69 $\mu g\ m^{-3}$, while the concentration from the construction activities exhibited a similar drop – from 145.17 to 51.36 $\mu g\ m^{-3}$.

TABLE I. Average $PM_{10}$ concentration values () obtained from monitoring and modeling

| $PM_{10}$ concentration, μg $m^{-3}$ | Traffic | Construction activities |
|---|---|---|
| Modelled (on the road) | 98.45 | 145.17 |
| Monitored (behind the green barrier) | 26.69 | 51.36 |
| Relative decrease (behind the green barrier), % | 72.9 | 64.6 |

Considering the EPA's $PM_{10}$ breakpoints for assessing the health impact of $PM_{10}$ concentrations,[36] the modelled values for both sources fall within the moderate interval (55–154 μg $m^{–3}$). The green barrier (monitored values) lowers them down to the good interval (0–54 μg $m^{–3}$), thereby mitigating the risk of short or long-term health effects. Specifically, for traffic-induced emission, the monitored value (26.69 μg $m^{–3}$) falls in the middle of the good interval; however, in the case of construction activities (51.36 μg $m^{–3}$), the monitored value is close to the upper interval limit, nearing the "unhealthy for sensitive individuals" threshold. This highlights a potential health concern in relation to $PM_{10}$ concentrations, originating from construction activities.

The influence of construction activities on environmental pollution can be additionally analysed by comparing the $PM_{10}$ emission intensity from two sources. The absolute values of $PM_{10}$ concentrations, both modelled and monitored (Table I), indicate that construction activities need particular attention as a significant $PM_{10}$ pollution source.

The relative decrease in $PM_{10}$ concentrations behind the green barrier is moderately balanced (Table I), yet a more pronounced reduction is observed for traffic, when compared to construction activities as a pollution source. This difference in the effectiveness of UGS can be attributed to the nature of the pollution particles emitted from these two sources, and the mechanisms of their interaction with the surface of leaves – suggesting that vegetation might be more efficient in mitigating the traffic-originated particle species.

The average hourly $PM_{10}$ concentration values obtained through monitoring are presented in Fig. 5 for both traffic and construction activities. The frequency of traffic during working days is revealed, considering two distinct rush hours. They also highlight a slowdown in construction activities between 10 and 11 AM, corresponding to the breakfast break, and suggest that particles take approximately 2 h to settle after work cessation. The higher $PM_{10}$ values from construction activities may be attributed to the previously documented limited use of mitigation measures on building sites in Novi Sad.[37]

The modelling of $PM_{10}$ concentrations simulated air pollution at the source (on the road), which would decrease on their path to buildings in the absence of vegetation to perform physicochemical processes and interact with air pollutants. The extent of that decrease would depend on meteorological factors, yet it would be much less significant than when street greenery is present. The notable decrease in $PM_{10}$ concentrations observed behind the green barrier during the monitoring underscores the effectiveness of vegetation in mitigating urban air pollutants. This reduction in both traffic and construction-related $PM_{10}$ concentrations highlights the role of the green infrastructure in alleviating the adverse effects of the anthropogenic activities on air quality in urban environments. The intricate physicochemical processes involving PM and leaves, namely adsorption, absorption and chemical transformations, enable vegetation to function as natural filters, regulating the composition of PM, reducing its toxicity, and thereby improving air quality. It is important to emphasize that the protective role of street vegetation in these terms is contingent upon various factors, including street geometry and morphology,[38] traffic volume,[6] the type of vegetation and its distribution,[13] as well as ventilation conditions influenced by wind patterns.[39]

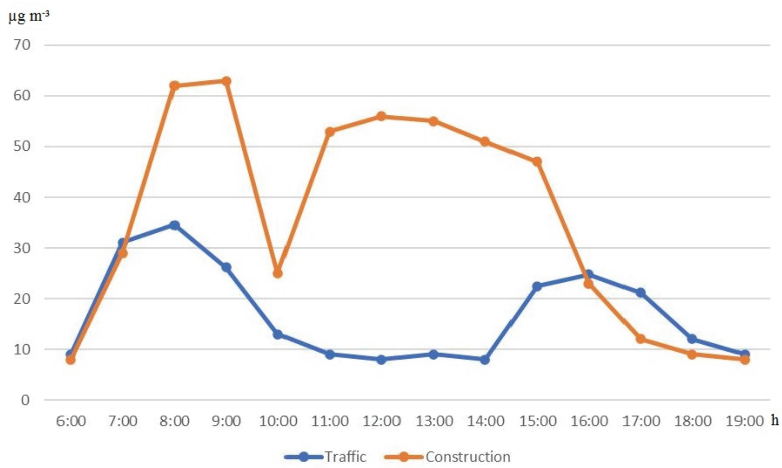


Fig. 5. Average hourly $PM_{10}$ concentration values obtained from monitoring.

The research findings highlight the broader challenges that Novi Sad faces in managing air pollution through urban green spaces (UGS). These results offer a valuable tool for sustainable urban planning and environmental management in the city, leading potential actions. Firstly, it is essential to identify the areas within the city with elevated air pollution levels where the strategic placement of vegetation can effectively mitigate pollutants. Secondly, there should be a priority on preserving and protecting existing vegetation, while also strategically planning for the creation of new UGS in urban regeneration projects. This approach will help maintain or enhance air quality in targeted neighbourhoods. Additionally, it is crucial to develop the UGS-related regulations that take into account factors such as traffic volume, residential density, and other urban planning parameters. Furthermore, efforts should be made to explore the strategies aimed at optimizing traffic flow, reducing congestion, and promoting alternative transportation modes to minimize traffic-related emissions.

Consideration should also be given to the implementing measures that mitigate emissions during construction activities. This can be achieved by carefully selecting parameters, methodologies and indicators for monitoring and evaluating the effects of construction projects. Lastly, integrating the air quality monitoring programs into the city's infrastructure, incorporating the air pollution assessments into the city's land use planning process, and using monitoring data to inform the future urban planning decisions are vital steps to ensure the sustainable air quality management in Novi Sad. These recommendations are also closely tied to the the necessary measures to reduce the UGS-related issues outlined in local documents.

## CONCLUSION

The research explored the effectiveness of vegetation in mitigating air pollution in a street in Novi Sad, with a focus on $PM_{10}$ emissions from traffic and construction activities. The research findings suggest that strategically implemented green infrastructure holds the significant promise for enhancing air quality in urban environments by successfully reducing the concentration of pollutants derived from anthropogenic activities. Future studies could assess the capacity of different plant species related to their physicochemical interactions with PM, in order to gain a better understanding of the physical and chemical impacts of pollutants on plants, which is essential for assessing their long-term viability as natural filters and air pollution mitigators. The research also highlighted the role of UGS as "environmental defenders" and underscored the importance of incorporating environmental management into urban planning to foster healthier and more sustainable cities. Regarding Novi Sad, its new Master Plan adopted in 2022 envisions substantial improvements and enhancements to the city's green infrastructure.[40] In addition to Novi Sad joining EBRD Green Cities in 2019, this signals the local government's shift toward adopting a proactive and environmentally responsible approach to addressing the current UGS-related issues, demonstrating the city's commitment to ensuring sustainable urban development. Therefore, the research findings, complimented by an overview of relevant literature in the field, can be regarded as a technical support to the city administrators and local stakeholders, which should be designed to facilitate the effective development and the implementation of UGS-related policy measures identified in the city's strategies and plans.

*Acknowledgements.* The paper was written within the project "Innovative Approaches and Advancement of Processes and Methods in Higher Education in Architecture, Urbanism and Scene Design" of the Department of Architecture and Urban Planning (Faculty of Technical Sciences, University of Novi Sad, Serbia). This research has been supported by the Ministry of Science, Technological Development and Innovation through project no. 451-03-47//2023-01/200156 “Innovative scientific and artistic research from the FTS (activity) domain”.

ИЗВОД

## УТИЦАЈ УРБАНОГ ЗЕЛЕНИЛА НА СМАЊЕЊЕ КОНЦЕНТРАЦИЈЕ PM ЧЕСТИЦА: СЛУЧАЈ УЛИЦЕ У НОВОМ САДУ

МИЉАН ШУЊЕВИЋ[1], ДЕЈАНА НЕДУЧИН[1], РУЖИЦА БОЖОВИЋ[2], МАЈА СРЕМАЧКИ[1], БОРИС ОБРОВСКИ[1] и ИРИНА СУБОТИЋ[1]

[1]*Факултет техничких наука, Универзитет у Новом Саду, Трг Доситеја Обрадовића 6, Нови Сад* и [2]*Факултет техничких наука, Универзитет у Приштини са привременим седиштем у Косовској Митровици, Књаза Милоша 7, Косовска Митровица*

Услед брзог урбаног развоја и раста, градови широм света суочавају се са порастом загађења ваздуха, првенствено изазваним повећаним концентрацијама урбаних суспендованих честица (PM), које потичу из различитих антропогених извора, као што су моторни саобраћај, грејање фосилним горивом и индустријске и грађевинске активности. Зеленило има капацитет да, путем физичко–хемијских процеса, природно филтрира суспендоване честице, служећи као ефикасан инструмент урбаног планирања за побољшање квалитета ваздуха. Кроз студију случаја улице у Новом Саду, другом по величини граду у Србији, истражује се ефикасност зеленила у смањењу честичног загађења које потиче од саобраћаја и грађевинских активности. Користећи методе мониторинга и моделовања, у раду се мере и предвиђају концентрације $PM_{10}$ честица, а затим се евалуира ефикасност зеленила у њиховом смањењу. Резултати указују на значајно смањење измерених концентрација $PM_{10}$ честица иза зелене баријере у поређењу са моделованим концентрацијама у близини извора загађења (на путу). Наглашава се значај зеленила као природног ублаживача загађења ваздуха у урбаним срединама и кроз формулисане препоруке се залаже за бољу интеграцију стратешког управљања животном средином у урбано планирање.

(Примљено 17. јануара, ревидирано 2. фебруара, прихваћено 7. марта 2024)

## REFERENCES

1. T. M. T. Lei, M. F. C. Ma, *Sustainability* **15** (2023) 10993 (https://doi.org/10.3390/su151410993)
2. A. Mukherjee, M. Agrawal, *Environ. Chem. Lett.* **15** (2017) 283 (https://doi.org/10.1007/s10311-017-0611-9)
3. M. F. Zakaria, E. Ezani, N. Hassan, N. A. Ramli, M. I. A. Wahab, *IOP Conf. Ser.: Earth Environ. Sci.* **228** (2019) 012017 (https://doi.org/10.1088/1755-1315/228/1/012017)
4. F. Karagulian, C. A. Belis, C. F. C. Dora, A. M. Prüss-Ustün, S. Bonjour, H. Adair-Rohani, M. Amann, *Atmos. Environ.* **120** (2015) 475 (https://dx.doi.org/10.1016/j.atmosenv.2015.08.087)
5. J. Li, H. Chen, X. Li, M. Wang, X. Zhang, J. Cao, F. Shen, Y. Wu, S. Xu, H. Fan, G. Da, R. Huang, J. Wang, C. K. Chan, A. L. De Jesus, L. Morawska, M. Yao, *Atmos. Environ.* **212** (2019) 305 (https://dx.doi.org/10.1016/j.atmosenv.2019.05.048)
6. K. V. Abhijith, P. Kumar, J. Gallagher, A. McNabola, R. Baldauf, F. Pilla, B. Broderick, S. Di Sabatino, B. Pulvirenti, *Atmos. Environ.* **162** (2017) 71 (https://dx.doi.org/10.1016/j.atmosenv.2017.05.014)

7. D. Cheriyan, J. Choi, *J. Clean. Prod.* **254** (2020) 120077 (https://dx.doi.org/10.1016/j.jclepro.2020.120077)
8. E. Sekhavati, R. J. Yengejeh, *Front. Public Health* **11** (2023) 1130620 (https://dx.doi.org/10.3389/fpubh.2023.1130620)
9. H. Yan, G. Ding, H. Li, Y. Wang, L. Zhang, Q. Shen, K. Feng, *Sustainability* **11** (2019) 1906 (https://dx.doi.org/10.3390/su11071906)
10. T. Li, Y. Yu, Z. Sun, J. Duan, *Part. Fibre Toxicol.* **19** (2022) 67 (https://doi.org/10.1186/s12989-022-00507-5)
11. UN-Habitat, *World Cities Report 2022: Envisaging the Future of Cities*, United Nations Human Settlements Programme, Nairobi, 2022, https://unhabitat.org/wcr/ (accessed November 3, 2023)
12. A. Diener, P. Mudu, *Sci. Total Environ.* **796** (2021) 148605 (https://dx.doi.org/10.1016/j.scitotenv.2021.148605)
13. S. Janhäll, *Atmos. Environ.* **105** (2015) 130 (https://dx.doi.org/10.1016/j.atmosenv.2015.01.052)
14. S. Wang, S. Cheng, X. Qi, *Front. Public Health* **8** (2020) 551300 (https://dx.doi.org/10.3389/fpubh.2020.551300)
15. M. Fadhil, M. N. Hamoodi, A. R. T. Ziboon, *IOP Conf. Ser.: Earth Environ. Sci.* **1129** (2023) 012025 (https://doi.org/10.1088/1755-1315/1129/1/012025)
16. A. Shishegaran, A. Shishegaran, M. Najari, A. Ghotbi, A. N. Boushehri, *Clean. Eng. Technol.* **1** (2020) 100002 (https://dx.doi.org/10.1016/j.clet.2020.100002)
17. A. Lee, H. Jordan, J. Horsley, *RMHP* **8** (2015) 131 (https://doi.org/10.2147/RMHP.S61654)
18. City of Novi Sad, *Strategy for the Development of the Green Spaces System of the City of Novi Sad 2015–2030*, Official Gazette of the City of Novi Sad, No. 22/2015, Novi Sad, 2015 (in Serbian)
19. A. Przybysz, A. Nawrocki, E. Mirzwa-Mróz, E. Paduch-Cichal, K. Kimic, R. Popek, *Environ. Sci. Pollut. Res.* (2023) (https://dx.doi.org/10.1007/s11356-023-28371-6)
20. J. Liu, Z. Cao, S. Zou, H. Liu, X. Hai, S. Wang, J. Duan, B. Xi, G. Yan, S. Zhang, Z. Jia, *Sci. Total Environ.* **616–617** (2018) 417 (https://dx.doi.org/10.1016/j.scitotenv.2017.10.314)
21. U. Weerakkody, J. W. Dover, P. Mitchell, K. Reiling, *Urban For. Urban Green.* **30** (2018) 98 (https://dx.doi.org/10.1016/j.ufug.2018.01.001)
22. S. Lu, X. Yang, S. Li, B. Chen, Y. Jiang, D. Wang, L. Xu, *Urban For. Urban Green.* **34** (2018) 64 (https://dx.doi.org/10.1016/j.ufug.2018.05.006)
23. S. Chen, H. Yu, X. Teng, M. Dong, W. Li, *Sci. Total Environ.* **853** (2022) 158656 (https://dx.doi.org/10.1016/j.scitotenv.2022.158656)
24. J. H. M. Schippers, *Adv. Bot. Res.* **105** (2023) 113 (https://dx.doi.org/10.1016/bs.abr.2022.10.001)
25. EEA, *Urban Green Infrastructure, 2018*, European Environment Agency, 2018, https://www.eea.europa.eu/data-and-maps/dashboards/urban-green-infrastructure-2018 (Accessed October 28, 2023)
26. D. L. Badiu, C. I. Iojă, M. Pătroescu, J. Breuste, M. Artmann, M. R. Niță, S. R. Grădinaru, C. A. Hossu, D. A. Onose, *Ecol. Indic.* **70** (2016) 53 (https://dx.doi.org/10.1016/j.ecolind.2016.05.044)

27. F. de la Barrera, S. Reyes-Paecke, R. Truffello, H. De La Fuente, V. Salinas, R. Villegas, S. Steiniger, *Urban For. Urban Green.* **79** (2023) 127791 (https://dx.doi.org/10.1016/j.ufug.2022.127791)
28. S. Pouya, M. Aghlmand, *Environ. Monit. Assess.* **194** (2022) 633 (https://dx.doi.org/10.1007/s10661-022-10298-z)
29. City of Novi Sad, *Sustainable Development Strategy of the City of Novi Sad*, Official Gazette of the City of Novi Sad, No. 68/2017, Novi Sad, 2017 (in Serbian)
30. M. Petrović, L. Bajić, I. Stamenković, *Novi Sad - Strategic Framework of Urban Greenery in 2021, BOŠ,* Movement of the Highlanders of Novi Sad & Ministry for Human and Minority Rights and Social Dialogue, Novi Sad, 2021 (in Serbian)
31. EEA, *EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019: Technical Guidance to Prepare National Emission Inventories (EEA Report No 13/2019)*, European Environment Agency, Luxembourg, 2019
32. National Greenhouse Gas Inventories Programme, *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Institute for Global Environmental Strategies, Hayama, 2006 (https://www.ipcc-nggip.iges.or.jp/public/2006gl/)
33. *Traffic Safety Strategy of the Republic of Serbia 2023-2030*, Official Gazette of the Republic of Serbia, No. 84/2023, Belgrade, 2023 (in Serbian)
34. PE Urbanizam, *Traffic Study of the City of Novi Sad with the Dynamics of Traffic Regulation*, Urban Planning, Development and Research Centre PE "Urbanizam" Novi Sad, Novi Sad, 2009 (in Serbian)
35. M. Šunjević, D. Reba, V. Rajs, B. Vujić, M. Ninkov, M. Vojinović-Miloradov, *Therm. Sci.* **27** (2023) 2275 (https://dx.doi.org/10.2298/TSCI220215108S)
36. EPA, *EPA Code Tables: AQI Breakpoints*, United States Environmental Protection Agency, 2024, https://aqs.epa.gov/aqsweb/documents/codetables/aqi_breakpoints.html (accessed January 3, 2024)
37. M. Šunjević, D. Reba, V. Rajs, B. Vujić, D. Nedučin, M. Vojinović-Miloradov, *FU Arch. Civ. Eng.* **20** (2022) 193 (https://dx.doi.org/10.2298/FUACE221004015S)
38. Y. Dai, A. Mazzeo, J. Zhong, X. Cai, B. Mele, D. Toscano, F. Murena, A. R. MacKenzie, *Atmosphere* **14** (2023) 1385 (https://dx.doi.org/10.3390/atmos14091385)
39. GLA, *Using Green Infrastructure to Protect People from Air Pollution*, Greater London Authority, London, 2019, https://www.london.gov.uk/programmes-and-strategies/environment-and-climate-change/environment-publications/using-green-infrastructure-protect-people-air-pollution (accessed October 28, 2023)
40. City of Novi Sad, *Master Plan of the City of Novi Sad until 2030*, Official Gazette of the City of Novi Sad, No. 33/2022, Novi Sad, 2022 (in Serbian).