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Original Research

Road Traffic Noise Exposure in the City of Novi Sad: Trend Analysis and Possible Solutions

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Abstract

This paper evaluated exposure to road traffic noise in the city of Novi Sad, the second largest city in the Republic of Serbia. It has been investigated using analysis and systematization of the results on noise intensity in the city of Novi Sad, whether this parameter is within the approved limits for noise intensity during the day and night and whether it is in accordance with provisions of national norms of permissible noise levels in the environment, that is whether this parameter endangers people or not. In this work were used data from the Institute for Public Health of Vojvodina-Department of Residential Hygiene, which were obtained by measuring the noise intensity at 18 points in the city. Levels of noise, during the period of analysis, are usually higher than permitted and range from 1dB(A) to 8dB(A) during the day, and from 1db(A) to 9dB(A) at night. It has been determined that the noise intensity is in strong positive correlation ($r_s = 0.73$) with the number of vehicles in traffic. Even though the noise intensity in the period observed has a decreasing trend, the fact that it is still higher than permitted in school and residential zones is particularly worrying. It has also been determined that traffic noise is one of the leading urban problems in the city of Novi Sad, and therefore it is necessary to implement some of the plans for protection, mentioned in the work, for its reduction.

Keywords: road noise pollution, traffic, environment, City of Novi Sad, Serbia

Introduction

Noise is a naturally unpleasant experience, which is present all the time as a harmful factor in the environment and is among the physical factors harmful to health. The European Union has marked road traffic noise in the environment as one of the leading ecological problems in Europe [1]. According to data of the World Health Organization (WHO), the basic level of road traffic noise increases for one dB(A) every year. About 120 million people have hearing problems. In the European Union, approximately 40% of the population is exposed to residential noise levels of above 55 dB(A) during daytime and more than 30% are exposed to the same noise levels at night. This exposure may cause serious annoyance and sleep disturbance. Therefore, noise represents one of the leading risk factor distortions of overall health integrity [2, 3].

The EU gives a lot more consideration to this problem than other parts of the world [4]. According to the references of the European Commission, all members of the European Union are obligated to produce strategic noise maps for urban areas with populations of over 250,000 [5].

Noise is a specific form of pollution in the modern world. It was observed as a problem at the beginning of urbanization and housing in the cities, and it became a serious ecological problem with the beginning of industrialization at the end of the 18th and the beginning of the 19th centuries. The development of modern technologies, urbaniza-

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tion, and rapid industrialization, especially the development of traffic and the car industry, have led to noise as a serious ecological problem of the modern world [6-13].

Nowadays, exposure to noise is one of the most important criteria in the selection of a residence [14, 15]. Research indicates the high influence of road traffic noise on front building facades that are closer to roads, which makes those parts of buildings unfit for residential purposes. Courtyars, the last parts of buildings and roofs, are least impacted by traffic noise. They are the safest places to be used for residential purposes and research has also shows that the height of the building is not an effective means of reducing traffic noise in the upper parts of the building [16].

Noise pollution is not less harmful than any other form of pollution. Longer exposure to high noise can cause temporary or permanent mental and physical damage to human body functions [17-20]. Individual sensitivity to noise is an important factor in evaluating the effects of disturbing noise [21]. Results of long-term study have shown that about 10% of the population is more sensitive to noise, especially children younger than 6 and adults older than 65. Women are more sensitive than men in their middle age. Individual sensitivity is affected by neurovegetative condition and the vascular system [22-24], some virus infections, use of alcohol and tobacco, and professional exposure to neurotoxin materials [25, 26].

Noise intensity of 35 dB(A) extends a time-needed to fall asleep, and this is only shallow sleep. A noise level of 45 dB(A) causes spontaneous awakening, and awakening as a result of such derangement occurs during sleep, whereas the strength of 50 dB(A) or more prevents a person from having any rest. It can be concluded that the permanent effect of noise decreases human life expectancy by 8-10 years [27].

It is difficult to have communication in a noisy environment due to the voice communication masking effect [28]. A frequency range of 300 Hz to 3 kHz is especially important for understanding one's speech, and this is the range of the majority of the sound energy of noise pollution [26].

The noise level present in the environment is not high enough to damage hearing, but it causes a whole range of audio and extra audio effects [26]. Noise has become a very serious problem due to urban development, where transport is a necessity [29]. Industrial society depends on mechanical transport for efficient distribution and exchange of people and goods, for schools, shops, factories, and many other sectors [30].

Based on questionnaire research, it was determined that in German towns with over 5,000 people, 14-16% are endangered by road traffic noise. In towns with 5,000 up to 20,000 inhabitants this percentage is 17-18%, in towns of 20,000 to 100,000 inhabitants it is19-25%, while in cities with over 100,000 inhabitants, 22-33% of the population feels a psychophysical burden and anxiety [28].

The main focus of this paper is on road traffic noise from cars, vans, busses, and motorbikes. Each of these creates a specific form of noise [31]. The causes of the problem are engines, internal audio, brakes, and tires. Some responsibility is on drivers, who should take care of their car's condition. For example, car brakes should not squeak. Drivers also need to be aware that their cars certainly produce noise, which should lead them to driving without causing inconvenience to other people, for example, avoiding a "harsh" ride in quiet residential areas and avoiding night driving, etc.

The aim of this paper is to determine through review, analysis, and systematization of results on the intensity of noise in the city of Novi Sad whether this parameter is within the permissible values for the intensity of noise during the day and night, and if it is in accordance with the legal provisions of national norms of permissible noise levels, or whether this parameter influences the environmental degradation of man. On the basis of these results, the goal is to identify and map more suitable and less suitable areas for urban life. Another goal of this work is to find solutions and list suggestions for decreasing the level of noise.

Materials and Methods

Study Area

Novi Sad is the second largest city in the Republic of Serbia and the largest city of the Autonomous Province of Vojvodina. Geographic location is 19º50′41″ eastern longitude and 45º15′18″ northern latitude. It stands on the banks of the River Danube south of the region Bačka; altitude of 76 to 82 m. The municipality land area is about 702.7 km^2, and it has population of 360,000 and 512 inhabitants/km^2 according to the last census conducted in 2011 [32]. Due to favorable geographical location, Novi Sad represents the crossroad of the main inland and waterways in Vojvodina, with numerous highways and railroads, and some of them are of international importance [33].

The development of Novi Sad as the administrative-political, industrial and economic center, due to intensive housing and other forms of construction work, dictates needs for public utilities development where urban and suburban public transportation has a crucial role. Ongoing development of urbanization and industrialization is required by daily travelling business people, students, and the entire population of the village and the surrounding area. For urban public transport, buses, which were introduced in 1958, are still the main mean of transport together with taxis. Intensive urbanization and expansion of the city has increased the number of cars and the unsolved problems of parking, traffic jams, and residential noise have been the biggest urban problems for the city of Novi Sad [33]. Tax exemption on the import of new and used vehicles from Western European countries has contributed to the increase in the number of vehicles in Novi Sad and to an increase in ecological problems.

Data and Processing

Residential noise monitoring is one of the indicators for environmental quality. Monitoring of noise levels in the city is determined by noise source and the results are

Table 1. Permissible level of road traffic noise in the intended zone [41].

Intended zone	Permitted level of Residential noise (dB(A))	
	Day	Night
I Areas for recreation, hospitals, large parks	50	40
II Tourist zone, small and rural settlements, camps and school zones	50	45
III Only residential blocks	55	45
IV Business and residential blocks, playgrounds	60	50
V City center, highway, motorway, and city road zones	65	55
VI Industrial zone	70	70

obtained on the basis of whether it is possible to take possible measures in terms of more appropriate and humane urban planning. Measuring residential noise in the area of Novi Sad has constantly been applied since 1980.

Evaluation of road traffic noise in the environment is carried out according to standard methodology in accordance with valid legal basis. The methods used in measuring road traffic noise in the environment are defined by the following standards:

1. SRPS ISO 1996-1:2008 [34]
2. SRPS ISO 1996-2:2008 [35]
3. SRPS ISO U.J6. 205:2007 [36]
4. SRPS ISO U.J6.090:1992 [37]

A series of laws in Serbia treat in different ways environmental issues, in whole or particular aspects, such as: food, water, air, soil, etc. [38-43]. This is an attempt to create a solid legal basis in accordance with law and bylaw acts that would create for all subjects of social life obligations in dealing with everyday life and work, and the basics of responsibility and the penalty for violations of these regulations. Unfortunately, law and bylaw acts by which the level of environmental noise is regulated are not obeyed, and noise is often considered to be a marginal problem.

All obtained values of road traffic noise are applied with applicable standards, which regulate permitted levels in certain areas. Values range from 50 dB(A) during the day and 40 dB(A) during the night in the areas of recreation, parks and hospitals to 70 dB(A) (during the day and night) in purely industrial areas of the city (Table 1).

Raw data from the Institute for Public Health of Vojvodina – Department of Residential Hygiene were obtained for the analysis of noise in Novi Sad [26]. Data were obtained by measuring the noise intensity on roads in the residential, school, and sporting-recreational zones where the speed limit is 40 and 50 km/h.

The measuring points do not include the industrial zone, therefore maximum daily measured level of road traffic noise value is 65 dB(A) during the day and 55 dB(A) during the night. In accordance with the regulations of Directive 2002/49/EC [5] and the act of noise indicators, limited values, methods for estimation of noise indicators, disturbance and harmful noise effects in the environment [38], and road traffic noise in the environment was measured over a three-day period (day 06:00-18:00, evening 18:00-22:00, and night 22:00-06:00).

The system used to measure the noise level in the environment consists of:

1. Brüel & Kjær transmitting noise analyzer type 2250
2. BZ5503 – utility software for hand-held analyzers
3. Softver Noise Explorer Type 7815, version 4.15

At all 18 measuring points the measuring was done in the same way, setting a microphone at a distance of at least 5 m from the road and 1.5 m above the ground.

The percentage of "highly annoyed" persons (HA) due to road traffic noise was calculated with the equation:

$$HA\,[\%] = 0.5118\cdot(L_{den} - 42) - 1.436\cdot10^{-2}\cdot(L_{den} - 42)^2 + 9.868\cdot10^{-4}\cdot(L_{den} - 42)^3$$

We used software package STATISTICA 12. Obtained data were processed by the use of descriptive statistical analysis, which represents a method for determinig certain parameters relevant for the description of behaviour of observed characteristics. The following indicators were determined: average value ($\bar{X}$), extreme values (minimum and maximum), median (Me), modus, standard deviation (σ), variation coefficient (Cv) [44].

In order to determine correlation between the intensity of noise and the number of vehicles, Spearman's correlation coefficient was calculated using the formula:

$$r_s = 1 - \frac{6\cdot\sum d_i^2}{n^3 - n}$$

...where d represents the difference in values of ranks of two observed variables, and n is the number of different series [44].

The linear regression model has been derived for the analysis of noise intensity trend in the city of Novi Sad for the past 20 years.

ArcGIS 9.2 software by ESRI Company has been used in the paper. Maps were made in GSC_WGS_1984 Geographic Coordinate System, D_WGS_1984 Date, with Prime Meridian Greenwich. The process of making noise maps of Novi Sad was done in the following stages: collecting material, database building, and digitization. Use of geographic information system (GIS) and its associated databases is an efficient medium for showing spatial relationship, where standardization personal data and methods and their harmonization with European standards are significant. GIS is a system that provides new views and interpretations of its raw and united data, which are sometimes hard to correlate without spatial dimensions [45]. The idea of connecting "raw" data with real points and areas (i.e. coordinates within GIS) has contributed to map visualization.

Table 2. Measuring points, the value of daylight and nighttime noise levels, and the percentage of highly vulnerable populations, 2010 [26].

Measuring point	Location	L_{day} dB(A)	L_{night} dB(A)	% HA	Zone
1.	Corner of Subotički Boulevard and Đorđe Magarašević street	68	59	22.6	Residential
2.	Ivan Gundulić elementary School	65	59	14.1	School
3.	Car Dušan Street	71	63	24.1	Residential
4.	Sajmište Sports Center	66	58	16.0	Sport-recreative
5.	Corner of Partizanska and Đorđe Zličić streets	73	64	26.8	Next to traffic roads
6.	Car Lazar Boulevard	68	60	23.5	Next to traffic roads
7.	Maksim Gorki Street	69	61	23.9	City centre
8.	Uspenska Street	68	60	23.4	City centre
9.	Svetozar Marković Gymnasium	65	57	21.5	School
10.	Corner of Jovan Dučić Boulevard and Bata Brkić Street	65	56	10.6	Residential
11.	Corner of Kornelije Stanković and Joakim Vujić streets	69	61	22.4	Next to traffic roads
12.	Kej žrtava racije	70	62	27.3	City centre
13.	Oslobođenja Boulevard	69	62	22.2	Next to traffic roads
14.	Corner of Futoški Put and Knez Miloš Boulevard	69	60	17.6	Next to traffic roads
15.	Jovan Dučić Elementary School	66	58	21.1	School
16.	Corner of Vršačka and Jovan Popović streets	64	57	21.8	Residential
17.	Rumenačka Street	69	62	23.1	Next to traffic roads
18.	Corner of Oslobođenja Boulevard and Narodni Front Street	69	62	24.7	Next to traffic roads

Results and Discussion

During the analysis, average annual and monthly residential noise values at the measuring points in the city were tracked and analyzed to the maximal values recorded during the tracking period compared to the values regulated by the Law on Noise Protection [41] and the regulation on measuring method of noise and the reporting extent of measured noise [42].

Results of monitoring residential noise from 1991 to 2010 (Fig. 1) showed that the highest road traffic noise level was recorded at the beginning of the monitoring period during 1991 and 1992 in the amount of 82 dB(A). Since that period average annual road traffic intensity value has been decreasing and it has not risen above 70 dB(A) since 1998. The lowest value was recorded at the end of the monitoring period (2005, 2008, and 2010) at 68 dB(A). However, it has been rising above limited value of 65 dB(A) for 3 to 17

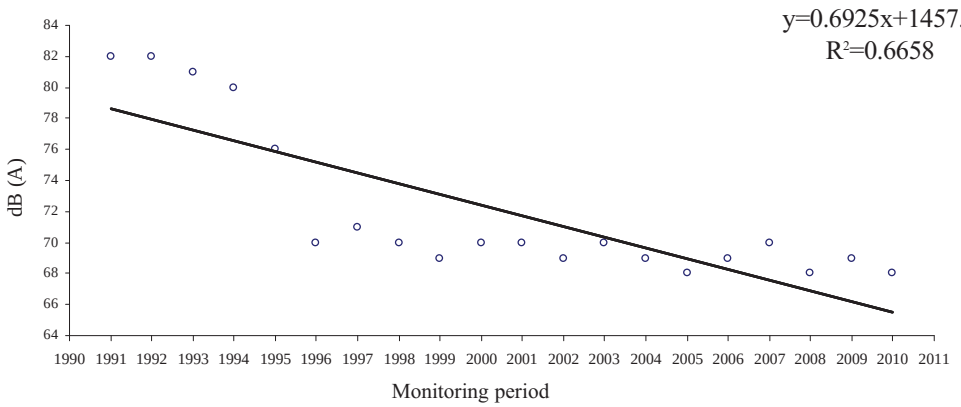

Fig. 1. Noise sound pressure levels in the city of Novi Sad from 1991 to 2010.

Table 3. Descriptive statistical analysis of daily and night noise intensity in Novi Sad in 2010.

	Valid N	Min	Max	$\bar{X}$	σ	Cv
L_{day}	18	64	73	67.94	2.36	3.48
L_{night}	18	56	64	60.05	2.26	3.76

dB(A). However, the linear trend observed over 20 years is declining. Determination coefficient (R^2=0.6658) is not high, meaning that 66.58% of the connection is explained by linear regression model. Renewal of the public transport company fleet and the presence of newer vehicles in Novi Sad which produce less noise have resulted in a decrease in the noise intensity in the observed period. Ecological awareness of the population and mass usage of bicycles have also contributed to a decrease in noise intensity and decrease in pollution and in the traffic jam.

Measuring results of road traffic noise in 2010 at 18 measuring points (Table 2) allow more precise analysis, on the basis of which could suggest certain measures to reduce road traffic noise.

Results of descriptive statistical analysis of daily and night noise intensity in the city of Novi Sad in 2010 are shown in Table 3. During 2010 minimal annual average daily value of equivalent road traffic noise level (L_{day}) in the environment in the city of Novi Sad was determined at measuring point No. 16 in the amount of 64 dB(A), and maximum average daily value of equivalent road traffic noise level was determined at measuring point No. 5 in the amount of 73 dB(A). Average annual value of daily equivalent road traffic noise level in the city of Novi Sad was in the amount of 67,94 dB(A) in 2010.

Compared to total determined amount (216) of average monthly equivalent, day road traffic noise level in the environment of the city of Novi Sad was 40 (18.52%) in accordance with and 176 (81.48%) over the limited amount, according to the Act of National Normative of Permitted Daytime Noise Levels of 65 dB(A) during 2010.

During 2010 minimal annual average night value of equivalent road traffic noise level (L_{night}) in the environment in the city of Novi Sad was determined at measuring point No. 10 in amount of 56 dB(A), and maximum annual average night value of equivalent road traffic noise level was determined at measuring point No. 5 the in amount of 64 dB(A). Average annual night value of equivalent road traffic noise level in the city of Novi Sad was in amount of 60.05 dB(A) in 2010.

Compared to total determined amount (72) of average monthly equivalent, night road traffic noise level in the environment of the city of Novi Sad was 4 (5.56%) in accordance with and 68 (94.44%) over the limited amount, according to the act of national normative of permitted noise level for night of 55 dB(A).

Road traffic noise on some locations in the first place depends on traffic type, share of heavy traffic, slope of the street, street type, height and house density, surface, vehicle speed, distance of traffic lights and crossroads in general, general technical condition of traffic, etc. At the location, assuming the same mode of traffic, road traffic noise in local environment measuring point depends on several parameters, first of all period of the day, day of the week, season, etc.

Measuring the noise level of daily traffic in Novi Sad was also accompanied by a number of heavy and light vehicles and motorcycles in 2010 (Fig. 2). It was found that the average frequency value of light passing vehicles was 419 vehicles/15 minutes, average frequency value of heavy passing vehicles was 17 vehicles/15 minutes, and average frequency value of motorcycle passing was 3 motorcy-

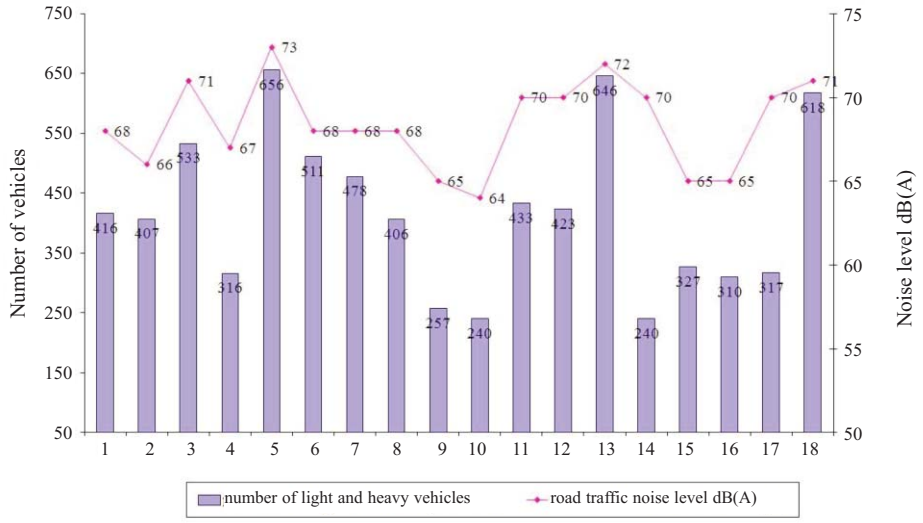

Fig. 2. Frequency level of passing of light and heavy vehicles and daily road traffic noise levels.

cles/15 minutes. It is characteristic for vehicles (passenger cars) to make noise at frequencies between 250 and 100 Hz, while for heavy vehicles (trucks, busses) it is characteristic to make noise at frequencies between 500 and 400 Hz. Mopeds and motorcycles make noise at very low frequencies (30-200 Hz) [26]. These results are the annual average based on 648 daily measurements during 2010 in the 15-minute period.

Statistical analysis shows that the noise level is in a strong positive correlation (Spearman Rank Order Correlations, $r_s = 0.73$) with a number of light and heavy passing vehicles (Fig. 3).

Road traffic noise level usually exceeds values permitted for certain city zones. The highest noise intensity has been recorded on measuring points on boulevards with heavy traffic.

In zones along the city road traffic (measuring points 5, 6, 11, 13, 14, 17, and 18) level of noise in most cases is higher than permitted standards from 1 dB(A) to 8 dB(A) during the day and from 1 dB(A) to 9 dB(A) during the night (Figs. 4 and 5).

Particularly concerning is the level of road traffic noise which exceeds permitted levels in school and residential zones. In school zones (measuring points 2, 9, and 15) the road traffic noise level is higher by 12 dB(A) to 16 dB(A) related to permitted level of road traffic noise per-use zones (Table 1). In the residential zone (measuring points 1, 3, 10, and 16) the level of road traffic noise is higher by 9 dB(A) to 16 dB(A) than permitted standards during the day and by 11 dB(A) to 18 dB(A) during the night. In the city center (measuring points 7, 8, and 12) the level of road traffic noise is higher by 9 dB(A) to 5 dB(A) than permitted standards during the day and by 5 dB(A) to 7 dB(A) during the night. The city has no measuring points in the walking zone, therefore the noise registered in the center is traffic noise; measuring points are near the roads that pass through the city center.

All population groups of different age, gender, and health are exposed to the source of road traffic noise in urban environment [46, 47]. In the urban environment there is a great number of people exposed to noise higher than 65 dB(A) with traffic of at least 500 motor vehicles an hour (of which at least 15% are heavy vehicles). It can be noticed that the most endangered population in Novi Sad is in the city center (27.3% HA) and next to city roads (17.6%-27.6% HA).

Based on the results mentioned in this paper it is recorded that noise intensity in the whole period and on almost all measuring points is higher than what is regulated and permitted. Given these results and comparing them with per-

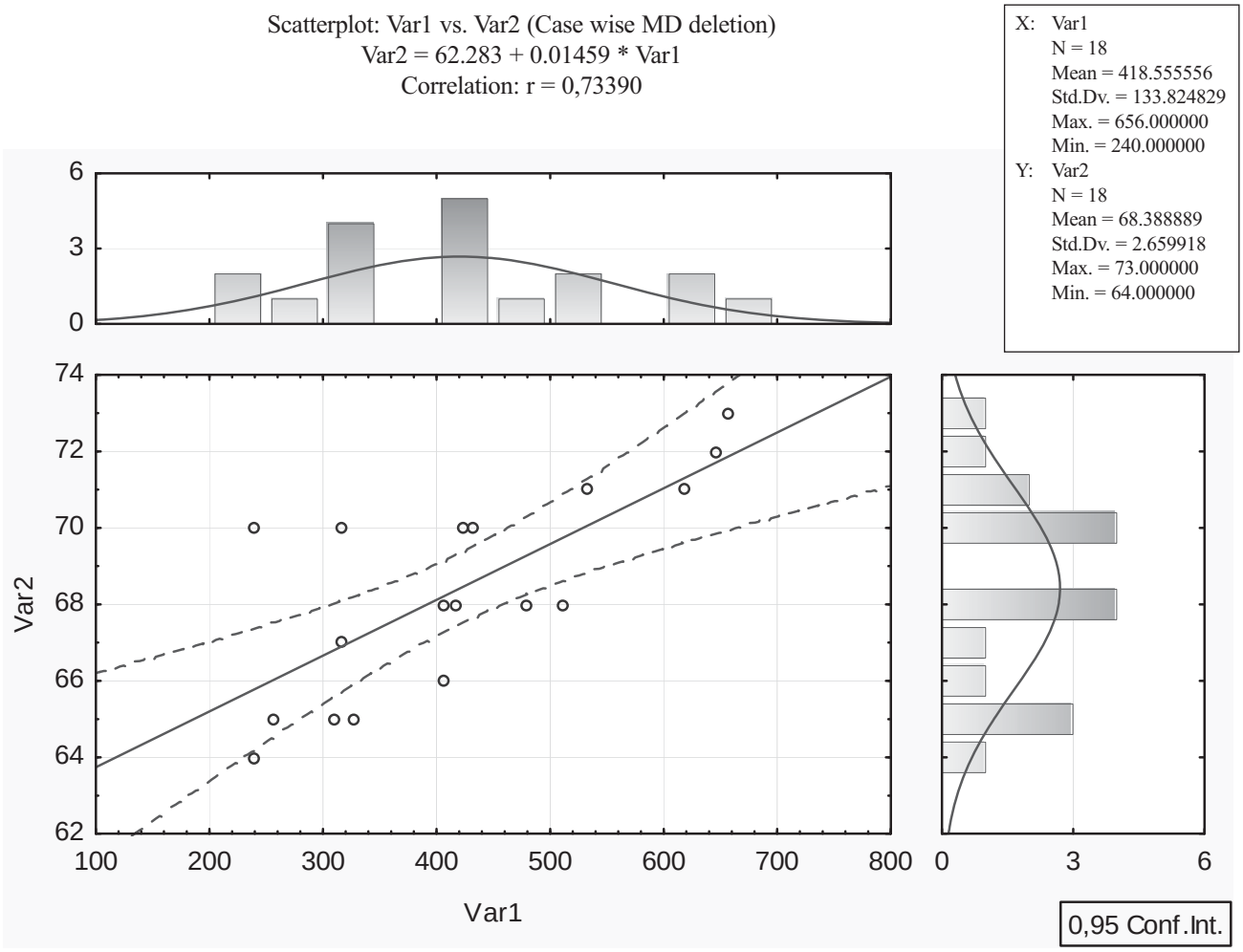

Fig. 3. Scatterplot matrix for number of vehicles (Var1) and noise intensity in dB(A) (Var2).

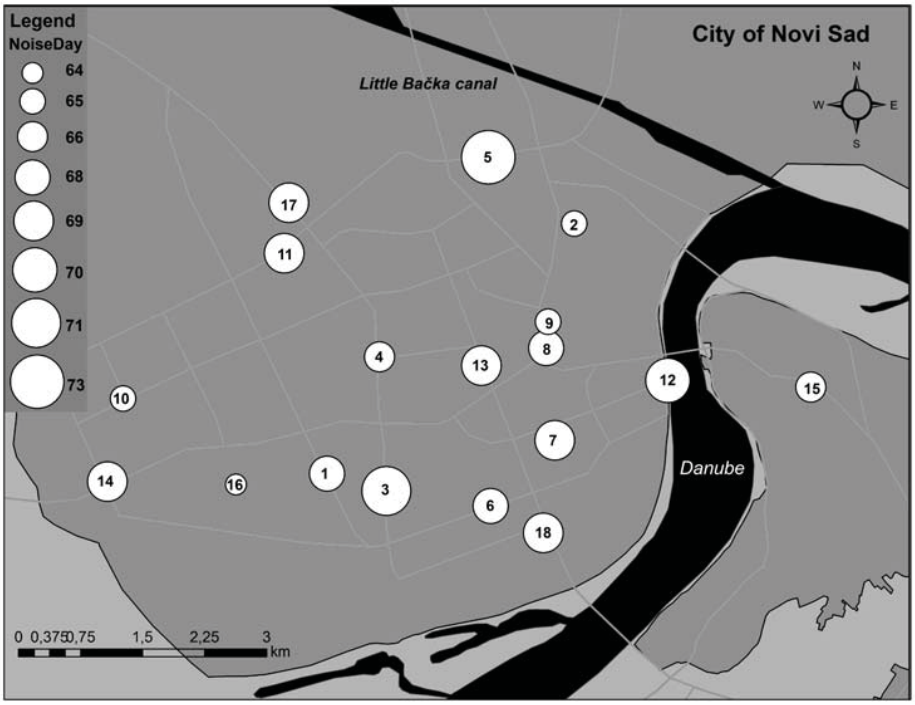

Fig. 4. Road traffic noise sound pressure levels in the city of Novi Sad during the day.

mitted values for the day and the night, it is clear that there are real conditions that are harmful to the human body and overall life satisfaction.

Noise protection is carried out in various ways. Sound barriers are commonly used for traffic noise. Absorbant materials used for this purpose mostly have broadband and non-selective adsorption properties. Modern materials technology opens up the possibility of using composite structures with optimal absorption and acoustic insulation properties. Accurate knowledge of the spectral characteristics of the source, due to the use of composite materials, provides achieving the required results in reducing the noise level permitted to measure with saving of material and space.

Numerous functions of green areas are evidence of their immense importance in any modern settlement. Their influence on the improvement of quality of the city environment is proportional to their size, distribution, and general quality. However, it is not enough to say that the benefits of

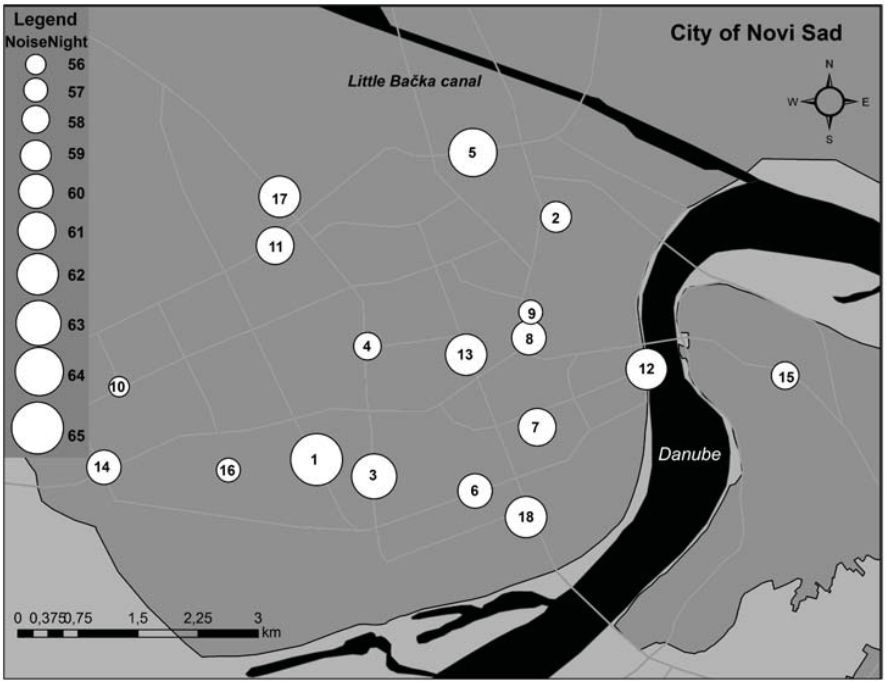

Fig. 5. Road traffic noise sound pressure levels in the city of Novi Sad during the night.

green areas are large: they have become one of the main structural elements of each urban area. Because of this, the city's green areas in almost all the major cities can significantly ease lives of inhabitants, and the simplicity and economy of urban green makes this possibility quite valuable.

In major urban areas, the noise level can be reduced by building wide boulevards with adequate construction of buildings and good organization of traffic [48]. Raising green spaces that reduce noise has been shown as an effective protection against noise. The intensity of the reduction depends on the physical properties of sound, dendrology composition, height, width, and location of green barriers in relation to the noise source and the receiver [49-51]. It is recommended to raise the green belt between the street and pavement width of 10-50 m, where trees and shrubs will be planted. Such a green belt can reduce noise by 8-10 dB(A). Research has shown that the crowns of deciduous trees absorb about 25% of sound energy, which is especially visible in streets without trees with average heavy traffic, where noise is almost five times louder when compared with a green street [52].

It has been emphasized in previous studies [53] that for "optimal" protection against noise, a green bar should have a width of 20-35 m, as narrow strips are less affected by noise, and a wider strip practically does not give any additional effect. With more dense trees and bushes planted in the protective bar against noise and the larger the area of green mass of vegetation in it, the bigger effect is in reducing sound energy falling on the surface. The combination of hedges with trees also gives a positive effect in reducing noise, and thick green plantations of good quality (combination of tree and shrub) reduce the overall noise level of 14 to 15 dB(A) [54].

Dendrological deciduous species that are good sonic insulators are: *Viburnum lantana*, *Viburnum rhytiphyllum*, *Ilex aquifolium*, *Catalpa bignonioides*, *Carpinus betulus*, *Tilia* sp., and *Quercus* sp. Dendrological conifer species are recommended for protection against noise throughout the year. Particularly useful are: *Pinus nigra*, *Pinus sylvestris*, *Pseudotsuga menziesii*, *Picea* sp., and *Abies alba* [55]. Unfortunately, in many streets in Novi Sad, especially in the old city center, physical qualities for planting greenbelts, which would protect from noise, do not exist due to the narrow streets and the closeness of buildings to the road. A somewhat better situation is at wide boulevards in the city suburbs, where the possibilities for this type of protection exist but are not used.

Another way of reducing the harmful effects of noise is the availability of green spaces. Some previous studies found that high neighborhood quality in terms of attractive appearance, and the presence of parks and green spaces lowered dissatisfaction with traffic noise to a significant degree [56]. Good availability to nearby green areas furthermore can enhance the positive effects of access to a quiet side, where these nearby green areas also play an important role in moderating the adverse effects of traffc noise [57, 58]. Unfortunately, in the last couple of years the green areas in Novi Sad have decreased. Parking places, residential buildings, and malls are emerging, absorptive surface is decreasing, and the condition of the environment in the city is deteriorating.

An interdisciplinary approach and the application of up-to-date acoustic methods of measuring and predicting noise in the environment ensure noise reduction. System management of environmental noise represents a complete set of instruments known as "4M": measuring, monitoring, mapping, and management [26].

- Measuring – the use of acoustic measuring in order to accurately characterize the observed noise sources in the environment
- Monitoring – using unsupervised methods of acoustic measuring in order to provide more accurate monitoring time variability of the observed noise sources
- Mapping – using the instrument noise maps and action plans as a starting instrument in establishing the management system of environmental noise
- Management – the use of all instruments in one whole, lively, interactive system

Conclusion

Noise pollution in Novi Sad is not recognized and accepted as an environmental problem as much as it should be. It has been scientifically proven that noise is potentially dangerous for health, communication, productivity of inhabitants; and therefore life quality. Nevertheless, this problem has been marginalized in the pile of other urban-problems.

Analysis of the measuring results points to several facts. It is recorded that in all zones, both day and night levels exceed the permitted values. Such large overdrafts are the result of unregulated traffic and the absence of measurements that could at least partially reduce noise levels. On the other hand, the night values indicate that harassment of citizens is caused mostly by high traffic noise levels in a period planned for relaxation.

During the analyzed period in zones along the city roads, traffic noise levels in most cases were higher than permitted by 1 dB(A) to 8 dB(A) during the day, and from 1 dB(A) to 9 dB(A) during the night. Particularly worrying is the fact that noise levels exceed the level of the school and residential zones. In school zones, the noise level is increased by 12 dB(A) to 16 dB(A) compared to the permitted noise levels. In residential zones, the noise level is increased by 9 dB(A) to 16 dB(A) during the day and 11 dB(A) to 18 dB(A) during the night. In the city center, and business and residential zones, the noise level is increased by 3 dB(A) to 5 dB(A) during the day and by 5 dB(A) to 7 dB(A) during the night.

This alarming situation of noise pollution demands strategic planning and systematic work of everyone involved to reach the goal, which is permitted noise levels in the city zones. Having in mind that traffic noise has the largest impact on creating residential noise, the first thing to be done is to propose measurements aimed at traffic regulation, and then to choose quieter city zones for hospitals, schools, university facilities, etc. in future planning.

When the fact that noise causes harmful effects to human health, mood and life satisfaction is taken into consideration, and it is clear that it is necessary to protect people. Protective measures can be taken in three ways:

1. Preventing noise at the source
2. Noise reduction by distancing from sources (using bisecting road transport noise)
3. Use of personal protective equipment against noise

Since it is impossible to reduce the number of vehicles in traffic and the frequency of their use, some preventive measures could be taken to protect human health. In order to reduce residential noise it is necessary to:

- Constantly monitor residential noise levels in the territory of the city of Novi Sad
- Ensure proper urban planning for the city
- Control the noise levels emitted by motor vehicles during technical control
- Constantly monitor residential noise levels emitted by motor vehicles
- Expand the network of streets with automatic traffic control and synchronization of traffic lights
- Increase the number of measuring points in the city
- Reallocate measuring points to determine the day and the night residential noise levels in order to obtain average monthly authoritative day and night residential noise levels in the city
- Planned greening of public spaces
- Provide easy access to parking areas
- Provide acoustic insulation of buildings
- Developing action plans to reduce noise levels in the city of Novi Sad, in accordance with Directive 2002/49 and the existing legal basis, the main goal of which is to reduce noise levels in the environment in order to reduce the number of people disturbed by noise.

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