

Noise pollution in the Suceava Metropolitan Area. Preliminary research

Pollution bruit dans la Région Métropolitaine de Suceava. Recherche préliminaire

Alina NISTOR¹, Bogdan NISTOR^{2*}, Dumitru MIHĂILĂ¹, Petruț-Ionel BISTRICEAN¹, Mihaela ȚICULEANU (CIURLICĂ)¹, Gina LAZURCA (ANDREI)¹

¹Department of Geography, “Ștefan cel Mare” University of Suceava, Romania

²Gymnasium School No.4 Suceava & Gymnasium School “Ion Creangă” Suceava, Romania

* Correspondence to: Bogdan NISTOR. E-mail: nistorbobo@yahoo.com.

CC BY 4.0

Vol. 34.1 / 2024, 62-80



GEOREVIEW

Received:
6 June 2024

Accepted:
1 July 2024

Published online:
10 July 2024

How to cite this article:

Nistor, A., Nistor, B., Mihăilă, D., Bistricean, P.-I., Țiculeanu (Ciurlică), M., Lazurca (Andrei), G. (2024) Noise pollution in the Suceava Metropolitan Area. Preliminary research. Georeview, 34, 1, <https://doi.org/10.4316/GEOREVIEW.2024.01.05>

ABSTRACT: The analysis of noise levels in the Suceava Metropolitan Area aims to quantify its averages and maxima at several representative points in relation to noise pollution sources. Measurements were carried out in 23 observation points in two campaigns in 2020. Ten analog sound level meters were used to determine the noise level. In the two campaigns, the average noise level was highest (above 60 dB) at the observation points located near major boulevards, where road and pedestrian traffic is heavy throughout the day. The lowest average noise levels (below 40 dB) were recorded in the Climatology Laboratory in the E USV building (30.9 dB), far from any major source of noise pollution. Low noise levels were also recorded in the observation points located on secondary streets, away from the main traffic arteries (Narciselor Street - 42.5 dB), in Pătrăuți locality where noise sources are less than in the urban area (42.3 dB), and at the old style Church of St. John the New (40.3 dB) which is located on the outskirts of George Enescu district. Interventions are needed in certain places, with ingenious solutions to reduce noise levels and more extensive noise monitoring.

KEY WORDS: noise pollution, noise, Suceava Metropolitan Area.

RÉSUMÉ: L'analyse du niveau sonore dans la zone métropolitaine de Suceava vise à quantifier ses moyennes et maximales en plusieurs points représentatifs, en relation avec les sources de pollution sonore. Les mesures ont été réalisées dans 23 points d'observation, au cours de deux campagnes réalisées en 2020. Pour déterminer le niveau de bruit, 10 sonomètres analogiques ont été utilisés. Dans les deux campagnes, le niveau sonore moyen a enregistré les valeurs les plus élevées (plus de 60 dB) dans les points d'observation situés à proximité des grands boulevards, où le trafic routier et piétonnier est intense tout au long de la journée. Les valeurs les plus basses du niveau sonore moyen (inférieur à 40 dB) ont été enregistrées au Laboratoire de Climatologie du Corps E USV (30,9 dB), loin de toute source importante de pollution sonore. De faibles niveaux de bruit ont également été enregistrés dans les points d'observation situés dans les rues secondaires, loin des principales voies de circulation (Strada Narciselor - 42,5 dB), dans la localité de Pătrăuți où les sources de bruit sont moindres par rapport à la zone urbaine (42.3 dB) et à l'église ancienne Saint-Jean-le-Nouveau (40,3 dB) située à la périphérie du quartier George Enescu. Des interventions sont nécessaires à certains endroits, à travers des solutions ingénieuses pour réduire le niveau sonore et un contrôle plus large de celui-ci.

MOTS CLÉS: pollution sonore, bruit, zone métropolitaine de Suceava.

GEOREVIEW, 2024, DOI: <https://doi.org/10.4316/GEOREVIEW.2024.01.05>

1. Introduction

Noise can be defined as unwanted or harmful external sound generated by human activities, which includes noise emitted by means of transport, road, rail, and air traffic and noise from industrial sites (Law no. 121/2019). Prolonged exposure to noise has negative consequences for human health: hearing loss, high blood pressure, headaches, myocardial infarction, stress, sleep, memory and behavioral disorders, depression, fatigue, aggressive behavior, irritability, etc. According to the European Environment Agency (EEA), 16 600 premature deaths and more than 72 000 hospital admissions occur each year in Europe due to noise pollution (a person's ears need at least 16 hours of rest to compensate for two hours of exposure to 100 dB) (<https://www.eea.europa.eu/ro/articles/poluarea-fonica-este-o-problema>).

Of all traffic types (road, rail, air), road traffic is a major source of pollution, even if public transport and personal diesel and petrol cars are gradually being replaced by electric or hybrid cars. In Europe, about 125 million people in urban areas are exposed to road noise levels of 55 dB, and more than 37 million people are exposed to noise levels above 65 dB. Road traffic noise levels exceeding 55 dB affect at least 20% of the EU population. About 15% of the EU population is exposed to road traffic noise levels exceeding 50 dB at night (<https://noise.eea.europa.eu/>).

The number of people exposed to noise levels from road, rail, and air traffic, as well as from industrial activities in urban agglomerations in European countries, including 17 cities in Romania (Arad, Bacău, Baia Mare, Botoșani, Brăila, Brașov, București, Buzău, Constanța Craiova, Cluj Napoca, Iași, Oradea, Pitești, Ploiești, Sibiu, Timișoara) can be viewed at <https://noise.eea.europa.eu>. The latest EEA data (2017) show that more than 100 000 inhabitants in the Romanian cities are affected by road noise pollution. Of the 18 municipalities included in the study, based on the ratio of the total number of inhabitants to the number of those affected by traffic noise, the lowest noise levels were characteristic of the municipalities of Satu Mare, Arad, and Brasov, and the highest for the municipalities of Pitesti, Bacau, and Sibiu.

According to national legislation, during the daytime (between 07.00 and 23.00), the outdoor noise level should not exceed 55 dB. At night (between 23.00 and 07.00), the limit is 45 dB.

In our country, research on noise exposure of the population was conducted only in 2000 and only in large cities: in Cluj Napoca, a noise mapping was carried out over a period of 7 years (2000 - 2007) and it was found that 6.67% of the city's population is exposed to excessive noise (Popescu et al., 2013); in Iasi, on Sărăriei and C.A. Rosetti streets in 2015, it was observed that street noise values varied between 43 and 65 dB in August, the month when most inhabitants are on holiday, and between 47 and 74.5 dB in October, when classes resume at university centers (Oiste et al., 2015).

According to the 2020 Urban Barometer developed as part of Romania's Urban Policy, just over 57% of the urban population is satisfied with noise levels. Around 68% of inhabitants are satisfied in small towns (with less than 20000 inhabitants), and a lower level of satisfaction of 48%, in towns with more than 100000 inhabitants (<https://citadini.ro/barometru-urban-2020/>). In the North-East Region of Romania, the level of satisfaction with noise is 75%, but in the cities of Suceava and Piatra Neamț, it exceeds 80% (85% and 81% respectively).

Until 2021, according to Law no. 121 of 3 July 2019 on the assessment and management of environmental noise, Suceava municipality was not one of the agglomerations with a population of over 100 000 inhabitants for which strategic noise maps and related action plans had to be drawn up. As a result of the amendments and additions made by Law No 181/14 June 2022, the

municipality of Suceava was also included in Annex 7 to the law, for which strategic noise maps and related action plans must be drawn up in accordance with the provisions of the law.

From 2013 until now, the monitoring of the noise level in the environment was carried out by the Environmental Protection Agency Suceava (APM Suceava), with quarterly frequency, in a total of 28 monitoring points, in the localities: Suceava (10 points), Falticeni (2 points), Siret (2 points), Radauti (5 points), Vatra Dornei (3 points), Gura Humorului (3 points) and Campulung Moldovenesc (3 points). The monitoring of the noise level had as objective the identification of the main areas / functional facilities where the permissible limits of the noise level were exceeded and which present risks to the health of the exposed population. The location of the observation points in the city of Suceava considered the determination of noise levels mainly due to noise sources related to road traffic: Calea Unirii – near the intersection with Mirauti Street, Calea Unirii – General School „Jean Bart”, Vasile Alecsandri Street - National College „Stefan cel Mare”, George Enescu Boulevard – Sports High School, Corneliu Coposu Street intersection no. 9 With Bistrita Street – new block, Stefan cel Mare Street – vis - a – vis the Courthouse, Marasesti Street - vis - a – vis the General School no. 3, Narciselor Street– Bicom Hotel, Ana Ipatescu Street – Central Park, Stefan cel Mare Street – parking Store Bucovina (www.anpm.ro).

For the Suceava Metropolitan Area, no noise pollution study has been carried out so far. Suceava does not yet appear on the strategic map of noise levels, and that is why we considered this research and analysis of noise pollution in this area necessary. The objectives of the research are: i) recording the values of the average and maximum noise levels in indoor and outdoor observation points; ii) comparative analysis of the daily and weekly regime of the noise level; iii) identification of noise pollution sources; iv) comparative analysis of average noise levels recorded in urban and suburban environments.

2. Study area

The noise monitoring study in the first two campaigns was carried out in 23 observation points located in the AMSv: in Suceava municipality and Pătrăuți commune located in Dragomirnei Plateau and Fălticeni Plateau. Both relief subunits are part of the Suceava Plateau and are separated by the Suceava River valley (*Bacauanu, 1983; Efros et al., 2004*). The landforms are represented by wide veiled plateaus, hills, deluvial slopes and alluvial plateaus modeled as steps.

The climate is transitional temperate (*Ciulache, 2004*), being specific to the low hills and foothills (300 - 500 m). Northwesterly winds predominate (39.2%), the multiannual average temperature is 7.9°C, and the calculated average precipitation is 620.1 mm (*Tanasa, 2011*).

The configuration of the terrain and the climatic features allow the development of human activities (industry, trade, construction, transport, tourism) that generate noise all year round, with a slight decrease in intensity in the winter season.

Geographical position, resources, relief, and historical conditions (the Citadel of Suceava was the capital of Moldavia) have determined the development of Suceava compared to other localities in economic, cultural, and demographic terms. According to 2024, the population of Suceava municipality was 119 694 inhabitants, on an area of 52 km², with a density of 2 302 inhabitants per km², unlike the commune of Pătrăuți, where the population density is 129.6 inhabitants per km² (4 890 inhabitants live on an area of 37.7 km²). Urban agglomerations are noise generators due to the large number of population and various and intense anthropogenic activities, compared to rural settlements with a smaller number of inhabitants and fewer sources of noise pollution.

In the Suceava Metropolitan Area, 2 hourly observation campaigns for noise pollution were carried out in 2020: the first campaign was between 30 October - 1 November 2020 in 17 observation points located around the University "Ștefan cel Mare" Suceava; the second campaign was between 11 December - 15 December 2020 in 6 observation points (Pătrăuți, George Enescu Boulevard - Lidl, near the Sports High School, Old-Rite Church of St. John the New in the George Enescu district, near the Technical College of Food Industry, near the Palace of Justice) (Figure 1).

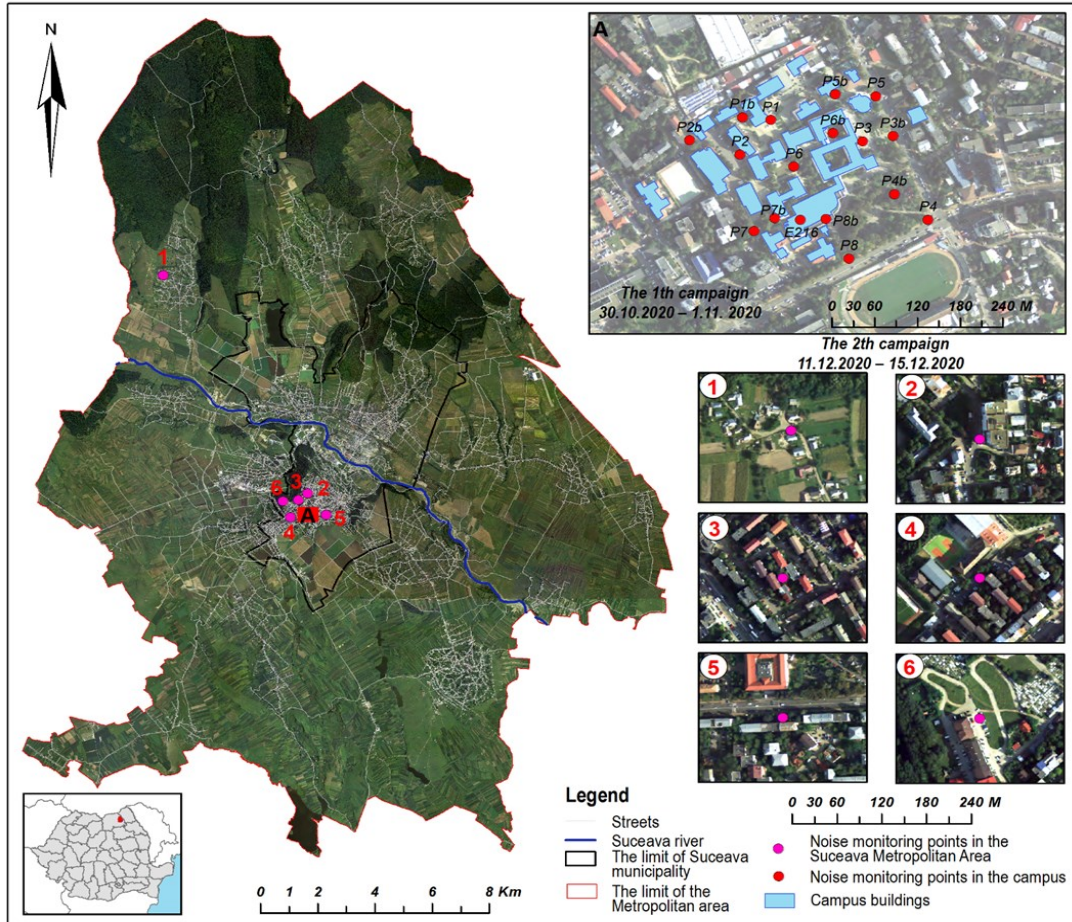


Figure 1 Location of urban noise monitoring points in AMSv during campaign 1 (30.10 - 1.11.2020) - which targeted the USV campus, and campaign 2 (11.12 - 15.12.2020) - with 5 observation points located in Suceava municipality and one point in Pătrăuți locality, in the rural environment.

3. Methods

Several research methods were used during the research: *i)* documentation of noise pollution in the study area as analyzed in the literature, *ii)* obtaining the necessary data by the method of stationary observations at the monitoring points - time of minimum 2 minutes for each parameter per point with observations - from the 58th minute of the ending hour to the 02nd minute of the starting hour, *iii)* processing, analysis and comparative interpretation of statistical data, *iv)* graphical transposition of the values of noise levels and *v)* interpretation of the graphic and cartographic material. In the two noise pollution monitoring campaigns, 10 analog sound level meters were used at all observation points in the AMSv, to determine noise levels. These sound level measuring instruments

are easy to use and are designed for sound quality control, measures the sound level from 30dBA to ~ 130dBA and the sound intensity in a wide range of frequencies (31.5Hz ~ 8KHz). The use of these instruments was necessary for the analysis of noise intensity in dB, as they provide real and accurate data on environmental noise pollution, determination of noise type, and exceedances of limit values during the day (at 1.5 m height above ground - 55 dB and noise curve Cz 50) and at night (at 1.5 m height above ground - 45 dB and noise curve Cz 40) in relation to their causality (*Order no. 119/2014*).

4. Results and discussion

In order to identify the cause and effect relations between road traffic and noise pollution and to find solutions regarding the optimization of the vehicle flow, studies have been conducted so far in some of the Romanian cities. In the city of Pitesti, noise level monitoring was carried out with the portable digital sonometer LD 831 in the three main traffic light intersections – Sontu Major, the intersection of Podul Viilor roundabout, the intersection of the roundabout of the Rectorate, during on working days around 18.30, when it is the peak of traffic in the evening (*Titu et al., 2022*). In the city of Iasi, direct observations made with the digital sonometer Quest Technologies, Model 1400 at five-hour intervals (07:00 - 08:00; 10:00 - 11:00; 13:30 - 14:30; 18:00 - 19:00; 19:00 - 20:00), in 30 points located along different types of roads in the period August – October 2009, showed exceedances of the limit values admitted in 5 observation points in September, 8 Observation points in October and a difference between the high noise level values recorded during the week from Monday to Friday, and the weekend with lower values; the maximum noise level values were recorded at the observation points on the main streets, the technical category I - Main Street (63.3 dB– 74.5 dB), not exceeding the limit values allowed according to *STAS 10009/1988* of 75 dB (*Oiste et al., 2015*). In the city of Sibiu, the monitoring of the noise level in an intense circular intersection of Sibiu (north-south road traffic intersects with east-west road traffic) was carried out using a 2100 sound model developed by Quest Technologies, only during the day (07.30 – 18.00) and identified high, constant values of noise level above 77.30 dB, far exceeding the permissible noise limit values during the day (55 dB); the maximum noise level of 93.40 dB was recorded in the time interval 07.46 to 08.00, due to intense road traffic (*Deac et al., 2017*). A comparison with other studies is impossible, because it is difficult to find a similar study in Romania, in another city, similar in population, as well, size and configuration of the street strip to highlight significant similarities and differences.

The monitoring of the noise level in Suceava county was carried out by APM Suceava in accordance with the provisions of „Acustica in construction. Urban acoustics. Permissible limits on urban noise level“ (*STAS 10009/1988*), which set the permissible LAeq limits (equivalent continuous sound level, A-weighted, in decibels, having the same total acoustic energy as the measured fluctuating level): LAeq -75 dB for the technical category I - Main Street (the intersection of Mirauti Street with Calea Unirii, Calea Unirii - General School no. 5 „Jean Bart”); LAeq -70 dB for streets of technical category II - Link Streets (Str. Marasesti, Sch.General no. 3; Stefan cel Mare Street – Suceava Courthouse; George Enescu Boulevard 38, near the Sports High School; intersection Corneliu Coposu Street with Bistrita Street; Vasile Alecsandri Street - „Stefan cel Mare” National College); LAeq - 65 dB for streets of category III – Collector Streets (Narciselor Street – Technical College of Food Industry); LAeq - 60 dB for parks (Central Park Suceava); LAeq - 90 dB for car parks at the limit of the operating area (Bucovina Commercial Complex parking lot) (*Directive 2002/49/EC*).

During the monitoring campaigns organized by APM Suceava (2013 – 2021) and the monitoring campaigns 1 and 2 carried out in the range of 30.10 – 1.11.2020 and 11.12 – 15.12.2020, respectively, there were used observation points located on the same main traffic arteries (George GEOREVIEW 34.1 (62-80)

Enescu Boulevard, Narciselor Street, 1 Mai Boulevard – Stefan cel Mare Boulevard – Calea Unirii). Some of these points coincided or were located in close proximity of public institutions (Suceava Courthouse, Technical College of Food Industry, Sports High School). This allowed a comparative analysis of the recorded noise level.

In the monitoring campaigns carried out by APM there were overruns at the monitoring points, and, of the LAeq permissible limit values of 75 dB in Calea Unirii – near the intersection with Mirauti Street (2013 – 78,2 dB; 2015 – 75,3 dB; 2016 - 77 dB; 2019 – 75 dB; 2020 – 76,1 dB) in George Enescu Boulevard – Sports High School (2013 – 72,7 dB; 2015 – 72,6 dB; 2016 – 74,6 dB; 2017 – 72,3 dB; 2018 - 74,2 dB; 2019 – 71,7 dB; 2020 – 72,1 dB;), in Stefan cel Mare Street – vis - a – vis the Courthouse (2013 - 78,7 dB; 2014 -73,6 dB; 2015 – 73,6 dB; 2016 – 72,8 dB; 2017 – 73,2 dB; 2019 – 72,8 dB; 2020 – 74,7 dB); of 65 dB in Marasesti Street - vis - a – vis the General School no. 3 (2013 - 71,2 dB; 2019 - 66,5 dB; 2020 – 66,7 dB), Narciselor Street – Bicom Hotel (2013 – 64,2 dB; 2018 – 68,2 dB; 2020 – 67,8 dB), Ana Ipatescu Street – Central Park (2013 - 68,1 dB; 2016 - 68,2 dB); de 70 dB in the parking lot of the Bucovina Store (2013 – 70,4 dB) (*Reports on the state of the environment in Suceava County 2013 - 2021*).

In 2017, the provisions set out in „Acustica. Permissible noise level limits in the environment” (*STAS 10009/2017*) regulate the permissible noise level limits provided for in *STAS 10009/1988* for technical category I - Main streets, from 75 dB to 75 - 85 dB and for car parks at the limit of the operating area, from 90 dB to 70 dB. That is why in 2017 and 2018, there have been no exceedances of the limit values allowed at the monitoring points located in Calea Unirii – near the intersection with Mirauti Street and in Calea Unirii - General School no. 5 „Jean Bart” (LAeq values of 75,2 dB - 2017 / 76,2 dB – 2018 and 70,5 dB – 2018 were within the new permissible limits set 75 - 85 dB) (*Reports on the state of the environment in Suceava County 2013 - 2021*).

Since 2019 the streets Calea Unirii, intersection with Mirauti Street, Calea Unirii - General School no. 5 „Jean Bart” have switched from the type of streets of technical category I - main street, to streets of technical category II, link streets, thus, the limit of permissible noise values changed from 75 dB to 70 dB (*Law no. 189 of 25 October 2019*). The streets of technical category II - link streets were included at technical category III streets - Collector Streets, thus, the limit of permissible noise values changed from 70 dB to 65 dB: Vasile Alecsandri Street - "Ștefan cel Mare" National College, Corneliu Coposu Street, bl. 9, Mărășești Street - General School no. 3. For this reason, according to the report on the state of the environment in the municipality of Suceava, between the years 2019 / 2020 the most exceedances were recorded: 10 / 13 exceedances of the continuous acoustic pressure level of over 65 dB, on Nicolae Coposu Street, no. 9 (4 measurements / 4 exceedances - 69.2 dB; 4 measurements / 4 exceedances - 74.7 dB), "Ștefan cel Mare" National College (4 measurements / 4 exceedances - 67.8 dB; 4 measurements / 4 exceedances - 68,6 dB), Narciselor Street (4 measurements / 1 exceedance – 65.2 dB; 4 measurements / 2 exceedances – 67.8 dB), Mărășești Street vis-a-vis the Secondary School no. 3 (4 measurements / 1 exceedance – 66.5 dB; 4 measurements / 3 exceedances – 66.7 dB) and 11 / 12 exceedances over 70 dB on George Enescu Boulevard (4 measurements / 3 exceedances – 71.7 dB; 4 measurements / 3 exceedances – 72.1 dB), Calea Unirii intersection with Mirăuți street (4 measurements / 4 exceedances – 75 dB; 4 measurements / 4 exceedances – 76.1 dB), Ștefan cel Mare Street vis-a-vis Suceava Courthouse (4 measurements / 4 exceedances - 72.8 dB; 4 measurements / 4 exceedances - 74.7 dB), Calea Unirii - "Jean Bart" General School (4 measurements / 1 exceedance - 70.5 dB in 2020) (*Law no. 121 of 3 July 2019 regarding the assessment and management of ambient noise*).

Unlike the monitoring campaigns carried out by APM Suceava, which followed the exceedances of the permissible limit values of the equivalent continuous sound level (LAeq) in the urban environment according to *STAS 10009/1988* and *STAS 10009/2017*, in noise monitoring campaigns

1 and 2, we followed the determination of the diurnal noise level values in the USV park and campus and a comparative analysis of the diurnal noise level (dB) regime between Patrauti Periurban observation perimeter and the observation points located in the perimeters with urban agglomerations of AMSv. The maximum averages exceeded 70 dB at the observation points P5, P4, P8 of the Campus of the University Stefan cel Mare, located in the immediate vicinity of the traffic arteries (Bulevardul 1 Mai and Strada Universitatii) and recorded values ranging from 60 dB to 70 dB in the observation points near the Palace of Justice (Stefan cel Mare Boulevard) and the one located at the end of George Enescu Boulevard near Lidl, perimeters with intense road and pedestrian traffic. The average noise level recorded the highest values above 60 dB, during the day (above the permissible limit of 55 Db), between 07 – 09 and 16 – 19, and over 45 dB noise limit allowed at night, at the points located on main streets and at intersections where traffic is intense and blockages are frequent (George Enescu Boulevard, 1 Mai Boulevard).

Research addressing urban road noise in the context of European legislation requirements on noise pollution, identified how the level of road noise is determined by the way road traffic is regulated in intersections and on the main traffic arteries of residential areas. Thus, solutions were identified to reduce noise pollution: streamlining traffic by building ring roads; introducing roundabouts instead of traffic light intersections; reconfiguring the intersection in a multi-lane roundabout to delay the circulation on the ring lane (for example, the „turbo” construction solution), since traffic at traffic lights is intermittent with strong accelerations in step 1 (specific for on-off mode), instead, at the roundabout, road traffic can be carried out without stopping, with medium acceleration in lane 1 or can be of type „stop and go” (for easy braking and acceleration in gear) (Titu *et al.*, 2022).

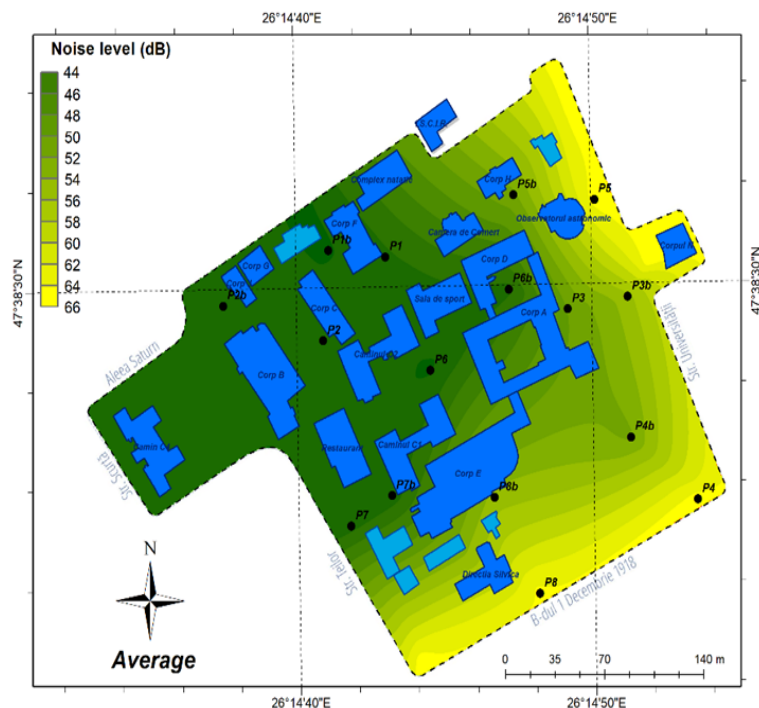


Figure 2 Average noise level in AMSv during campaign 1 (30.10.2020 - 1.11.2020) on the USV campus.

In the first campaign, the observation points were located in and around the USV campus as follows: P1 and P1b on the side and in front of the F Building, respectively; P2 near the C Building and P2b near the I Building; P3 in front of the A Building and P3b in the park at the main entrance of Stefan cel Mare University; P4 and P4b in the University Park (facing the City Hall and the stadium); P5 and

P5b in front and behind the Astronomical Observatory, respectively; P6 and P6b in the middle of the university campus and inside the old campus (surrounded by laboratories, offices and classrooms); P7 near the USV Canteen and P7b on the side of the C1 Dormitory; P8 on the side of E Bulding and P8b in the University Park (close to 1 December Boulevard, near the Forestry Directorate), and E216 the only point located inside E Bulding (Figure 2). Noise level observations were conducted from 30 October to 1 November 2020, between 07.30 and 19.30 (36 hours of observations). The objective of the campaign was to determine the daytime noise levels in the USV park and campus with high accuracy.

The average noise level values gradually decreased from the observation points located near the main traffic arteries (60 - 66 dB) towards the observation point located in the park, where the noise pollution is attenuated by the tree canopy (52 - 60 dB), towards the observation points located inside the university campus (44 - 52 dB) surrounded by the university buildings which constitute a noise barrier (Figure 2).

The highest average noise level, with values exceeding 60 dB, was recorded at the observation points located on 1 December Boulevard and University Street (P3b, P8, P5, and P4), as the main factor of noise pollution is the heavy road traffic throughout the day. Intermediate values of the average noise level (40.9 - 51.7 dB) were recorded at the observation points P4b, P1b, P3, P5b, P7b, and P8b located inside the park, the University campus, and on secondary streets. The lowest average noise level was calculated for the Climatology Laboratory in E-Building (30.9 dB), located far away from any important source generating noise pollution (Figure 3).

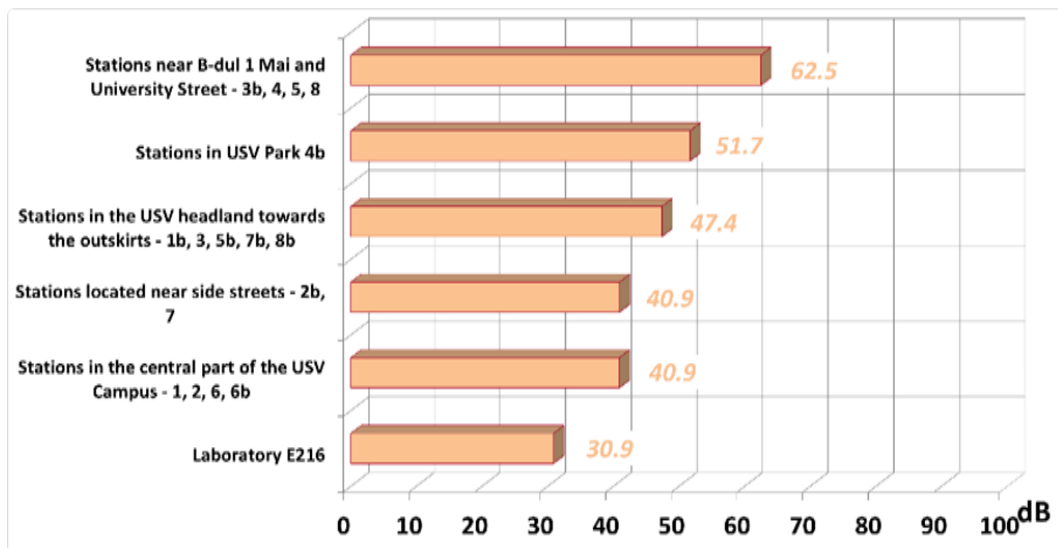


Figure 3 Mean values for average noise level during campaign 1 (30.10.2020 - 1.11.2020) on the USV campus.

For the maximum noise levels, we calculated the maximum averages that exceeded 70 dB at the observation points P5, P4, P8, and, located in the proximity of pollution sources (highly circulated pedestrian and road arteries during the day). At the observation point located away from the traffic arteries, inside the University Park, the averaged values of the hourly noise maxima ranged between 54 and 70 dB, and at the observation points inside the university campus, between 44 and 54 dB (Figure 4).

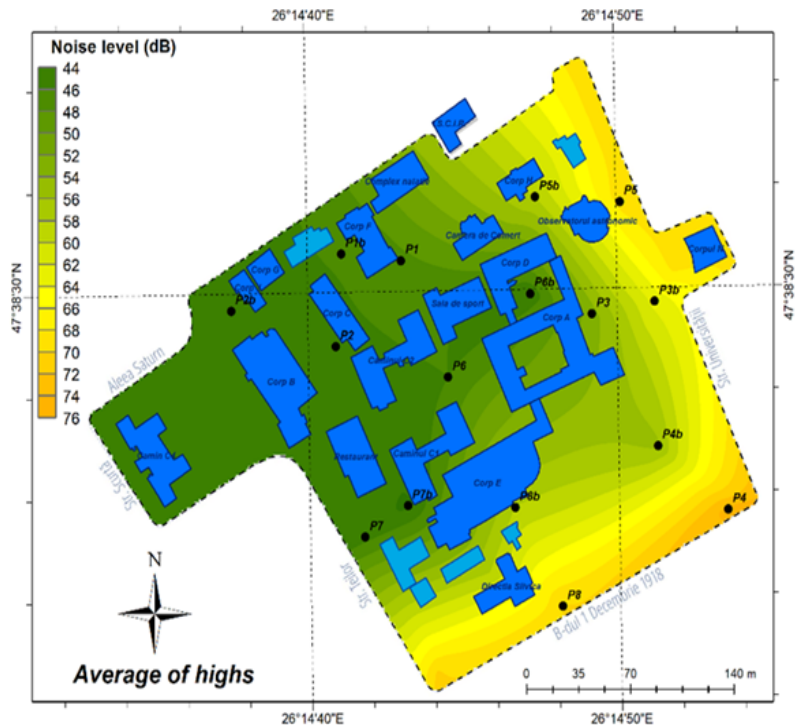


Figure 4 Average noise level of AMSv peaks during campaign 1 (30.10.2020 - 1.11.2020) on the USV campus.

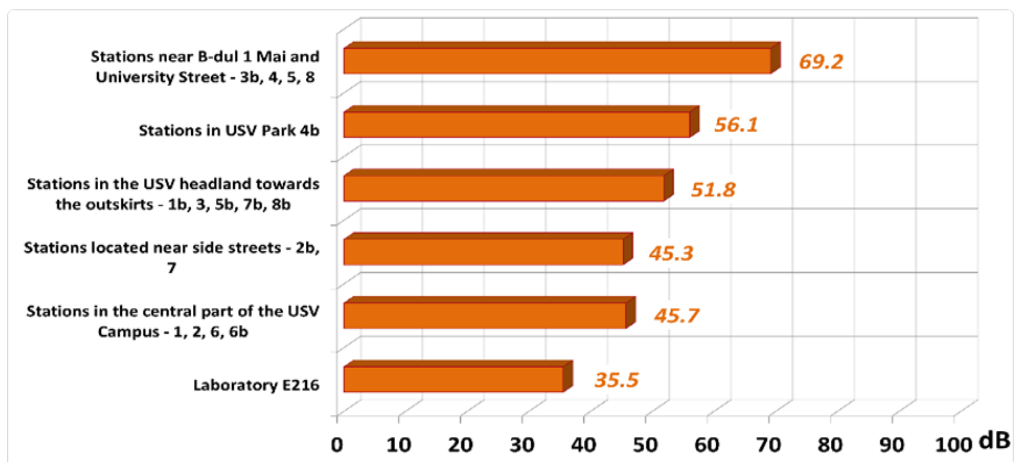


Figure 5 Average values for maximum noise level during campaign 1 (30.10.2020 - 1.11.2020) on the USV campus.

The highest average value for maximum noise levels (69.2 dB) was calculated for the observation points located near the intersection of Boulevard 1 Mai and University Street and the lowest (35.5 dB) for the interior of the E216 laboratory in E Building. The average values for maximum noise levels gradually decreased by about 5 dB, the further the monitoring points were located from the noise pollution sources: 56.1 dB (at observation point P4 in the USV Park); 51.8 dB (at observation points P1b, P3, P5b, P7b, P8b in the University Campus); 45.7 and 45.3 dB at observation points located on side streets (P1, P2, P6, P6b), respectively in the centre of the USV Campus (P2b, P7) (Figure 5).

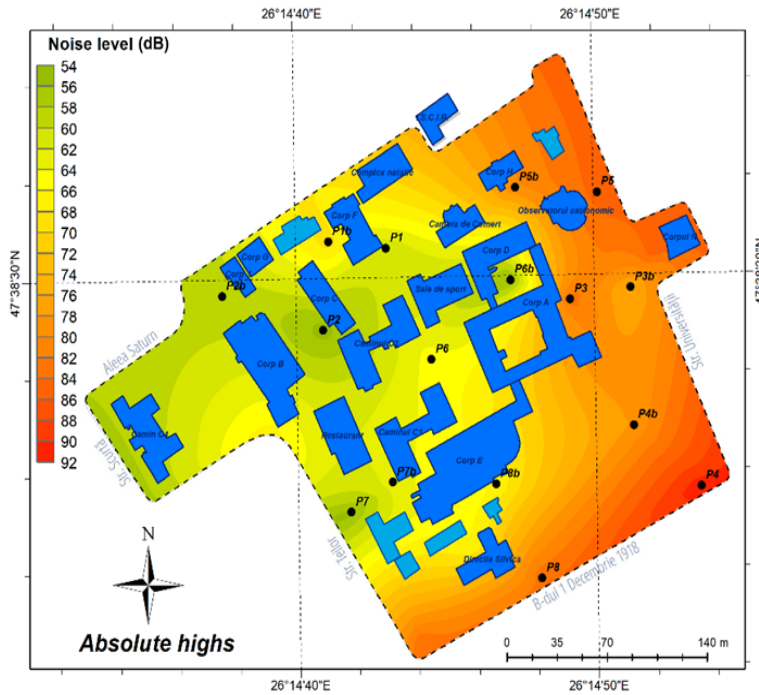


Figure 6 Absolute maximum noise level in AMSv during campaign 1 (30.10.2020 - 1.11.2020) on the USV campus.

The absolute maximum noise levels exceeded 90 dB at observation point P4, located very close to the intersection of 1 May Boulevard and University Street, and remained high (86 - 90 dB) at the monitoring points located in University Park (P4b) and near 1 May Boulevard and University Street respectively (P8 and P5) (Figure 6).

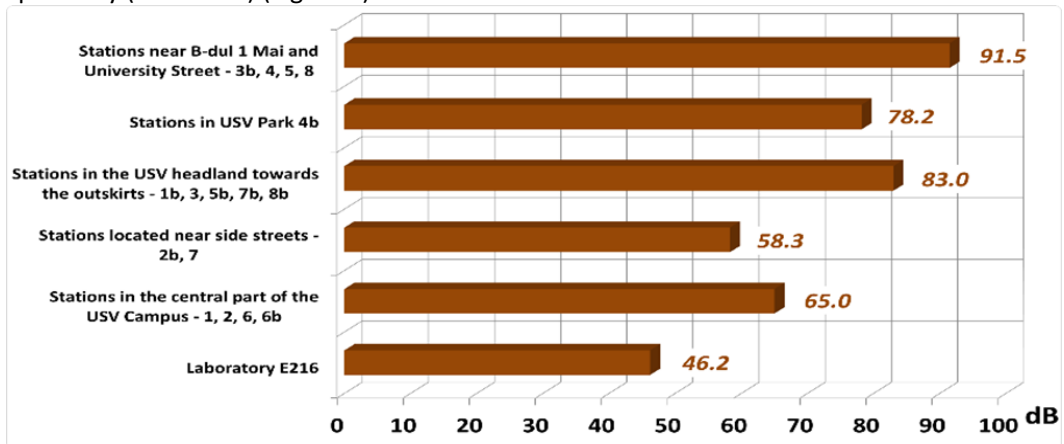


Figure 7 Absolute maximum values of noise levels during campaign 1 (30.10.2020 - 1.11.2020) on the USV campus.

The maximum noise level recorded values of: 91.5 dB at 08:00 at observation point P4 near the main traffic arteries, 83 dB at 11:00 at monitoring point P3 on the USV Campus; 78.2 dB at 14³⁰ at observation point P4b in the USV Park; 65 dB at 16:30 point P6b in the central part of the USV Campus; 83 dB at 10:00 at point P2b on the edge of the USV Campus and 46.2 dB at 17:30 point located inside the E216 building (Figure 7).

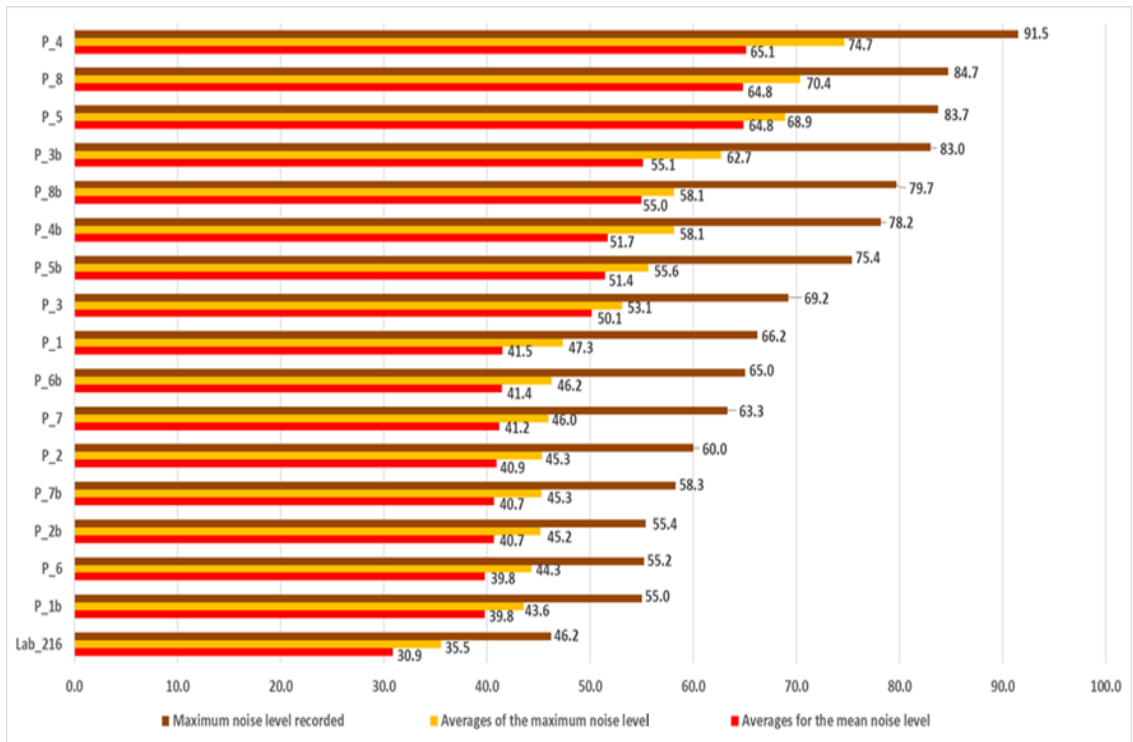


Figure 8 Noise levels at observation points on the USV campus during campaign 1 (30.10.2020 - 1.11.2020).

The main causes of these peaks were: car horns, ambulance and fire brigade sirens, due to traffic noise. Among all the 17 observation points on the USV campus, the highest values of the three noise parameters analyzed (average, average maximum, maximum) were recorded at observation point P4, located near the intersection of 1st May Boulevard and University Street (main traffic arteries for public and private transport). Noise levels were low at the outdoor observation points located further away from the noise pollution sources, in the center of the USV campus (P6), and at the periphery (P7b, P2b, P1b). The lowest values of noise levels were recorded at the indoor observation point in Laboratory E216 (Figure 8).

The second campaign took place between 11 December 2020 at 08:00 and 15 December 2020 at 08:00 in 6 observation points: Pătrăuți, George Enescu Boulevard (Lidl), near the Sports High School, Old-Rite Church of St. John the New in George Enescu district, near the Technical College of Food Industry, near the Palace of Justice (Figure 1). The campaign also included nocturnal observations. *The objective* was to obtain information on daytime and night-time noise levels at five representative points in Suceava and to compare them with a point in a neighboring peri-urban locality.

The highest values for the average noise level were recorded near the Palace of Justice (65.4 dB), followed by Lidl (55.9 dB) and near the Sports High School (50.4 dB) due to heavy road traffic on Stefan cel Mare Boulevard (1 May) and George Enescu Boulevard. The lowest average values (below 50 dB) were recorded at the points located on secondary streets, far from the main traffic arteries (Narciselor Street - 42.5 dB), in the peri-urban settlement of Pătrăuți where noise sources are less than in the urban area (42.3 dB) and at the Old-Rite Church of St. John the New (40.3 dB) which is located on the outskirts of the George Enescu district, near Sfânta Vineri Cemetery and the Șcheia Forest (Figure 9).

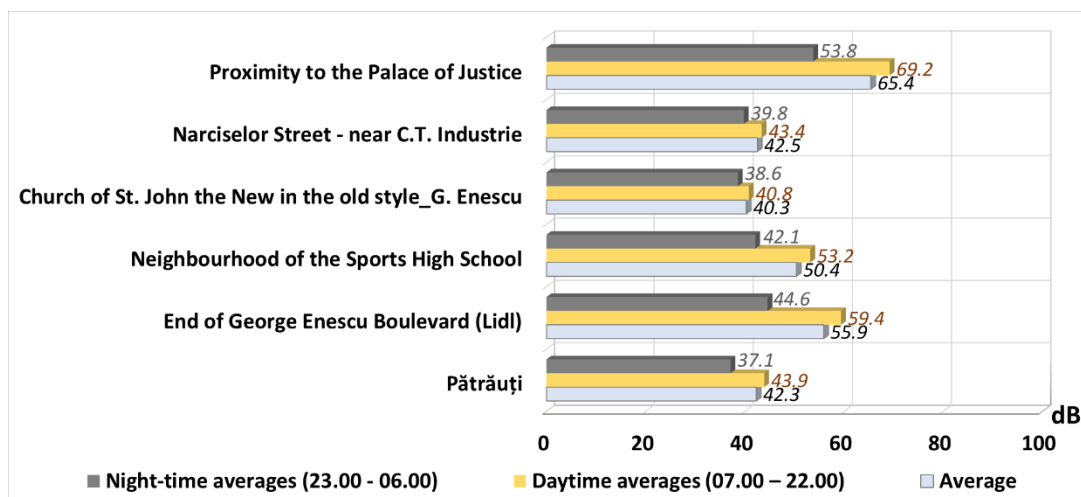


Figure 9 Average values for daytime and night-time average noise levels during campaign 2 (11.12.2020 - 15.12.2020).

The differences in the average noise level for day and night exceeded 10 dB at the observation points in the vicinity of the Sports High School (11.1 dB), George Enescu Boulevard (14.8 dB), and the Palace of Justice (15.4 dB), because various activities related to sports, education, commerce, transport, justice, administration are carried out during the day in these perimeters, while during the night these activities cease or significantly decrease in intensity. In the peri-urban locality of Pătrăuți, in the district of blocks far from the secondary traffic arteries (Narciselor Street) and on the outskirts of the city (Old-Rite Church of St. John the New, George Enescu district), the differences were much smaller (6.8 dB, 3.6 dB and 2.2 dB respectively), because human activities during the day are not as diverse and intense as in the perimeters which are points of greater interest in the development of daily activities for the city population (Table 1).

Table 1 Average noise level values (dB) for day and night during campaign 2 (11.12.2020 - 15.12.2020).

	Pătrăuți	End of G. Enescu Boulevard (Lidl)	Neighborhood of the Sports High School	Old-Rite Church of St. John the New	Narciselor Street - near C.T. Industrie	Proximity to the Palace of Justice
Average	42.3	55.9	50.4	40.3	42.5	65.4
Daytime averages (07.00 - 22.00)	43.9	59.4	53.2	40.8	43.4	69.2
Night-time averages (23.00 - 06.00)	37.1	44.6	42.1	38.6	39.8	53.8
Average differences between day and night	6.8	14.8	11.1	2.2	3.6	15.4

The average values of the maximum noise levels were 69.7 dB at the observation point near the Palace of Justice and 63.2 dB at the end of George Enescu Boulevard near Lidl, perimeters with heavy road and pedestrian traffic. The lowest value of the average maximums was calculated in the monitoring point located at the outskirts of George Enescu district, near the Old-Rite Church of St.

John the New, a quiet area without traffic and other anthropogenic activities that generate noise pollution (Figure 10).

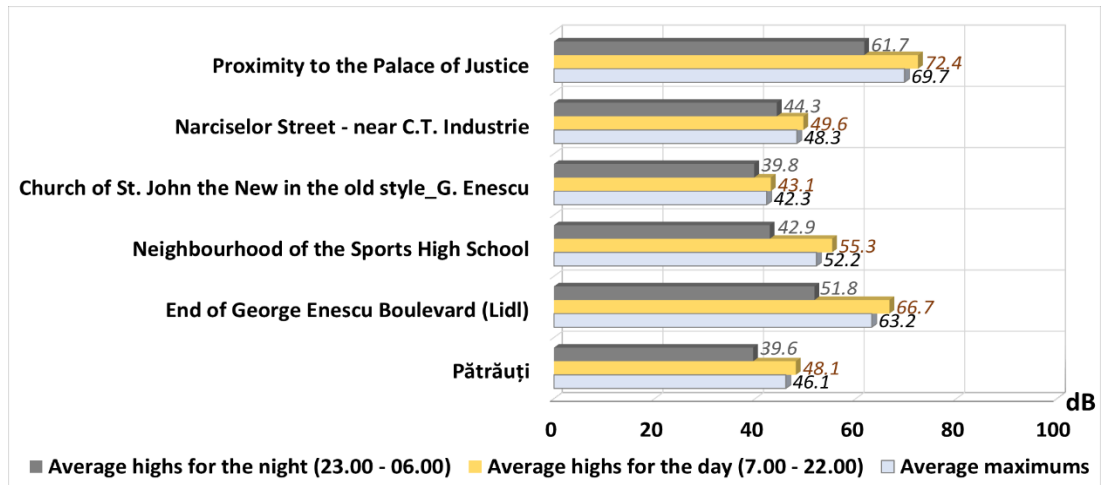


Figure 10 Average values for maximum noise level during campaign 2 (11.12.2020 - 15.12.2020).

Diurnal environments were higher than the average at night, because at night, the sources of noise pollution are reduced in number and intensity as activities in the fields of education, the economy and justice stop and the population diminishes their activity, going home to rest. (Table 2).

The average values for different hourly intervals of the noise level in the locality of Pătrăuți are low, below 40 dB in the hourly interval 19.00 – 06.00, because human activities are not as diverse as in the urban environment. Noise pollution is also low during the day; between 06.00 and 19.00 hours, averages do not exceed 50 dB (Figure 11.a).

At the observation point on George Enescu Boulevard, the lowest noise level was recorded between 00.00 and 06.00 (35 - 45 dB), as almost all activities stopped or reduced in intensity during the night. Once the daily activities of the population started again at 07.00, the hourly average noise levels did not fall below 50 dB, exceeding 60 dB between 10.00 and 17.00, when road traffic also intensified (Figure 11.b).

Table 2 Average maximum noise level values (dB) for day and night during campaign 2 (11.12.2020 - 15.12.2020).

	Pătrăuți	End of G. Enescu Boulevard (Lidl)	Neighbourhood of the Sports High School	Old-Rite Church of St. John the New	Narciselor Street - near C.T. Industrie	Proximity to the Palace of Justice
Average highs	46.1	63.2	52.2	42.3	48.3	69.7
Average highs for the day (07.00 - 22.00)	48.1	66.7	55.3	43.1	49.6	72.4
Average highs for the night (23.00 – 06.00)	39.6	51.8	42.9	39.8	44.3	61.7
Average differences between day and night highs	8.5	14.9	12.4	3.3	5.3	10.7

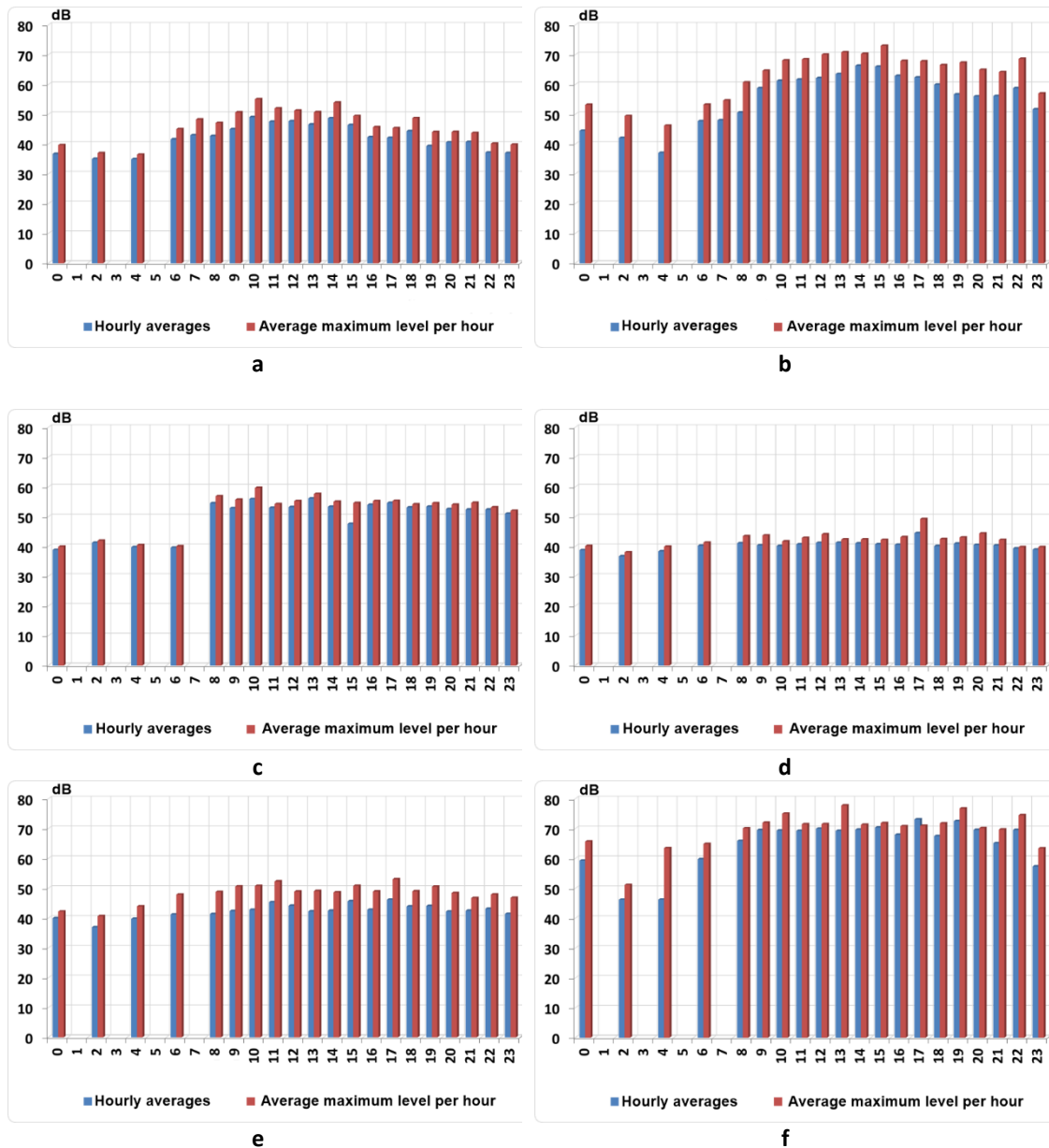


Figure 11 Diurnal noise level regime (dB) outlined by the means of hourly averages of average noise level (blue columns) and hourly averages of maximum noise level (red columns) at Pătrăuți - a, End of George Enescu Boulevard (Lidl) - b, vicinity of the Sports High School - c, Old-Rite Church of St. John the New in G. Enescu - d, Narciselor Street - near the C.T. of Food Industry - e, Proximity of the Palace of Justice - f in the interval 11 December at 08.00- 15 December at 08.00.

At the monitoring point located in the vicinity of the Sports High School, the hourly average values remained constant between 08.00 and 3.00 (50 - 55 dB), with one exception (15.00), because the high school is located further away from the main traffic axes, between blocks of flats on one side and a wooded perimeter on the other. The only sources of noise pollution are the activities of students and teachers on the sports field and within the high school until 20:00, and the household and recreational activities in the neighborhood after people return from work (Figure 11.c).

At the observation point located near the Old-Rite Church of St. John the New in George Enescu District, the hourly average noise values varied very little over 24 hours, between 38 and 45 dB, as there are no specific sources of noise pollution, the area is quiet, away from road traffic, mostly surrounded by forest (Figure 11.d).

Noise levels were low at the observation point located on Narciselor Street; average values did not exceed 40 dB between 23.00 and 08.00, ranging between 40 and 50 dB (from 08.00 until 23.00), as the only sources of pollution are represented by activities in apartments, around blocks and low road traffic (Figure 11.e).

At the observation point located near the Palace of Justice, noise pollution recorded the highest values of all six monitoring points (hourly average values ranged between 65 and 78 dB from 08.00 until 23.00 because the main noise generating source is road traffic through braking and acceleration processes and less by the presence of heavy vehicles in traffic on Ștefan cel Mare Boulevard (Figure 11.f).

In the observation points located on Narciselor Street (secondary street, near the Technical College of Food Industry), the Old-Rite Church of St. John the New from the George Enescu District and the Periurban locality of Patrauti, the average noise level values did not exceed the permissible limit value of 55 dB by day and 45 dB by night, noise pollution is reduced and does not create discomfort for the population living in these perimeters. The observation point in the proximity of the Palace of Justice located on Ștefan cel Mare Boulevard was the only one in which there were overruns of the limit values allowed both day and night, because the boulevard is intensely circulated because it is interested in the European road E85 (to Falticeni, Bacau, Iasi, Romania, Piatra Neamt) in the SV part of Suceava (Cartier Obcini) and with the European road E58 that leads to the cities of Botosani and Dorohoi, in the part of NE (Burdujeni District). The average maximum level per hour recorded the highest values at the observation point located on George Enescu Boulevard, at 15.00 (74dB) and at the observation point on Ștefan cel Mare Boulevard near the Palace of Justice, at 13.00 (78 dB), perimeters with high road traffic.

At observation points near major boulevards and intersections in the AMSv, noise is a chronic problem for the population. Multi-modal noise abatement measures must be found along major boulevards. On secondary roads, in more secluded districts, the noise level decreases, and the residents' living and resting are no longer disturbed to such an extent. Noise research in the AMSv is a priority, especially as noise pollution is expected to increase in the future due to urban sprawl and increased demand for mobility. Although new vehicle models become increasingly quiet, the growing volume of road traffic is resulting in increased noise emissions. Many of the city's central streets are almost daily crowded, so cars travel at lower speeds throughout the day, producing a permanent background noise.

A measure that can be taken in MSv on reducing noise pollution would be the gradual replacement of petrol and diesel vehicles (diesel cars are the first in terms of pollution noise, because they are ignited by compression, which causes increased pressure in the combustion chamber and louder noise, unlike petrol engines) with "green cars", but one problem is their autonomy, because there are not enough charging stations. In 2019, the City Hall of Suceava launched the tender for the "System of integrated ecological public transport in Suceava", worth 15.2 million lei, funds obtained through the Regional Operational Programme – POR, for investments in charging stations for electric vehicles in order to ensure optimal conditions for parking, charging and maintenance of public transport means (electric buses). Since 2022 in the city of Suceava, 28 electric stations have been used to charge 500 electric cars per day and 59 electric charging stations for buses (*Local Action Plan Suceava for the promotion and implementation of electric vehicles and charging infrastructure in*

Suceava - Document realized through the EVUE project "The pilot electromobility network of European cities" – 6091 co-funded by URBACT II Programme).

Promoting the concept of electromobility among citizens in order to increase the number of electric vehicles used for economic and private activities in Suceava could have the effect of implementing a car rental system electric by companies operating in the field of distribution and implementation of a rental system for electric bicycles to address citizens and tourists, which can contribute by their low contribution to the improvement of urban living conditions (*Local Action Plan Suceava for the promotion and implementation of electric vehicles and charging infrastructure in Suceava - Document realized through the EVUE project "Electromobility network pilot of European cities" – 6091 co-funded by URBACT II Program*).

Traffic fluidization is a priority that the city hall of Suceava tried to partially solve in 2019 by applying markings with yellow cross diagonal lines, contained in an outline that delimits, in the intersection, the place of intersection of roads, in the intersections of Suceava: between Marasesti street and 1 Mai Boulevard, in the area of Pictor Vladimir Florea Park and the intersection of George Enescu Boulevard with the Tulip Alley) (<https://suceavalive.ro/s-au-refacut-portiunile-de-carosabil-hasurate-cu-galben-din-intersectiile-din-suceava-ce-trebuie-sa-faca-soferii/>).

For traffic decongestion, in 2020 a third bridge over the Suceava River was put into use, Unirii Bridge - alternative route Centru – Mirauti-Iulius Mall – Treatment plant ACET – exit on the European road E58. „The little belt” Suceava - Botosani was officially opened for traffic up to 3.5 tons that will intersect with the bypass road no. 2 of Suceava on the route: Cumpărătura- Ipotești – Tișăuți – Salcea a ring around the city (Integrated Action Plan Suceava Freight Tails Action Planning Network - Innovative logistics solutions for transport and distribution of goods). To solve the fluidization of circulation in the commercial area of Suceava (Complex Comercial Bazar – Iulius Mall Suceava – Shopping City), the option to be considered is that of a suspended road to be used by those who do not want to enter the shopping area while the current structure is used for access to shopping centers.

Other measures to meet European requirements for sustainable development, transport efficiency and the reduction of noise pollution would be: infrastructure modernisation and use of personal and shared electric and hybrid transport; investments that will increase the attractiveness of the public transport service and its territorial expansion; development of the infrastructure for cycling (in 2020, the implementation of a network of 20 km cycle paths in the municipality of Suceava, other than those on the sidewalk, was considered, but in 2022 it was found that the proposal to move cyclists to the roadway was unrealistic; in 2024, the proposal came back and was approved for the „Integrated management and urban modelling project aimed at streamlining traffic and improving the quality of life”, in order to finance it within the North– East Regional Programme 2021 – 2027, an integration of two-axis bicycle paths (Sofia Vicoveanca Boulevard - Calea Unirii – Calea Burdujeni; Calea Obcinilor – George Enescu Boulevard – Marasesti Street–Nicolae Balcescu Street) which together with the existing ones, to create a continuous urban network that provides links with areas of local and tourist importance; the implementation of measures to regulate the one-way road traffic (the single-way design and the dedicated lane for public transport of people in Suceava will be implemented only in the 2024 - 2028 mandate, due to the lack of financing „at the latest in 2026” (<https://www.monitorulsv.ro/Ultima-ora-local/2024-03-27/Proiectul-sensurilor-unice-in-municipiul-Suceava-in-asteptare-pana-in-2026>); circulation to be provided on three lanes, with one lane on the opposite direction for public transport and intervention vehicles, and, from Suceava County Hospital to the roundabout with Nicolae Balcescu Street (McDonald's area) and on George Enescu Boulevard and Calea Obcinilor, until the roundabout that will be developed in the area (Integrated Strategy Of Urban Development of Suceava Urban Area 2021 - 2030). The noise pollution

in Amsv is favored by: the chaotic development and systematization of the city from an urban and infrastructure point of view, which is currently defective in terms of transport and distribution of goods; the existence of shopping centers in the middle of the city and the lack of traffic decongestion points in these areas; improper planning of functional areas of the municipality; limited space to extend existing roads or specific routes for electric vehicles; poor positioning in terms of access for some institutions /objectives, traffic generators, etc, without a number of parking spaces adapted to the needs of the population (*Integrated Action Plan Suceava Freight Tails Action - Planning Network - Innovative logistics solutions for freight transport and distribution*).

A study led by the US Consumer Energy Center shows that solutions can be found to reduce noise pollution: engine shutdown if stationary for more than 30 seconds (maintaining the engine running for two minutes while the car is queuing at McDonald's Drive consumes the same amount of fuel as a car that runs for about a mile and a half); establishing areas where cars are not allowed to stand with the engine running, such as the surroundings of schools, residential districts or the drive-throughs of fast food restaurants; setting signs in the above mentioned areas; conducting campaigns to inform drivers about the importance of stopping the engine if they will be stationary for several minutes; establishing penalties if the established conditions are not met (*Integrated Action Plan Suceava Freight Tails Action Planning Network - Innovative logistics solutions for freight transport and distribution*).

5. Conclusion

In AMSv, there are multiple factors that contribute to noise pollution. The municipality of Suceava has only one bypass for transit traffic and industrial traffic. The urban road infrastructure is precarious and unable to cope with all the traffic to meet the travel needs of the population, staff of public institutions, and economic agents within the municipality and between the municipality of Suceava and neighboring municipalities (Pătrăuți, Mitocu Dragomirnei, Adâncata, Salcea, Ipotestii, Bosanci, Șcheia, and Moara). The number of electric buses (25 large ZTE electric buses purchased in 2020), electric and hybrid cars is still small, but great progress has been made on this component in recent years.

In noise pollution monitoring campaign 1 (30.10.2020 - 1.11.2020), inside and in the immediate vicinity of the USV Campus, the mean, average maximum and absolute maximum values of noise levels gradually decreased from the outdoor observation points located in the immediate vicinity of the main traffic arteries (62.5 - 69.2 dB) to the monitoring points located in the USV Park (51.7 -56.1 dB), inside the university campus (51.7 - 51.8 dB), and on the periphery of the campus (40.9 - 45.3 dB). The lowest values (30.9 - 35.5 dB) were recorded at the observation point located in room E216 of E Building, as it is indoors, away from the main noise sources (traffic, children's playground in the USV Park, town hall). The maximum noise level values recorded at the monitoring points ranged from 91.5 dB (intersection of 1 May Boulevard and University Street) to 46.2 dB (inside the USV E216 Laboratory). The Suceava University campus needs to be quieter and ingenious noise protection solutions need to be found. Protecting the entire perimeter of the USV with a sound screen made of vegetation or other sound-absorbing materials would be necessary to ensure the comfort of students, teachers, and administrative staff.

In the second monitoring campaign carried out from 11 to 15 December 2020, the average noise levels the highest at the observation point near the Palace of Justice (65.4 dB), at the monitoring point near Lidl store at the end of George Enescu Boulevard (55.9 dB), due to the heavy pedestrian traffic on the two main boulevards: Stefan cel Mare (1Mai) Boulevard and George Enescu Boulevard. The noise level recorded the lowest average values (below 50 dB) in the observation points located

far from the sources of pollution, on the secondary streets (Narciselor Street - 42.5 dB), in the peri-urban settlement Pătrăuți (42.3 dB) and at the Old-Rite Church of St. John the New (40.3 dB), which is located on the outskirts of the George Enescu district, near Sfânta Vineri Cemetery and the Șcheia Forest. In the hourly interval 23.00 – 06.00, the hourly noise averages were generally below 40 dB in the observation points located in Pătrăuți, near the Old-Rite Church of St. John the New in the George Enescu district. During the day (06.00 - 22.00), noise values did not exceed 55 dB at these three monitoring points. The noise level values were lower compared to those recorded at the other three points located near the Palace of Justice, the Sports High School, and George Enescu Boulevard (Lidl), where they were frequently above 55 dB up to 72 dB. The values increased at all monitoring points from 06:00, when the population resumed their daily activities, remaining constant with small fluctuations during the day until 22:00, after which they started to decrease slightly. The observations show for the points located at the main road arteries in the AMSv, a need to reduce noise pollution in order to approach the WHO recommended noise exposure levels, both during the day and at night.

References

- Bacauanu V., Barbu N., Pantazica M., Ungureanu A., Chiriac D. (1980). *Moldova Plateau. Nature, man, economy*, Scientific and Encyclopedic Publishing House, Bucharest, 345 p.
- Efros V., Popescu D.A., Popescu L.G. (2004). *Geology, exploitation and exploitation of levels of sandstone in the Deepland area and implications for land use*, *Annals of the University „Stefan cel Mare” Suceava, Geography Section*, year XIII – 2004, year XIII <TAG1>, gp. 17 – 24.
- Ciulache S. (2004). *Meteorology and climatology*, University Publishing House, Bucharest.
- Deac C., Petrescu V., Gligor A. (2017). *Reducing the noise pollution level along main roads in Sibiu, Romania by optimizing the traffic flow*, *MATEC Web of Conferences* 112, 09013, IManE&E 2017, DOI: 10.1051/mateconf/20171120901b.
- Oiste A.M., Mihai F.C., Chelaru D.A. (2015). *Soundscape in North-Eastern Part of Iasi City (Sararie – Ticau District)*, *Bulletin USAMV series Agriculture* 72(1)/2015, DOI 10.15835/buasvmcn-agr: 11190.
- Popescu D.I., Moholea I.F., Morariu - Gligor R.M. (2013). *Urban Noise Annoyance Between 2001 and 2013 – Study in a Romanian City*, *Archives of Acoustics*, Vol. 38 No. 2 pp. 205–210 (2013), DOI: 10.2478/aoa-2013-0024.
- Tanase I. (2011). *The climate of Suceava Plateau – risk phenomena, implications for sustainable development. Summary of the doctoral thesis*, University „Stefan cel Mare” Suceava.
- Titu A.M., Boroiu A.A., Mihailescu S., Pop A.B., Boroiu A. (2022). *Assessment of Road Noise Pollution in Urban Residential Area-A Case Study in Pitesti, Romania*, *Applied Science*, 12, 4053., <https://doi.org/10.3390/app12084053>.
- Directive 2002/49/EC on the assessment and management of ambient noise.
- Law no. 121 of 3 July 2019 on the assessment and management of ambient noise (published in the Official Gazette no. 604 of 23 July 2019)
- Law no. 189 of 25 October 2019 amending and supplementing Government Ordinance no. 43/1997 on the regime of roads (published in the Official Gazette no. 865 of 28 October 2019).
- Law no. 181/14 June 2022 amending and supplementing Law no. 121/2019 on the assessment and management of ambient noise (published in the Official Gazette no. 582 of 15 June 2022)
- Order no. 119 of February 4, 2014 for the approval of hygiene and public health rules regarding the living environment of the population, the ministry of health (published in the official monitor no. 127 Of 21 February 2014).

Integrated Action Plan Suceava Freight Tails Action Planning Network - Innovative logistics solutions for freight transport and distribution ([https://evp.primariasv.ro/dm_suceava/site.nsf/D506AEE6C0DC6B00C22580ED0032A916/\\$FILE/Plan%20Integrat%20de%20Actiune%20-%20FREIGHT%20TAILS.pdf](https://evp.primariasv.ro/dm_suceava/site.nsf/D506AEE6C0DC6B00C22580ED0032A916/$FILE/Plan%20Integrat%20de%20Actiune%20-%20FREIGHT%20TAILS.pdf)).

Integrated urban development strategy Suceava 2021 – 2030 (https://www.primariasv.ro/dm_suceava/site.nsf/pagini/strategia+integrata+de+dezvoltare+urbana+a+zonei+urbane+functionale+suceava+20212030-000324CA).

Local Action Plan Suceava for the promotion and implementation of electric vehicles and charging infrastructure in Suceava - Document realized through the project EVUE “ The pilot electromobility network of European cities ” – 6091 Co-funded by URBACT II Programme ([https://www.primariasv.ro/dm_suceava/site.nsf/atasament/6B6A9693C8B2CC4AC225869E00320FAC/\\$FILE/Plan%20Local%20de%20Actiune%20-revizuit%20%20EVUE%20II%20.pdf](https://www.primariasv.ro/dm_suceava/site.nsf/atasament/6B6A9693C8B2CC4AC225869E00320FAC/$FILE/Plan%20Local%20de%20Actiune%20-revizuit%20%20EVUE%20II%20.pdf))

Reports on the state of the environment in Suceava county for the years 2013 – 2021 (<http://apmsv.anpm.ro/rapoarte-anuale1>).

STAS 10009 - 88 Construction Acoustics. Urban acoustics. Admissible limits of urban noise level.

STAS 10009/2017 Acoustics in construction. Urban acoustics. Admissible limits of urban noise level.

<https://citadini.ro/barometru-urban-2020/>

<https://noise.eea.europa.eu>

<https://suceavalive.ro/s-au-refacut-portiunile-de-carosabil-hasurate-cu-galben-din-intersectiile-din-suceava-ce-trebuie-sa-faca-soferii>

<https://www.eea.europa.eu/ro/articles/poluarea-fonica-este-o-problema>

<https://www.monitorulsv.ro/Ultima-ora-local/2024-03-27/Proiectul-sensurilor-unice-in-municipiul-Suceava-in-asteptare-pana-in-2026>

www.anpm.ro