DOI: 10.7251/QOL2601035M
UDC: 613.956-055.15:159.922.7
Original scientific paper

Assessment and Modeling of Environmental Noise From Open-Air Concerts in a Student Residential Area

Dragana Nešković Markić[1], Predrag Ilić[2] Zoran P. Popović[2], Ljiljana Stojanović Bjelić[1], Srđan Šabić[2]

[1] *Pan-European University "APEIRON", Banja Luka, Bosnia & Hercegovina, ljiljana.v.stojanovicbjelic@apeiron-edu.eu, dragana.d.neskovicmarkic@apeiron-edu.eu*

[2] *PSRI Institute for protection and ecology of the Republic of Srpska, Banja Luka, Banja Luka, Republic of Srpska, Bosnia and Herzegovina, zokapop@yahoo.com, predrag.ilic@institutzei.net*

Abstract: This paper presents the results of a comprehensive study on the assessment of environmental noise levels at selected locations used for public events in the city of Banja Luka. The research was conducted with the aim of evaluating the impact of noise on the environment and public health, as well as determining compliance of the measured noise levels with applicable legal regulations and the recommendations of the European Union and the World Health Organization. The study includes a theoretical analysis of the physical and physiological characteristics of sound and noise, their propagation in space, perception, and effects on the human organism, as well as a review of the relevant legislative framework. Field measurements were carried out at several representative locations using standardized measuring equipment and prescribed methodologies, and the obtained results were analyzed and graphically presented through noise propagation models. Based on the results, conflict areas with elevated noise levels were identified, and specific urban planning, technical, and organizational measures for noise reduction were proposed. The noise modelling results enabled the definition of a noise protection zone and a maximum permissible sound emission level of 78.5 dB(A) for open-air concert organization in the studied student residential area. The conclusions of the study provide a professional basis for the development of decisions and action plans aimed at sustainable noise management during public events and the improvement of quality of life in the urban environment.

Keywords: noise, modeling, visualization, residental area.

INTRODUCTION

Continuous technological development, urban expansion, and intensification of human activities have led to an increasing degradation of environmental quality, particularly in densely populated urban areas (Barboza et al., 2008; Gašić et al., 2010; Ilić, 2015; Ilić et al., 2018a, 2018b, 2018c, 2019a, 2020a, 2020b; Wang et al., 2020; Ilić and Maksimović, 2021; Zhanibekov et al., 2022; Radović et al., 2022; Ćirišan et al., 2023; Popović and Ilić, 2023a, 2023b). As urban systems evolve, the pressure on environmental components intensifies, resulting in complex forms of pollution that directly affect human health and living conditions. While air and water pollution have traditionally been the focus of environmental protection efforts, environmental noise has emerged as one of the most widespread and persistent stressors in modern cities.

Urban environments are characterized by a constant presence of unwanted sound originating from transportation systems, commercial activities, construction works, and various social and cultural events. These sound emissions, when exceeding acceptable thresholds, are classified as environmental noise and represent a significant disturbance to everyday life (Ilić et al., 2012; Luković et al., 2018; Ilić et al., 2018a, 2018b; Fino, 2019; Ilić et al., 2019a, 2019b; Farooqi et al., 2023). The expansion of cities and the increasing concentration of population have led to a reduction of acoustically protected spaces, while zones intended for residence, education, and recreation are increasingly exposed to elevated noise levels.

Environmental noise is recognized as a major public health concern, with the World Health Organization identifying it as one of the leading environmental risks to human health, second only to air pollution (WHO, 2018). Numerous studies have demonstrated its association with adverse health outcomes, including sleep disturbance, cardiovascular diseases, cognitive impairment, stress-related disorders, and reduced quality of life (Basner et al., 2014, Mohamed et al., 2021). Unlike many other pollutants, noise exerts both immediate and long-term effects, influencing not only physiological responses but also psychological well-being and social functioning. The presence of sounds originating from both outdoor and indoor environments inevitably affects health, learning abilities, and students' academic performance (Ali et al., 2023). In student populations, prolonged and repeated exposure to elevated noise levels has been linked to increased stress, reduced concentration, and lower academic performance, particularly during nighttime periods (Buchari and Matondang, 2017; Zhang et al., 2019).

In urban settings, noise pollution is not solely associated with traffic and industrial activities. Recreational and cultural events, particularly open-air concerts and public manifestations, represent an increasingly important source of high-intensity noise. Such events are typically intermittent but can generate sound pressure levels significantly exceeding background noise, especially in acoustically sensitive zones such as residential areas, student campuses, and educational institutions. Previous research has addressed urban noise mapping, prediction, and management, providing methodologies for assessing spatial distribution of noise and identifying critical exposure zones (Ilić et al., 2021e; Božić et al., 2020; Božić et al., 2018). Studies conducted in the city of Banja Luka have highlighted traffic noise as a dominant source, but have also pointed to the growing importance of event-related noise in specific locations (Ilić et al., 2012, 2017, 2018c, 2018e, 2018f; Janjuš et al., 2015a, 2015b). While previous local studies in Banja Luka have primarily focused on mapping and assessing urban traffic-related noise, they have rarely addressed intermittent, high-intensity event-related noise in acoustically sensitive student residential settings. In contrast, this study targets open-air concert scenarios within a Zone III student campus environment by coupling baseline day/night field measurements with forward-looking acoustic propagation modelling. This approach enables scenario-based optimization of stage placement and orientation and provides operational outputs for event management, including the delineation of a noise protection zone and definition of a maximum permissible emission level for compliant concert organization.

Student residential areas represent a particularly sensitive category within the urban acoustic environment. The presence of large numbers of young people, combined with the need for rest, study, and social activities, creates a complex acoustic context in which both low background noise and controlled social events are expected. Excessive noise exposure in such environments may lead to sleep disturbances, reduced academic performance, increased stress levels, and long-term health effects (Farooqi et al., 2000, 2021, 2022; Popović and Ilić, 2023a). Therefore, careful planning and regulation of noise-generating activities in student zones are essential.

The Student Center "Nikola Tesla" in Banja Luka (Bosnia and Herzegovina) represents a typical multifunctional urban space, combining student accommodation, educational facilities, green areas, and public spaces frequently used for social and cultural events. Due to its location within a residential and educational zone, the organization of open-air concerts at this site requires a detailed assessment of environmental noise impact. Determining appropriate locations for sound sources, defining noise protection zones, and establishing maximum permissible sound levels are crucial steps in ensuring compliance with regulatory requirements and protecting the surrounding population.

Modern approaches to noise management emphasize the integration of field measurements with acoustic modeling and spatial visualization. Noise mapping and predictive modeling enable the assessment of different scenarios, allowing planners to evaluate the impact of sound source positioning, orientation, and intensity before events take place (Popović et al., 2024b). Such tools are particularly valuable in urban environments, where complex interactions between sound sources, buildings, terrain, and population distribution influence noise propagation.

The aim of this study is to assess environmental noise levels at the Student Center “Nikola Tesla” during daytime and nighttime periods in order to establish the existing baseline acoustic conditions, and to evaluate the suitability of the location for organizing open-air concerts. Special emphasis is placed on defining the optimal position of the sound source and determining the maximum allowable noise levels that ensure compliance with national regulations while minimizing adverse impacts on students and nearby residents. By combining in situ measurements with acoustic modeling and noise mapping, this work contributes to the development of scientifically grounded guidelines for sustainable management of event-related noise in sensitive urban environments.

MATERIALS AND METHOD

Location

The Student Center “Nikola Tesla” is located in an urban area of Banja Luka characterized by a combination of student accommodation facilities, educational buildings, and accompanying public spaces. The location is situated in a densely populated zone with frequent daily human activity, particularly during academic periods. Surrounding land use includes residential buildings, internal traffic routes, pedestrian zones, and green areas, which makes this location sensitive to increased noise levels, especially during the organization of public events. Due to its function and spatial context, the area represents a typical urban environment where noise impact can directly affect a large number of users, primarily students and nearby residents.

According to national noise zoning, the Student Center “Nikola Tesla” is classified as Zone III, which includes pure residential areas, educational and health institutions, and public green and recreational spaces. This classification implies stricter noise limits due to the sensitivity of the population, particularly students and residents. Noise was measured both during the day and at night at six representative measurement points (MT1–MT6) (Figure 1 and Figure 2). The six measurement locations (MT1–MT6) were selected to ensure representative coverage of the study area, taking into account differences in land use, proximity to dominant noise sources, building density, and spatial distribution of student residential facilities. This configuration enabled the capture of both background urban noise conditions and areas potentially exposed to increased sound levels during open-air concert events.

Figure 1. Measurement setup at location MT2 during daytime noise monitoring at the Student Center "Nikola Tesla", showing the sound level meter positioned at a height of 1.5 m above ground level."

Figure 2. Layout of measurement points (MT1–MT6) at the Student Center "Nikola Tesla", marked on the map with white balloons and corresponding location labels.

The model used for assessment of noise level

The assessment of noise levels was carried out using an acoustic propagation model based on standardized calculation methods for outdoor sound propagation in urban environments. The model takes into account the characteristics of the noise source, spatial configuration of the area, terrain morphology, presence of surrounding buildings, and distance between the source and receptor points. Sound attenuation due to geometric divergence, atmospheric absorption, ground effects, and shielding by obstacles was included, allowing for a realistic estimation of noise distribution and identification of zones with elevated noise exposure (Popović et al., 2024a).

The method of noise level calculation

Overview of the basic quantities, concepts and methods according to which the given assessment was performed are in accordance with the appropriate technical standard according to national regulation (Regulation on Limit Values of Noise Intensity, 2023). Noise level in the point (x, y) genarated by the source labeled with index i in the moment t_j postioned at (x_i, y_i), is given by next exression:

$$L_i(x, y, t_j) = L_0 + 10\log_{10}\frac{{d_0}^2}{(x_i - x)^2 + (y_i - y)^2}$$

where $L_0$is sound level of vehicle, according to the standard calculations (Du et al., 2021) measured at referent distance $d_0 = 7{,}5\ m$. Average contribution to the noise level at each point of the observed location, caused by the uniform movement of mobile heavy machinery along the mine roads, was taken into account. If there are several heavy machines (m total number) at the location, their total contribution to the noise level at each point of the space at a given moment is summarized as follows:

$$L(x, y, t_j) = 10\log_{10}\sum_{i=1}^{m} 10^{0{,}1L_i(x,y,t_j)}$$

Equivalent noise levels (L_{eq}) are obtained by averaging the loudness over time, at each point of the surface, as well as taking into account all possible contributions comming from heavy machines, whose work is foreseen on pile 3. These time averaging calculations were performed in according to the relation

$$L_{eq}(x, y) = 10\log_{10}\frac{1}{T}\int_0^T 10^{0{,}1L(x,y,t)}dt$$

where T is the full time of movement of the transport vehicle along the path with the greatest predicted contribution to the noise level in populated areas (Popović et al., 2024a).

RESULTS AND DISCUSSION

NOISE MEASUREMENTS

Noise measurements were conducted at six representative measurement points (MT1–MT6), strategically distributed across the location to capture spatial variability in noise exposure (Table 1).

Table 1. Measured noise values at the location Student Center "Nikola Tesla"

Measurment point	Coordinates of measuring points	L_{eq} day	L_{eq} night	L_1 day	L_1 night	L_{10} day	L_{10} night
MT 1	44°45'55.24"N 17°12'4.51"E	57,7	46,1	90,4	66,9	79,2	63,9
MT 2	44°45'56.88"N 17°12'0.64"E	56,8	55,6	88,1	77,1	83,1	75,6
MT 3	44°46'0.74"N 17°12'2.18"E	54,2	51,2	81,8	69,4	76,5	67,5
MT 4	44°45'59.87"N 17°11'58.27"E	67,9	69,5	91,2	83,6	85,5	79,4
MT 5	44°45'57.90"N 17°11'53.14"E	50,0	55,6	88,8	79,7	80,2	77,5
MT 6	44°46'2.02"N 17°11'51.56"E	55,0	50,2	76,2	71,3	71,2	66,9

DAYTIME NOISE LEVELS

During daytime measurements, the equivalent noise level (Leq) varied significantly across the location. Measurement points MT3, MT5, and MT6 recorded Leq values within the permissible daytime limit of 55 dB(A), indicating acceptable acoustic conditions in these areas.

However, at MT1, MT2, and MT4, measured Leq values ranged from 56.8 to 67.9 dB(A), exceeding the regulatory limit. The highest daytime Leq value was recorded at MT4, which is directly influenced by road traffic in Majke Jugovića Street. This confirms traffic as the dominant noise source during the daytime period.

Peak noise indicators further emphasize the acoustic burden:

- L1 (daytime) values ranged from 76.2 to 91.2 dB(A), exceeding the allowed limit of 70 dB(A) at all measurement points.
- L10 (daytime) values ranged from 71.2 to 85.5 dB(A), also exceeding the permitted value of 65 dB(A).

These elevated peak levels indicate frequent short-term noise events, typical of traffic flow, acceleration, braking, and occasional impulsive sounds, which significantly reduce acoustic comfort even where equivalent levels are marginally acceptable.

Nighttime noise levels

Nighttime measurements reveal a more critical situation. The equivalent noise level (Leq) during the night exceeded the permissible limit of 45 dB(A) at all measurement points, with values ranging from 46.1 to 69.5 dB(A). The highest nighttime Leq was again recorded at MT4, confirming persistent traffic influence even during night hours.

Peak noise indicators during nighttime further confirm excessive noise exposure:

- L1 (night) values ranged from 66.9 to 83.6 dB(A), exceeding the limit of 70 dB(A) at several points.
- L10 (night) values ranged from 63.9 to 79.4 dB(A), with most values exceeding the allowed 65 dB(A).

Given the function of the area as a student residential zone, these nighttime exceedances are particularly concerning, as they may contribute to sleep disturbance, reduced recovery, and long-term health effects.

The spatial distribution of measured equivalent noise levels (Leq) across all measurement points, in relation to the prescribed daytime and nighttime limits, is presented in Figure 3.

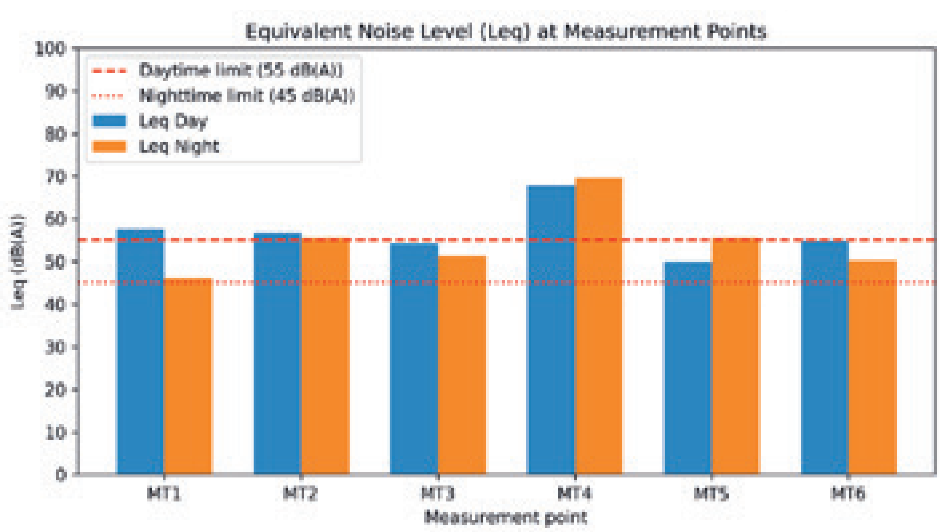

Figure 3. Equivalent noise levels (Leq) measured at MT1–MT6 during daytime and nighttime at the Student Center “Nikola Tesla”. Red horizontal lines indicate the legally prescribed limit values for environmental noise: a dashed line represents the daytime limit of 55 dB(A), while a dotted line represents the nighttime limit of 45 dB(A).

Traffic influence on noise levels

Traffic counting conducted at measurement point MT4 shows that road traffic is the dominant noise source at the location. Fifteen-minute traffic counts during both daytime and nighttime periods indicate that passenger cars constitute the majority of vehicles, with increased traffic intensity observed immediately after the start of the nighttime regulatory period (Table 2).

The persistence of relatively high nighttime traffic volumes explains the elevated nighttime noise levels and the limited reduction in Leq values compared to daytime measurements. This confirms that traffic noise represents a continuous pressure rather than an occasional disturbance at this location.

Table 2. Number of vehicles at the location Student Center "Nikola Tesla" during noise measurements

Measurement point	Motorcycles	Passenger cars	Vans	Busses	Vehicles >5t	Total
Daytime measurements						
MT1	-	3	-	-	-	3
MT2	-	-	-	-	-	0
MT3	-	-	-	-	-	0
MT4	15	378	24	-	-	417
MT5	-	-	-	-	-	0
MT6	-	-	-	-	-	0
Nighttime measurements						
MT1	-	-	-	-	-	0
MT2	-	-	-	-	-	0
MT3	-	-	-	-	-	0
MT4	-	132	3	-	-	135
MT5	-	-	-	-	-	0
MT6	-	-	-	-	-	0

Noise propagation and proposed sound source position

The proposed position of the sound source (stage) for public events is located at coordinates 44°45'57.07"N, 17°11'50.04"E. Acoustic modeling of sound propagation from this position shows that, under controlled orientation and sound power conditions, it is possible to maintain compliance with regulatory limits.

Specifically, the model indicates that:

- At the most exposed residential building (Control Point 1), the noise level does not exceed 50 dB(A), in accordance with the applicable regulation.
- Within the defined noise protection zone (marked by the red contour line), the maximum permissible noise level must not exceed 78.5 dB(A).

The noise map (Figure 3) clearly illustrates the directional propagation of the sound field, with contour lines connecting points of equal noise levels. This confirms that appropriate orientation of the sound system and strict control of emission levels are essential for minimizing environmental impact.

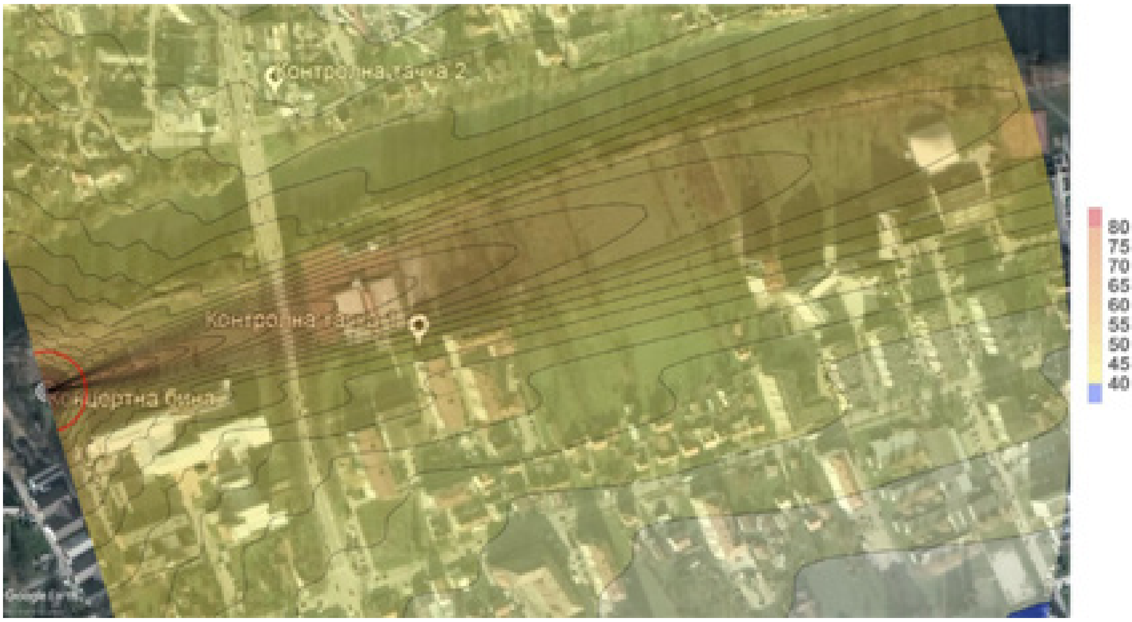

Figure 4. Direction and propagation of the sound front from the proposed stage location at the location Student Center "Nikola Tesla". Points on the map with the same noise level are connected by contours, and the values in the legend are given in dB

The obtained results are consistent with findings from previous studies conducted in university campus environments, which emphasize the importance of integrating field noise measurements with spatial and model-based approaches to adequately characterize noise exposure patterns. Studies combining in situ measurements and noise mapping have shown that such an approach enables the identification of spatial variability and localized areas of elevated noise levels within campus settings, providing a more comprehensive understanding of environmental noise distribution than measurements alone (Zannin et al., 2013). Similarly, propagation-model-based campus noise mapping has been demonstrated to be an effective tool for analysing different exposure scenarios and supporting spatial planning and management decisions in complex university environments (Huang et al., 2022). In this context, the results of the present study further confirm the applicability of measurement-supported modelling as a robust framework for assessing noise conditions in sensitive student residential areas.

CONCLUSION

This study provides a comprehensive assessment of environmental noise conditions at the Student Center "Nikola Tesla" in Banja Luka, with a particular focus on the suitability of the location for organizing open-air concerts in a sensitive urban and student residential environment. The combination of systematic field measurements and acoustic modeling enabled a detailed analysis of both existing background noise conditions and potential impacts associated with event-related sound emissions.

The results clearly indicate that the investigated area is already exposed to elevated noise levels, primarily due to road traffic, even in the absence of public events. Daytime exceedances of equivalent noise levels (Leq) were recorded at several measurement points, while nighttime measurements revealed widespread and consistent exceedances across the entire location. These findings confirm that traffic noise represents a continuous and dominant source of environmental noise pressure in the study area, significantly limiting the available acoustic capacity for additional noise-generating activities.

Peak noise indicators (L1 and L10) further emphasize the acoustic vulnerability of the location, showing frequent short-term noise events that exceed regulatory limits during both daytime and nighttime periods. Such noise characteristics are particularly critical in student residential zones, where uninterrupted rest, recovery, and favorable conditions for learning are essential. Persistent exposure to elevated noise levels may contribute to sleep disturbances, increased stress, reduced academic performance, and long-term health effects among students and nearby residents.

Despite these constraints, the applied acoustic propagation model demonstrated that, under carefully controlled conditions, the organization of open-air concerts at the Student Center "Nikola Tesla" can be managed in compliance with national noise regulations. The modeling results confirmed that appropriate positioning of the sound source, controlled orientation of the sound system, and strict limitation of sound power levels are key factors in minimizing noise propagation toward the most exposed residential buildings. The defined noise protection zone and the established maximum permissible noise level of 78.5 dB(A) within this zone provide clear operational boundaries for event planning.

The study highlights the importance of integrating measurement-based assessments with predictive noise modeling when planning public events in acoustically sensitive urban areas. Such an approach allows decision-makers to evaluate different scenarios in advance, identify potential risks, and implement preventive measures before regulatory exceedances occur. This is particularly relevant for multifunctional urban spaces, where residential, educational, and recreational functions coexist.

In a broader context, the findings underline the necessity of proactive noise management strategies in student residential zones. Urban planning and event organization should not rely solely on post-event monitoring, but rather on scientifically grounded planning tools that balance social and cultural activities with the protection of public health and quality of life. The methodology applied in this study offers a practical and transferable framework that can be used for similar locations in other urban environments.

Overall, this research confirms that sustainable management of event-related environmental noise is achievable through a combination of accurate field measurements, advanced modeling techniques, and strict adherence to regulatory requirements. By defining optimal sound source locations and maximum allowable noise levels, it is possible to support cultural and social activities while preserving the acoustic comfort and well-being of student populations and surrounding communities.

Conflict of Interest
The authors declare no conflict of interest.

REFERENCES

Ali, H. H. M., Farhan, A. H. and Jawad, A. S. (2023) Comprehensive Review of Noise Pollution Sources, Health Impacts, and Acoustic Environments Affecting College and University Students. Mesopotamian Journal of Civil Engineering, 2023, pp.86-97

Barboza, M. J., Carpenter, S. P., & Roche, L. E. (1995). Prediction of traffic noise: A screening technique. Journal of the Air & Waste Management Association, 45: 703–708. https://doi.org/10.1080/10473289.1995.10467398

Basner, M., Babisch, W., Davis, A., Brink, M., Clark, C., Janssen, S., & Stansfeld, S. (2014). Auditory and non-auditory effects of noise on health. The Lancet, 383(9925): 1325-1332. https://doi.org/10.1016/S0140-6736(13)61613-X

Božić, J., Ilić, P., & Bjelić Stojanović, LJ. (2018). Economic aspects of the city traffic noise: case study. EMC REVIEW, 8(1): 134-149. http://dx.doi.org/10.7251/EMC1801134B

Božić, J., Ilić, P., & Ilić S. (2020). Noise Levels in the Modern Urban Roundabout, Indian Journal of Environmental Protection, 40(12): 1264-1272.

Buchari & Matondang, N., (2017). The impact of noise level on students' learning performance at state elementary school in Medan. In AIP Conference Proceedings (Vol. 1855, No. 1, p. 040002). AIP Publishing LLC.

Ćirišan, A, Podraščanin, Z, Nikolić Bujanović, LJ, Mrazovac Kurilić, S, & Ilić, P (2023). Trend Analysis Application on Near Surface SO_2 Concentration Data from 2010 to 2020 in Serbia. Water Air Soil Pollution, 234:186. https://doi.org/10.1007/s11270-023-06111-3

Du, C., Qiu, X., Li, F., & Cai, M. (2021). A simulation of traffic noise emissions at a roundabout based on a cellular automaton model. Acta Acustica, 5, 42. https://doi.org/10.1051/aacus/2021037

Farooqi, Z. U. R., Ahmad, I., Ditta, A., Ilić, P., Amin, M., Naveed, A. B., & Gulzar, A. (2022). Types, sources, socioeconomic impacts, and control strategies of environmental noise: a review. Environmental Science and Pollution Research, 1-25. doi.org/10.1007/s11356-022-23328-7

Farooqi, Z. U. R., Ahmad, I., Zeeshan, N., Ilić, P., Imran, M., & Saeed, M. F. (2021). Urban noise assessment and its nonauditory health effects on the residents of Chiniot and Jhang, Punjab, Pakistan. Environmental Science and Pollution Research, 1-13. doi.org/10.1007/s11356-021-14340-4

Farooqi, Z. U. R., Sabir, M., Latif, J., Aslam, Z., Ahmad, H. R., Ahmad, I., Imran, M., & Ilić, P. (2020). Assessment of noise pollution and its effects on human health in industrial hub of Pakistan. Environmental Science and Pollution Research, 27(3): 2819-2828 doi.org/10.1007/s11356-019-07105-7

Farooqi, Z.U.R., Qadir, A.A., Ilić, P., Zeeshan, N., Tunguz, V., & Pržulj, N. (2023). Restoration and Preservation of Degraded Soils for Crop Production. In Ilić, P., Govedar Z., & Pržulj N. (Eds.), Environment (1st ed., pp. 243–283). Banja Luka: Academy of Sciences and Arts of the Republic of Srpska. https://doi.org/10.7251/EORU2309243F

Fino, A. (2019). Air Quality Legislation, Encyclopedia of Environmental Health (Second Edition), 61–70. https://doi.org/10.1016/B978-0-12-409548-9.11045-0

Gašić, B, MacLeod, M, Klánová, J, Scheringer, M, Ilić, P, Lammel, G, Pajović, A, Breivik, K, Holoubek, I, & Hungerbühler, K (2010). Quantification of sources of PCBs to the atmosphere in urban areas: A comparison of cities in North America, Western Europe and former Yugoslavia, Environmental Pollution, 158(10): 3230–3235 https://doi.org/10.1016/j.envpol.2010.07.011

Huang, X., Liu, J., & Meng, Z. (2022). Application of university campus noise map based on noise propagation model: a case in Guangxi University. *Sustainability*, *14*(14), 8613. https://doi.org/10.3390/su14148613

Ilić, P (2015). Pollution and air quality control in the function of environmental protection. Independent University, Banja Luka

Ilić, P, Nišić, T, Ilić, S, & Stojanović Bjelić, LJ (2020a). Identifying New 'Hotspot' Heavy Metal Contamination in Industrial Zone Soil. Polish Journal of Environmental Studies, 29(4): 2987–2993. https://doi.org/10.15244/pjoes/113095

Ilić, P, Popović, Z, & Gotovac-Atlagić, S (2019a). Effects of meteorological variables on nitrogen dioxide variation. Archives for Technical Sciences, 20(1): 65-72. http://dx.doi.org/10.7251/afts.2019.1120.065I

Ilić, P, Popović, Z, & Nešković Markić, D (2020b). Assessment of meteorological effects and ozone variation in urban area. Ecological Chemistry and Engineering S, 27(3): 373–38. https://doi.org/10.2478/eces-2020-0024

Ilić, P., & Maksimović, T. (2021): Air pollution and biodiversity. Pan-European University ''Apeiron'', Banja Luka.

Ilić, P., Farooqi, Z. U. R., & Stojanović Bjelić, LJ. (2021e). Determining, Mapping and Prediction of Noise Pollution, Indian Journal of Environmental Protection, 41(4): 379-384.

Ilić, P., Ilić, S., & Bjelić, L. S. (2018b). Hazard modelling of accidental release chlorine gas using modern tool-Aloha software. Quality of Life, 16(1-2): 38-45. http://dx.doi.org/10.7251/QOL1801038I

Ilić, P., Janjuš, Z., & Markić Nešković, D. (2017). Daily level of noise pollution in urban areas City of Banja Luka in the winter, Aktuelnosti 38: 9-22. https://doi.org/10.7251/AKT17380091

Ilić, P., Markić, D. N., & Pešić, Ž. Š. (2018c). Analyzing and mapping noise in the city of Banja Luka (Sime Matavulja Street). Business Studies, 10(19-20): 47-53. http://dx.doi.org/10.7251/POS18047I

Ilić, P., Markić, D. N., Bjelić, L. S., & Farooqi, Z. U. R. (2019b). Dispersion Modeling of Accidental Releases of Propane Gas. Quality of Life, 17(1-2): 41-46. http://dx.doi.org/10.7251/QOL1901041I

Ilić, P., Marković, S., & Janjuš, Z. (2012). Municipal noise and air pollution in urban part of Banja Luka. In Proceedings of the II Symposium of Biologists of the RS and the I Symposium of Ecologists of the Republic of Srpska (pp. 19-31). Banja Luka.

Ilić, P., Nešković Markić, D., & Stojanović Bjelić, LJ. (2018a). Variation concentration of sulfur dioxide and correlation with meteorological parameters. Archives for Technical Sciences, 18(1): 81-88. http://dx.doi.org/10.7251/afts.2018.1018.081I

Ilić, P., Neskovic-Markic, D., & Stojanovic Bjelic, LJ. (2018b). Measuring and mapping noise pollution in the City of Banja Luka, Archives for Technical Sciences, 18(1): 89-96. https://doi.org/10.7251/afts.2018.1018.089I

Ilić, P., Neskovic-Markic, D., & Stojanovic Bjelic, LJ. (2018c). Traffic noise levels in the City of Banja Luka, Quality of Life, 9(1-2): 20-26. https://doi.org/10.7251/QOL1801020I

Ilić, P., Stojanović-Bjelić, L., & Janjuš, Z. (2018f). Noise Pollution near Health Institutions. Quality of Life, 9(1-2): 56-63. https://doi.org/10.7251/QOL1801056I

Janjuš, Z., Bogdanić, D., Pavlović, S., Čekrlija, S., & Ilić, P. (2015). Generators noise in Kotor Varoš municipality. 28th International Process Engineering Congress PROCESSING '15, 28(1): 270-276.

Janjuš, Z., Ćetojević, V, Pavlović, S., Čekrlija, S., & Ilić, P. (2015). The noise impact of transport on environment city of Banja Luka. 28th International Process Engineering Congress PROCESSING '15, 28(1): 264-269.

Luković, M., Vićić, M., Popović, Z., Zeković, Lj., Kasalica, B., & Belča, I. (2018). Two-color pyrometer-based method for measuring temperature profiles and attenuation coefficients in a coal power plant, Combustion Science and Technology, 190(11): 2018–2029. https://doi.org/10.1080/00102202.2018.1481401

Mohamed, A.M.O., Paleologos, E.K. and Howari, F.M., 2021. Noise pollution and its impact on human health and the environment. In *Pollution assessment for sustainable practices in applied sciences and engineering* (pp. 975-1026). Butterworth-Heinemann.

Popović, P.Z., & Ilić, P. (2023a). Impact of noise to the environment in Republic of Srpska. In Ilić, P., Govedar Z., & Pržulj N. (Eds.), Environment (pp. 449–484). Banja Luka, Monograph LV: Academy of Sciences and Arts of the Republic of Srpska. https://doi.org/10.7251/EORU2309449P

Popović, P.Z., & Ilić, P. (2023b). Impact of radio-frequent radiation to the environment in Republic of Srpska. In Ilić, P., Govedar Z., & Pržulj N. (Eds.), Environment (pp. 485–525). Banja Luka, Monograph LV: Academy of Sciences and Arts of the Republic of Srpska. https://

doi.org/10.7251/EORU2309485P

Popović, Z. P., Ilić, P., Stojanović Bjelić, LJ, & Nešković Markić, D. (2024a). Modeling and Visualization of Noise Levels Near Mining Operations. *Quality of Life*, 15(3-4):96-110. https://doi.org/10.7251/QOL2403096P

Popović, Z., Ilić, P., Mushtaq, Z., Abdur, R., Stojanović Bjelić, L., Nešković Markić, D., Farooqi, Z. U. R., Jat Baloch, M. Y., & Riaz, S. (2024b). Noıse as an Aır Pollutant and Clean Energy for Sustaınable Agrıculture. In Water-Air-Soil for sustainable agriculture and people well being (pp. 196–239). IKSAD Publishing House. https://doi.org/10.5281/zenodo.10854957

Radović, B., Ilić, P., Popović, Z., Vuković, J., & Smiljanić, S. (2022). Air Quality in the Town of Bijeljina – Trends and Levels of SO_2 and NO_2 Concentrations. Quality of Life, 22(1–2): 46–57. https://doi.org/10.7251/QOL2201046R

Regulation on Limit Values of Noise Intensity (Official Gazette of the Republic of Srpska, No. 2/23)

Wang, X., Sun, Y., Guo, H., & Wang, H. (2020). Analysis of Soil Heavy Metal Hg Pollution Source Based on GeoDetector. Polish Journal of Environmental Studies, 31(1): 347–355. https://doi.org/10.15244/pjoes/139303

WHO (2018). Environmental noise guidelines for the European region (1st ed.). World Health Organization. https://www.who.int/publications/i/item/9789289053563

Zannin, P. H. T., Engel, M. S., Fiedler, P. E. K., & Bunn, F. (2013). Characterization of environmental noise based on noise measurements, noise mapping and interviews: A case study at a university campus in Brazil. *Cities*, *31*, 317-327. https://doi.org/10.1016/j.cities.2012.09.008

Zhang, Z., Zhang, Y. and Kang, J., (2018) An experimental study on the influence of environmental noise on students' attention. In *Proceedings of the 11th EuroNoise Conference, Crete*.

Zhanibekov, A., Issayeva, R., Golovatyi, S., Taspoltayeva, A., Aitimbetova, A., Nurtayeva, A., Kurganbekov, Z., & Tulbasiyeva, A. (2022). Assessment of Soil Contamination by Heavy Metals: A Case of Turkistan Region. Polish Journal of Environmental Studies, 31(2): 1985–1993. https://doi.org/10.15244/pjoes/142613

Recived: December 17, 2025

Accepted: January 14, 2026