DOI: 10.31319/2519-8106.1(46)2022.258429
UDC 621.129.12
D. Shmatko, PhD, Associate Professor, shmatkodima@ukr.net
A. Sasov, PhD, Associate Professor, sasov@ukr.net
V. Averyanov, PhD, Associate Professor, averynov@ukr.net
E. Velykodnuy, student master
Dniprovsky State Technical University, Kamianske

INVESTIGATION OF NOISE POLLUTION BY MOTOR VEHICLES OF THE PRIMAGISTRAL TERRITORIES OF KAMYANSKY

The paper conducts field observations of the intensity of traffic and determined the intensity of traffic by type of vehicle in the morning. Noise characteristics of traffic flows were obtained, which consist of equivalent and maximum sound levels at a distance of up to 10 meters from the axis closest to the calculated point of the traffic lane. Experimental and calculated data were compared with the regulatory requirements for the level of noise load on the main streets of local importance in Kamyanske. Measures to reduce noise pollution in highways were proposed.
***Key words**: territory, vehicle, measurement, research, result, calculation.*

У роботі проведені натурні спостереження за інтенсивністю руху автотранспорту і визначена інтенсивність руху за видами транспортних засобів у ранковий час доби. Були отримані шумові характеристики транспортних потоків які складаються з еквівалентних і максимальних рівнів звуку. Експериментальні та розрахункові данні порівнювались з нормативними вимогами рівня шумового навантаження на магістральних вулицях загальномісцевого значення м. Кам'янське. Були запропоновані заходи по зменшенню шумового забруднення примагістральних територій.
***Ключові слова**: територія, транспортний засіб, вимірювання, дослідження, результат, розрахунок.*

Problem's Formulation

The acoustic characteristics of the traffic flow are determined by the noise levels of cars. Noise from transport depends on many factors: engine power and mode, technical condition of the crew, the quality of the road surface, speed.

Road transport has the most adverse acoustic effect. Cars are the predominant source of intense and prolonged noise, with which no other can compare. Noise generated by moving cars is part of traffic noise. In the general case, the greatest noise is generated by trucks. At low speeds on highways and high speeds of the engine shaft, the main source of noise is usually the power plant, while at high speeds, low speeds and lower power of the power plant can be dominated by noise due to the interaction of tires with the road surface.

Due to the growing number of cars, the industrialization of cities, the growth of transport mobility of the population, the growth of technical equipment of the city economy, contacts between the man-made environment of the city and the natural environment are expanding. Recently, the average noise level from transport has increased by 12—14 dB, and the subjective volume has increased 3—4 times. On the main highways of large cities, noise levels exceed 90 dB and tend to increase annually by 0.5 dB, which is the greatest danger to the environment in areas of busy highways.

Currently, in large cities there are areas where it exceeds 70 dB (sanitary norm for night time — 40 dB). 60—80 % of urban noise is generated by vehicles.

Analysis of recent research and publications

In modern conditions of development of urban areas due to the growing number of cars (which are the most common source of noise), industrialization of cities, increasing transport mobility, increasing technical equipment of the city economy, increasing levels of noise pollution. Traffic noise is the main acoustic pollutant in almost all modern cities, and its contribution to the total share of noise in residential areas is 60—80 %. In the main areas, significant traffic noise is observed on average

18—20 hours a day, sometimes around the clock. Denisov V. in his research he found that the impact zone of the highway, depending on the intensity of traffic, meteorological and topographic conditions of the area extends to a distance of up to three kilometers from the edge of the carriageway [1].

According to research by some governmental and non-governmental organizations (such as the UK's Office for National Statistics), noise levels in European cities have increased 10—15 times over the past 20 years, affecting more than 50 % of urban dwellers. [2]

Vehicle noise while driving should be considered as a set of sounds of different frequency and intensity, which are perceived by human hearing and cause unpleasant subjective sensations, and as a physical factor are mechanical random oscillating movements that propagate in waves in an elastic medium. Tokar A., Mitnik Y. found that noise indicators depend on such factors as power, technical condition and mode of operation of the engine, type and quality of road surface and speed, driver qualification, features of traffic on certain sections of the road (intersections), frequency and signal strength of vehicles, etc. [3]

Formulation of the study purpose

The purpose of the work is to study the noise pollution of the urban area of Kamyansk by road.

Presenting main material

The sections of the city territory of Kamyansky, which are the most loaded with trucks, were selected to assess the noise pollution by motor transport on the main territory.

Observations of traffic intensity were carried out during the day. The counting of cars, light and medium trucks, heavy cars and buses was conducted separately. Determination of traffic intensity was carried out according to the following formula

$$N = \sum_{i-1}^{n} N_{\text{h}} \cdot \frac{60}{T_d}, \quad (1)$$

where N_h — hourly traffic intensity in transport units, bus/hour; T_d — measurement duration, min.

In generalized form, the results of studies of traffic intensity on sections of roads in Kamyansky are given in tabl. 1.

Table 1. The results of observations of traffic intensity and composition of vehicles on the research sections of roads

Place of measurement	Time measurement	Traffic intensity vehicles, bus / hour					
			Cars	Trucks	Heavy trucks	Buses	Total
Hrushevsky street	8^{15} — 10^{10}	%	53,2	38,8	6	4	100
		Number of vehicles	392	122	59	67	640
Anoshkin Avenue (section near the Metallurgical College)	8^{50} — 11^{20}	%	63,7	11,9	11,4	13	100
		Number of vehicles	368	53	54	31	506
Jubilee Avenue	9^{20} — 9^{55}	%	74,5	7,4	4,1	14,0	100
		Number of vehicles	792	95	59	43	989
Anoshkin Avenue (exit from the bridge)	10^{40} — 11^{15}	%	64,5	14,1	14,8	6,6	100
		Number of vehicles	394	60	81	10	545

From the analysis of the results of observations according to table. 1 we can conclude that the main contribution to traffic flows at the research sites is made by passenger transport on average about 77 %, light and medium loads — 11 %, heavy trucks — 9 % and buses — 3 %.

Noise level measurements were carried out in accordance with LTO 3.3.6.037-99 during the day directly on the side of the city's main streets, which are most congested with trucks and pass at a distance of 30—50 m from residential high-rises.

A portable noise meter type VSHV-003-M2 with a scale range from 20 to 130 dB was used for the research. The research was carried out on sections of asphalt roads. Measurements were performed at each point for 30 minutes. On the section of Hrushevskoho Street, the traffic is two-way in one lane in each direction. On the section of Jubilee Avenue, the traffic is two-way, with two lanes in each direction. In other research areas, traffic in two lanes in one direction. The measurement results are given in tabl. 2.

Table 2. Levels of noise pollution in residential areas Kamyansky

Place of measurement	Traffic intensity motor transport, bus / year	Time measurement	Noise level, dB
Hrushevsky street	640	8^{15} — 10^{10}	68—79
Anoshkin Avenue (section near the Metallurgical College)	506	8^{50} — 11^{20}	61—71
Jubilee Avenue	989	9^{20} — 9^{55}	65—78
Anoshkin Avenue (exit from the bridge)	545	10^{40} — 11^{15}	64—76

In accordance with the state building codes of Ukraine DBN B.1.1-31:2013 "Protection of territories, buildings and structures from noise" recommended normative noise levels of the settlement area — 55 dBA during the day and 45 dBA at night, noise levels for adjacent areas to: residential premises — 45—60 dB, public premises — 55—70 dB. For main streets of city and district importance — LAeq = 78 dBA, and LAmax = 93 dBA, respectively, DSTU-N B B.1.1-33: 2013.

As shown by the analysis of measurement results and their comparison with regulatory requirements in accordance with DSTU-N B B.1.1-33: 2013, the noise level on the experimental main streets of local significance exceeds by 2—4 dBA equivalent noise level LAeq = 78 dBA, but does not exceed LAmax = 93 dBA.

To calculate the noise characteristic, the method described in DSTU-N B B.1.1-33: 2013 was used.

Noise characteristics of transport flows are equivalent and maximum sound levels in dBA, which are determined either by full-scale instrumental measurements in accordance with GOST 23337, GOST 22283, or by calculations [4, 5].

Noise characteristics of road traffic flows (including trucks, cars, buses) are equivalent LAeq and maximum LAmax sound levels in dBA at a distance of 7.5 m from the axis closest to the calculated point of the lane.

The values of LAeq are determined by the formula

$$L_{Aeкв} = 44 + 0{,}26V + 10\,lg\left(\frac{N_3}{V_3}\right) + \Delta L_1 + \Delta L_2, \quad (2)$$

where V — the average speed of traffic flow on the race, km/h.

$$V = \frac{V_1N_1+V_2N_2+V_3N_3+V_4N_4}{N_1+N_2+N_3+N_4}, \quad (3)$$

where V_1, N_1 — respectively, the speed and intensity of passenger cars and their modifications for the carriage of goods, as well as trucks with a maximum permissible weight of up to 3.5 tons, incl. (cars); V_2, N_2 — respectively the speed and intensity of trucks and buses with a maximum permissible weight of up to 5 tons inclusive, units/hour. (trucks); V_3, N_3 — respectively the speed and intensity of movement of trucks and buses with a permissible maximum weight of 5 tons to 12 tons inclusive, as well as trolleybuses, units/hour. (medium trucks); V_4, N_4 — respectively the speed and intensity of movement of trucks and buses with a permissible maximum weight of more than 12 tons, units/hour (heavy

trucks); N_C — reduced (by sound energy) intensity of movement in units/hour;

$$Nc = N_1 + 4N_2 + 6N_3 + 8N_4, \quad (4)$$

V_C — reduced (relative to the speed of cars) average speed of traffic flow on the race, km/h.;

$$V_c = V_1 + 1{,}14V_2 + 1{,}18V_3 + 1{,}22V_4, \quad (5)$$

ΔL_1 — amendment to the DBA, which takes into account the type of pavement of the street or road;
ΔL_2 — amendment to the DBA, taking into account the longitudinal slope of the street or road.

The values of LAeq and LAmax are determined according to the number of lanes of the carriageway in both directions.

When located between lanes in different directions of dividing lanes, boulevards and pedestrian alleys, the noise characteristic of the flows of motor vehicles LAeq and LAmax must be determined separately for each direction.

Full-scale measurements and acoustic calculation of the noise characteristic of the flow of road transport should be carried out for the daytime, based on the average hourly traffic intensity Nz during the four-hour period with the highest traffic intensity [6, 7]. It is allowed to take the consolidated traffic intensity during the day, equal to 7 % of the average daily traffic intensity. At night Nc is taken for the noisiest hourly period.

This technique allows to determine the sound level at a distance of 7.5 m from the transport flow with the smallest error (standard deviation 1—2 dBA). In the calculations, the average flow speed was taken as 50 km / h, the correction for the road surface $\Delta L_1 = 0$ dBA for asphalt.

The results of calculations of the noise characteristics of the traffic flow at different research sites were calculated by formula (2) and are given in tabl. 3.

Table 3. Noise characteristics of traffic flow in different areas

Road section	Traffic intensity, bus / hour	Percentage of trucks, %	Correction ΔL_1, dBA	Correction ΔL_2, dBA	Equivalent noise level LAeq, dBA
Hrushevsky street	640	44,8	0	1	65,00
Anoshkin Avenue (section near the Metallurgical College)	506	23,3	0	0	68,43
Jubilee Avenue	989	11,5	0	0	64,85
Anoshkin Avenue (exit from the bridge)	545	28,9	0	1	66,12

As shown by the estimated data given in table 3, the noise characteristic of the transport flow LAeq is 65—68 dBA at a distance of 7.5 m from the axis of the transport lane closest to the calculated point. In comparison with the regulatory requirements, on the sections of the research roads the permissible level is exceeded by 1—2 dBA, which is created by trucks, the percentage of which from the total traffic flow is 14—21 %.

Conclusions

The method of determination of noise pollution from urban traffic flows is presented and the ways to reduce or eliminate the data of harmful factors are offered.

Noise levels are expected to be reduced through the use of screens, territorial gaps, noise protection structures, zoning and zoning of sources and objects of protection, and protective landscaping strips. Acoustic noise protection equipment is divided into sound insulation, sound absorption and silencers.

Some progress in noise reduction can be achieved with the appropriate tread pattern configuration and tire design. Important from the point of view of noise limitation is the structure of the asphalt pavement itself, which reduces noise, and noise absorption is achieved mainly due to the high porosity of such asphalt — 26 % is the volume of cavities (in conventional coatings it is about 6 %).

References

[1] Denisov V.N., Rogalev V.A. (2005). Problemi ekologizacií avtomobil'nogo transportu *[Problems of greening of road transport]*. Prosvit. [in Ukrainian]
[2] Zaporozhets O.I., Matvieiev O.L., Shamanskyi S.I. (2017). *Transportna ekolohiia : Navchalnyi posibnyk [Transport ecology: A textbook]*. Tsentr uchbovoi literatury. [in Ukrainian]
[3] Tokar A.P., Tokar K.A., Mytnyk Y.F. (2006). *Ekolohiia avtotransportnykh zasobiv z dyzelnymy dvyhunamy [Ecology of vehicles with diesel engines]*. Liha-Pres. [in Ukrainian]
[4] Vasylev A.V. (2004). Vozdeistvye shuma transportnykh potokov na selytebnuiu terytoriiu sovremennoho horoda [The impact of traffic noise on the residential area of a modern city]. *Tekhnohennaia y эkolohycheskaia bezopasnost.* Vol. 3 (15). 59–61. [in Ukrainian]
[5] Lezhneva O.I. (2017). Ekolohichna otsinka transportnoho shumu na vulychno-dorozhnii merezhi mista [Ecological assessment of traffic noise on the city road network]. *Visnyk KhNADU*. Vol. 77. 87–94. [in Ukrainian]
[6] Sheikina O.Iu. (2007). Akustychne zabrudnennia selitebnoho seredovyshcha mista vid transportnykh potokiv [Acoustic pollution of the residential environment of the city from traffic flows]. *Visnyk KDPU imeni Ostrohradskoho*. Vol. 5(46). 144–147. [in Ukrainian]
[7] Vnukova N.V. (2011). Otsinka akustychnoho zabrudnennia prydorozhnoi terytorii avtomobilnoi dorohy [Assessment of acoustic pollution of the roadside area of the highway]. *Vostochno-Evropeiskyi zhurnal peredovykh tekhnolohyi*. Vol. 4/6 (52). 42–47. [in Ukrainian]

ДОСЛІДЖЕННЯ ШУМОВОГО ЗАБРУДНЕННЯ АВТОТРАНСПОРТНИМИ ЗАСОБАМИ ПРИМАГІСТРАЛЬНИХ ТЕРИТОРІЙ м. КАМ'ЯНСЬКОГО

Шматко Д.З., Сасов О.О., Авер'янов В.С., Великодний Є.І.

Реферат

Транспортний шум є основним акустичним забруднювачем практично всіх сучасних міст, а його внесок у загальну частку шуму в житлових зонах складає 60—80 %. На примагістральних територіях значний транспортний шум в середньому спостерігається 18—20 годин на добу, іноді цілодобово. Встановлено, що зона впливу автомобільної дороги залежно від інтенсивності дорожнього руху, метеорологічних та топографічних умов місцевості поширюється на відстань до трьох кілометрів від кромки проїзної частини. Для проведення дослідження шумового забруднення примагістральних територій міста Кам'янське були попередньо проведено натурні спостереження за інтенсивністю руху та типом автотранспортних засобів і визначено відсоткова частина кожного з них. Спостереження за інтенсивністю руху проводились на найбільш завантажених транспортним потоком вулицях і у години доби коли цей транспортний потік найбільш інтенсивний.

Для досліджень шумових характеристик використовувався переносний шумомір ВШВ-003-М2. В результаті проведених досліджень були отримані шумові характеристики транспортних потоків, які складаються з еквівалентного і максимального рівнів звуку в децибелах. Були запропоновані заходи по зменшенню шумового забруднення примагістральних територій м. Кам'янське.

У загальному випадку методи зниження транспортного шуму були запропоновані по наступних трьом напрямам: зменшення шуму в джерелі його виникнення, включаючи вилучення з експлуатації транспортних засобів і зміну маршрутів їх руху; зниження шуму на шляху його розповсюдження за допомогою застосування шумопоглинаючої здатності рослин, а також шляхом використання екранів територіальних розривів, шумозахисних конструкцій, зонування і районування джерел і об'єктів захисту, захисних смуг озеленення; застосування засобів звукового захисту при сприйнятті звуку, а саме будови самого дорожнього покриття асфальту, що знижує шум, причому поглинання шуму досягається головним чином завдяки високій пористості такого асфальту — 26 % складає обсяг порожнин (у звичайних покриттях він становить близько 6 %).

Список використаної літератури

1. Денісов В.Н., Рогальов В.А. Проблеми екологізації автомобільного транспорту. Київ: “Просвіт”, 2005. 311 с.
2. Запорожець О.І., Матвєєв О.Л., Шаманський С.Й. Транспортна екологія : Навчальний посібник. Київ : “Центр учбової літератури”, 2017. 508 с.
3. Токарь А.П., Токарь К.А., Митник Я.Ф. Екологія автотранспортних засобів з дизельними двигунами. Львів : Ліга-Прес, 2006. 172 с.
4. Васильев А.В. Воздействие шума транспортних потоков на селитебную территорію современного города. *Техногенная и экологическая безопасность*. 2004. № 3 (15). С. 59–61.
5. Лежнева О.І. Екологічна оцінка транспортного шуму на вулично-дорожній мережі міста. *Вісник ХНАДУ*. Харків. 2017. Вип. 77. С. 87–94.
6. Шейкіна О.Ю. Акустичне забруднення селітебного середовища міста від транспортних потоків. *Вісник КДПУ імені Остроградського*. 2007. Вип. 5(46). С. 144–147.
7. Внукова Н.В. Оцінка акустичного забруднення придорожньої території автомобільної дороги. *Восточно-Европейский журнал передовых технологий*. Харків. 2011. № 4/6 (52). С. 42–47.