Asesorías y Tutorías para la Investigación Científica en la Educación Puig-Salabarría S.C.
José María Pino Suárez 400-2 esq a Lerdo de Tejada. Toluca, Estado de México. 7223898475
RFC: ATI120618V12

Revista Dilemas Contemporáneos: Educación, Política y Valores.
http://www.dilemascontemporaneoseducacionpoliticayvalores.com/

Año: VI Número: Edición Especial Artículo no.:96 Período: Diciembre 2018.

TÍTULO: Influencia de la contaminación acústica del transporte motorizado en el estado del medio ambiente de las zonas urbanas.

AUTORES:

1. Irina V. Makarova.
2. Vadim G. Mavrin.
3. Kirill A. Magdin.

RESUMEN: El crecimiento de la población urbana fue tan rápido que el medio ambiente de muchas ciudades del mundo ya no puede satisfacer muchas de las necesidades biológicas y sociales de las personas. El artículo está dedicado al análisis de la contaminación acústica de los flujos de tráfico. Se observó que el ruido proveniente de los flujos de tránsito es el mayor peligro para la salud humana, ya que el transporte motorizado. Para analizar el estado del medio ambiente, se realizaron estudios de campo de una gran ciudad. Como resultado de las mediciones, se descubrió que el nivel de sonido supera el máximo aceptable en cualquier valor medido de la intensidad del flujo y la distancia desde la carretera.

PALABRAS CLAVES: seguridad ambiental, impacto ambiental, tráfico rodado, contaminación acústica.

TITLE: Influence of noise pollution of motor transport on the state of the environment of urban areas.

AUTHORS:

1. Irina V. Makarova.
2. Vadim G. Mavrin.
3. Kirill A. Magdin.

ABSTRACT: The growth of the urban population was so rapid that the environment of many cities in the world can no longer satisfy many of the biological and social needs of people. The article is devoted to the analysis of noise pollution of traffic flows. It was observed that noise from traffic flows is the greatest danger to human health, since motorized transport. To analyze the state of the environment, field studies of a large city were conducted. As a result of the measurements, it was found that the sound level exceeds the acceptable maximum at any measured value of the intensity of the flow and the distance from the road.

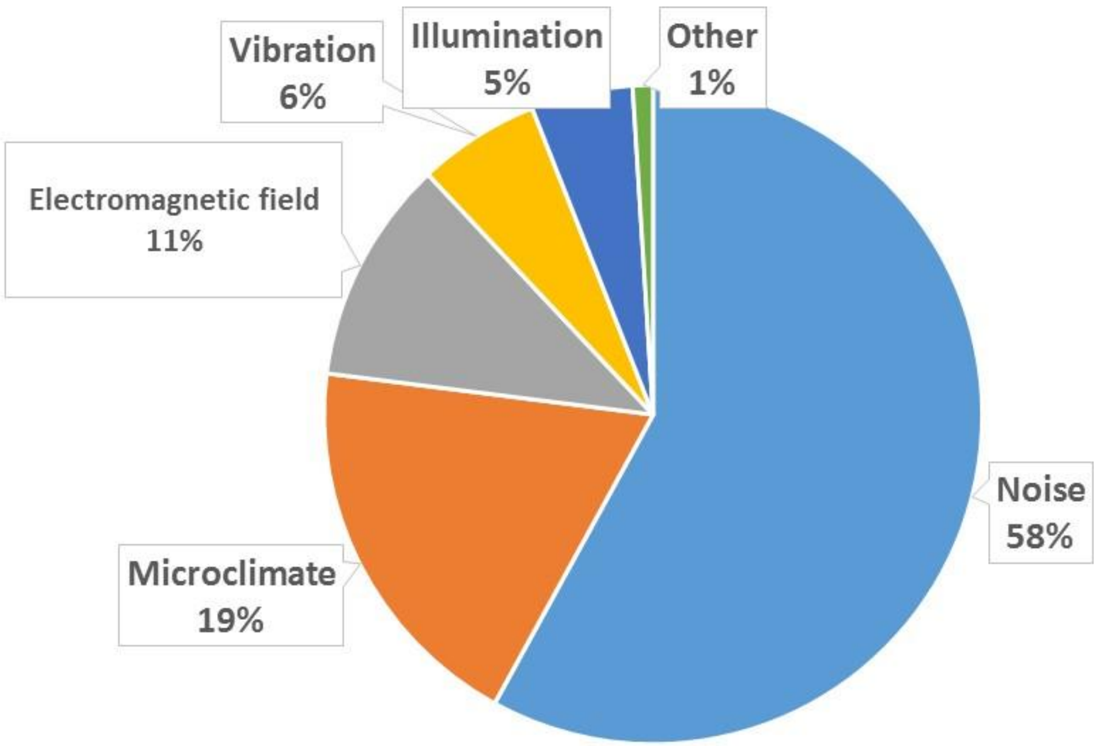
KEY WORDS: environmental safety, environmental impact, road traffic, noise pollution.

INTRODUCTION.

It is known that road transport is a source of significant negative impact on the environment and human health. It is believed that the main damage to the environment from vehicles occurs as a result of emissions of exhaust gases. So, according to the state report on the state and environmental protection of the Russian Federation, motor vehicles are major contributors to urban air pollution. And their share in air pollution increases every year (Gosudarstvennyi doklad, 2017).

At the same time, to such an ecological aspect of motor transport as noise it is not given enough attention, although its impact on the human body has not been fully studied. Meanwhile, the largest area of noise pollution in urban areas (up to 80%) is due to the impact of road traffic. So, in Russia the complaints structure for noise has the largest specific weight (Fig. 1).

Fig. 1. Structure of public complaints according to Ministry of Natural Resources and Environment of the Russian Federation.



Negative Noise Impact.

Noise is a sound fluctuation in the range of audible frequencies that can have a harmful effect on human safety and health. According to the World Health Organization, noise is the second most important environmental problem for human health after the quality of atmospheric air.

When a noise level on average of a year of 40 dB or more is applied to a person, negative health effects such as sleep disturbance and awakening are possible. With long-term average exposure to noise levels above 55 dB, blood pressure rises, the central nervous system is depressed, the rate of respiration and pulse changes, metabolism is altered, cardiovascular diseases, stomach ulcers, hypertension, diabetes, and psychiatric disorders are possible (Health implication of road, railway and aircraft noise in the European Union,2014; Stansfeld, S.A; Shipley, M., 2015).

Noise pollution disrupts cognitive functions, reduces the level of relaxation, leads to hormonal disorders, releases stress hormones such as cortisol, which affects metabolism (Murphy, E., Douglas, O., 2018). The danger of noise exposure is exacerbated by the property of the human body to accumulate acoustic irritation. The most vulnerable group for the negative impact of noise are children. In addition to the above, children are prone to attention reduction, deterioration of memory and sleep (Weyde, K.V; Krog, N.H; Oftedal, B. et al., 2017).

According to studies, the noise from traffic flows is the greatest danger to human health, since it is a source of constant linear noise in the immediate vicinity of human habitats. It is established that people react more sharply to lower levels of traffic noise while locating inside than on sidewalks and roadside. Significant changes on the part of the hearing organ, the central nervous system, the visual analyzer were detected at a noise level of 40-50 dBA. It is noted that the proportion of nighttime with increasing levels of noise, when people are most sensitive to noise, grows particularly intensively. In the European Union, social losses of the negative impact of noise from vehicles on the human body are estimated at € 40 billion (Pignier, N., 2015).

In addition, noise from traffic flows is seen in workplaces, especially when windows are open, which has a negative effect on labor productivity (Schlittmeier, S.J; Feil, A; Liebl, A; Hellbrück, J., 2015). Thus, the US economy annually loses $ 3.9 billion because of the decline in labor productivity caused by the negative impact of noise from vehicles (Swinburn, T.K; Hammer, M.S; Neitzel, R.L., 2015).

In places with a high noise level, a high concentration of pollutants in the lower layers of the atmospheric air is noted. Thus, a direct relationship between the values of the equivalent noise level from motor traffic flows and the concentrations of the smallest particles in the atmospheric air has been found (Shu, S; Yang, P; Zhu, Y., 2014).

Field surveys and analysis of data.

Naberezhnye Chelny city is the center of one of the leading agglomerations, forming together with the cities of Nizhnekamsk and Elabuga, the Kama innovative territorial-production cluster.

The geographical position and developed transport and production infrastructure of Naberezhnye Chelny make it the center of gravity of material, and, accordingly, transport flows. This makes Naberezhnye Chelny a powerful transport hub not only of regional but also of international importance. Therefore, it is extremely high indicators of the contribution of vehicles to noise pollution of the city's environment.

To measure the noise characteristics of the traffic flow, as well as to assess the influence of traffic parameters on the noise level, field surveys of problem areas of the road network are needed, since this is the most effective method for analyzing the situation on the roads. At the same time specific conditions and traffic indicators are fixed on the selected sections of the road network within a given period of time. This group of methods is currently the most common and is very diverse. Field surveys, being the only way to obtain reliable information about the state of roads, allow to give exact characteristics of existing transport and pedestrian flows (Makarova, I; Khabibullin, R; Mavrin, V; Belyaev, E., 2016).

To obtain more accurate data on noise pollution, measurements should be made at different times of the day and different days of the week at the most unfavorable sections of the road network in terms of flow parameters. To obtain the most reliable measurement results, the study of the state of the transport system should be carried out twice a year (winter and summer periods), as well as when making any changes to the configuration of the road network or the public transportation network.

According to the interstate standard GOST 20444-2014 "Noise. Transport flows. Methods for determining the noise characteristic" when measuring the noise characteristics of the transport flow, it is expedient to simultaneously determine its intensity and speed of motion (GOST 20444-2014, (2014)).

Transport noise is characterized as oscillating, as the level of its sound continuously varies with time. To analyze the characteristics of this type of noise, it is recommended to use the equivalent sound level L_{eq}. Equivalent (in energy) sound level is the value of the sound level of a constant noise source, which within the regulated time interval has the same mean-square deviation value as the considered non-constant noise whose sound level changes with time.

According to the spectral composition, transport noise is low- and medium-frequency and can propagate to considerable distances from the source. Measurement of the equivalent sound level should be carried out by integrating-averaging sound level meters of the 1st or 2nd class corresponding to GOST 17187. For a numerical estimate of noise, the "sound level" indicator is in dB. This is the sound pressure level (referred to all frequency bands), corrected for the curve of frequency correction "A", which characterizes approximately the frequency response of noise perception by the human ear, i.e. his subjective assessment.

Field surveys of the distribution of noise pollution from motor vehicles were carried out in the city of Naberezhnye Chelny on Mira Avenue, one of the busiest sections of the road network (Fig. 2). For these purposes, 1st class sound level meter was used in accordance with Gost 17187-2010, IEC 60651/60804 and IEC 61672-1 - OCTAVA-110A.

Fig. 2. Field surveys.

When measuring the noise characteristics of the transport stream, which may include various types of vehicles, the measuring microphone is located, in accordance with the measurement requirements, on the sidewalk or the roadside at a distance 7.5 ± 0.2 m from the axis nearest to the point measurement of the strip or track of vehicles at an altitude 1.5 ± 0.1 m from the level of the roadway. In the case of the location of a street or road in a notch, the measuring microphone is installed on the edge of the notch at a height 1.5 ± 0.1 m from the ground level. It is taken into account that in conditions of dense location of buildings it is allowed to place the measuring microphone at a distance of <7.5 m from the axis of the near to the measurement point of the road, but not closer than 1 m from the walls of buildings, continuous fences and other structures or relief elements which reflect sound.

When measuring the noise characteristics of an inhomogeneous transport flow, the following requirements were taken into account:

- The measuring microphone should be pointed towards the transport flow
- When using a sound level meter with indicator-arrow to determine the sound levels, the interval between their measurements should be between 2 and 3 seconds.

- Measurement of sound levels should be performed both in the presence and in the absence of moving vehicles.
- The values of the levels should be taken from the indications of the arrow of the sound level meter at the time of measurement.

The results of the survey showed that the measured sound level is much higher than the maximum acceptable value (55 dBA) for any measured values of flow intensity and distance from the road (Table 1 and 2).

Table 1. Results of measurements of noise characteristics at various intensity of motor traffic.

Total number of cars	Of them	Equivalent sound level, dBA.	Measurement conditions.				
	passenger cars	Trucks	Large buses	Minibuses	Others		
75	69	3	1	2		73,00	
80	85	1	1	3		75,00	
93	87	2	2	2		77,50	
98	92	1	2	3		77,70	t^0 = -1 ^{0}C
116	106	1	1	8		78,40	
126	112	0	1	13		78,70	V_{wind} = 1 м/с
131	116	3	3	8	1 tractor	78,80	
135	122	7	2	4		79,20	Duration of measurement = 2 min
138	129	3	2	4		79,40	
151	138	0	2	11		79,70	Traffic flow speed = 60 km / h
151	140	1	4	6		79,70	
156	142	2	1	11		79,80	
164	157	1	1	6		79,90	Distance from the road = 7,5 m
173	162	3	4	4		80,00	
181	170	3	5	3		80,10	
189	185	1	1	2		80,20	
200	190	3	2	5		80,30	

Table 2. Results of measurements of noise characteristics at a various distance from the road.

Distance from the road, m	Equivalent sound level, dBA	Maximum sound level, dBA	Minimum sound level, dBA	Measurement conditions
0	79,9	83,1	78,4	t^0 = -1 ^{0}C
2	78,5	78,8	73,1	
5	77,2	78,3	73,0	V_{wind} = 1 м/с
8	74,2	74,4	71,7	
10	72,0	74,2	71,5	Duration of measurement = 2 min
15	68,8	70,6	68,3	Traffic flow speed = 60 km / h
20	67,8	68,2	67,5	
25	66,1	66,6	65,3	Distance from the road = 7,5 m

The results of the correlation analysis have shown that only the total number of vehicles influences the equivalent sound level at current traffic flow parameters (high traffic intensity with a significant predominance of passenger cars in its structure), while the influence of their individual groups (trucks, buses and minibuses and others) is insignificant, that is consistent with other studies (Brinka, M; Schäffer, B; Pieren, R; Wunderli, J.M. (2018)) (Table 3).

Table 3. Dependence of the equivalent sound level on the number and structure of the transport flow.

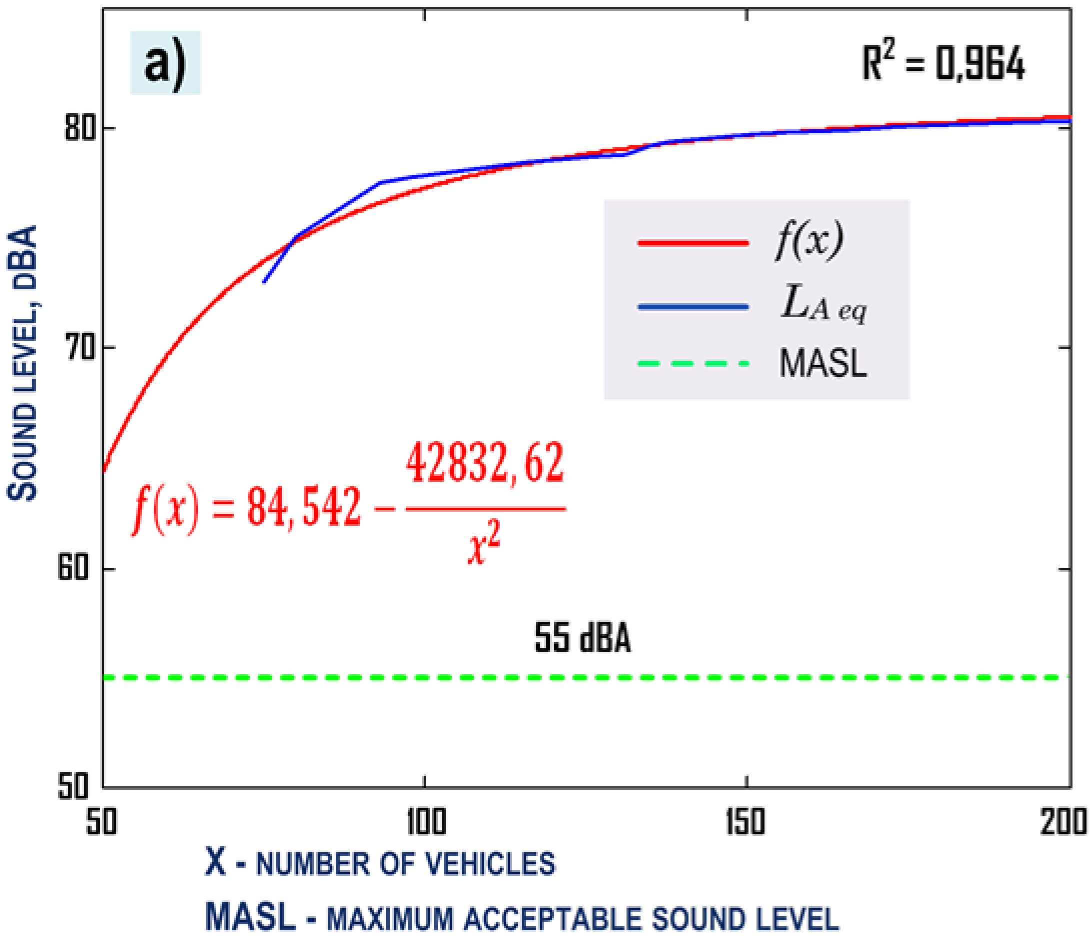
Factors	Number of vehicles					
	Total	passenger cars	Trucks	Large buses	Minibuses	Others
Dependence of the equivalent sound level on factors (correlation coefficient)	0,869	0,834	0,023	0,375	0,317	0,017

To determine the analytical form of the dependence of the sound level on the intensity of traffic, a regression analysis was performed, as a result of which a regression function was determined (1):

$$f(x) = 84.542 - \frac{42832.62}{x} \quad (1)$$

Where *f(x)* – value of equivalent sound level, *x* – total number of cars passing for 2 minutes. Coefficient of determination R^2=0,964 (Fig. 3), therefore, the obtained function describes the dependence of the equivalent sound level on the number of cars quite accurately.

Fig. 3. Dependence of the sound level on the number of cars, b) from the distance to the noise source.

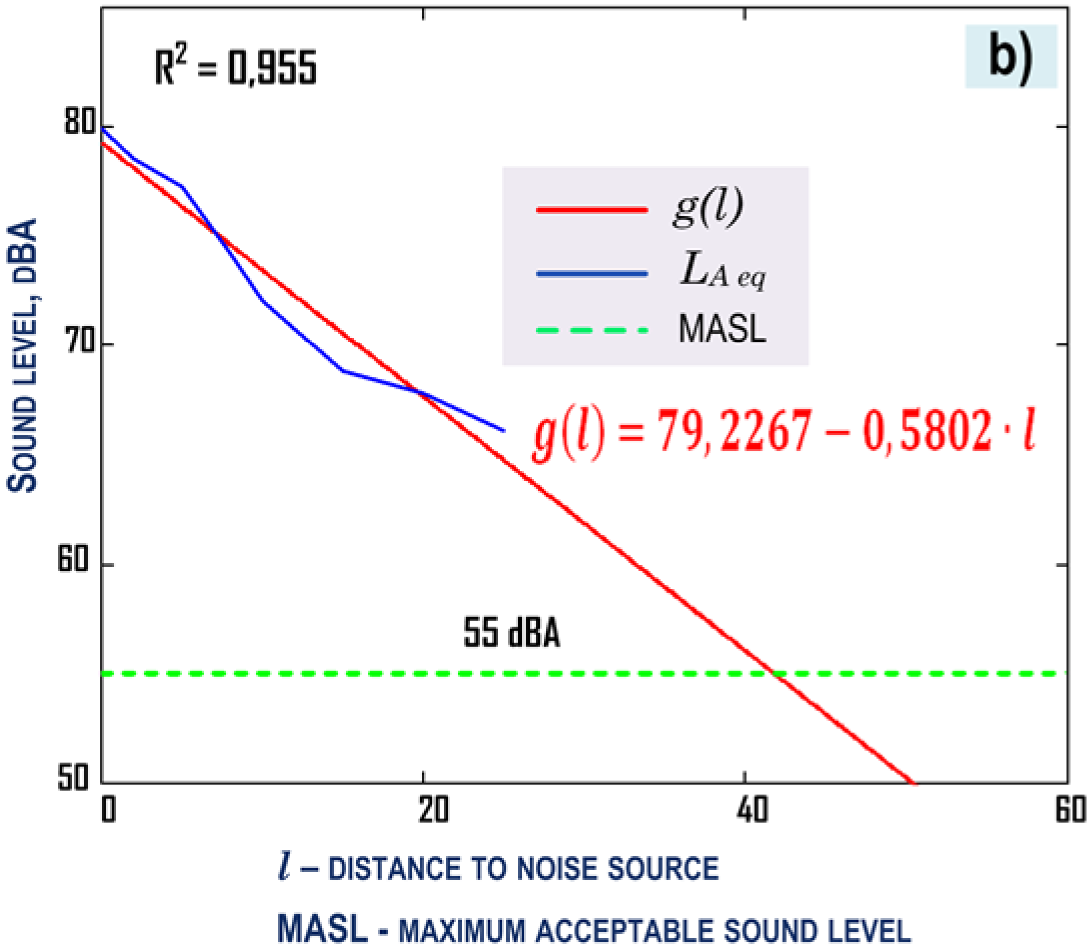


The regression function of the dependence of the equivalent sound level on the distance to the road (source of noise) has the form (2):

$$g(l) = 79.2267 - 0.5802 \cdot l, \quad (2)$$

where *g(l)* – value of equivalent sound level, *l* – distance to noise source. Coefficient of determination R^2=0,955 (Fig. 4). Thus, in the interval from 0 to 41m the sound level exceeds the maximum permissible value, and the location in this interval can have negative consequences on human health.

Fig. 4. Dependence of the sound level on the distance to the source of noise.



Noise Protection Methods.

To protect against external sources of noise in cities use different methods: in the source of noise - engineering and organizational and administrative; along the path of noise propagation - town-planning and construction-acoustic; in the object of noise protection - constructive construction (increasing the sound-insulating qualities of enclosing structures) and planning.

Reducing noise in the city should be facilitated by the expansion of a fleet of low-noise vehicles, such as electric cars and cars with hybrid engines. Considering that a significant share of the traffic flow is passenger vehicles, measures should be taken to encourage the transition to the priority use of public and bicycle transport.

The most effective construction and acoustic means of noise reduction include screens, soundproof buildings and noise-protective windows. Reducing the levels of noise penetrating into the premises from external sources should be ensured by rational layout of premises, observance of measures for sound insulation of enclosing structures, engineering equipment of buildings.

If it is necessary to place residential buildings on the border of microdistricts along transport highways, special noise-insulating buildings should be located. To ensure acoustic comfort on the territory of microdistricts, it is desirable to use compositional methods for grouping residential buildings, based on the creation of a closed space. Noise shields reduce transport noise due to absorption, change in wavelength, reflection, or diffraction.

On the high floors of multi-storey buildings, the positive effect of noise shielding is practically not felt (Wei-Jiang, Zhao; En-Xiao, Liu, Hee Joo, Poh; et al., 2017). Also, buildings and structures with reduced requirements for noise mode can be used as shields. In this case, they should be placed along the noise sources in the form of frontal and continuous building.

In addition, sound is well absorbed by plants. Even coniferous plants can reduce the level of noise emitted by cars by 6-9 dB. Positive results in the fight against noise can be achieved using special landing methods - in several rows. The best indicators show a combination of trees and shrubs (Van Renterghem, T; Forssen, J; Attenborough, K. et al., 2015).

However, according to studies, plants are ineffective in combating low-frequency noise. Therefore, to protect against noise from trucks and large buses, taking into account the predominance of low-frequency engine noise in them, it is necessary to use other measures (Van Renterghem, T; Attenborough, K; Maennel, M. et al. (2014)).

Organizational and administrative measures are aimed at preventing or regulating the operation of certain noise sources. These include the redistribution of traffic flows along the city's highways; restriction of movement at different times of the day in one direction or another; changing the composition of vehicles (for example, prohibiting the use of trucks and buses with diesel engines on some streets of the city), etc. In addition, buses with larger capacity should be used on transport routes, which will reduce traffic density and, accordingly, reduce the level noise.

CONCLUSIONS.

Thus, noise pollution from road transport has a significant negative impact on the environment of urbanized areas and human health. The regression functions found allow us to determine environmentally safe values of the intensity of traffic flows and the distance to the source of noise. However, it is obvious that other factors influence the noise level, so it is necessary to continue research in this direction.

BIBLIOGRAPHIC REFERENCES.

[1] Gosudarstvennyi doklad, (2017) «O sostoianii i ob okhrane okruzhaiushchei sredy Rossiiskoi Federatsii v 2016 godu» (State report "On the state and on the protection of the environment of the Russian Federation in 2016"). Moscow, Ministry of Natural Resources and Environment of the Russian Federation, 746 p.

[2] Health implication of road, railway and aircraft noise in the European Union, (2014) – National Institute for Public Health and the Environment. 59 p.

[3] Stansfeld, S.A., Shipley, M., (2015). Noise sensitivity and future risk of illness and mortality. Science of the Total Environment, 520: 114–119. DOI: 10.1016 / j.scitotenv.2015.03.053.

[4] Murphy, E., Douglas, O., (2018). Population exposure to road traffic noise: Experimental results from varying exposure estimation approaches. Transportation Research Part D 58: 70–79. DOI: 10.1016/j.trd.2017.11.006.

[5] Weyde, K.V., Krog, N.H., Oftedal, B; Magnus, P; Øverland, S; Stansfeld, S; Nieuwenhuijsen, M. J; Vrijheid, M; de Castro, Pascual. M; Aasvang, G. M., (2017). Road traffic noise and children’s inattention. Environmental Health, 16(1):127. DOI 10.1186/s12940-017-0337-y.

[6] Pignier, N., (2015). The impact of traffic noise on economy and environment: a short literature study. KTH Royal Institute Of Technology. 17 p.

[7] Schlittmeier, S.J., Feil, A., Liebl, A., Hellbrück, J. (2015). The impact of road traffic noise on cognitive performance in attention-based tasks depends on noise level even within moderate-level ranges. Noise Health, 17(76): 148–157. doi: 10.4103/1463-1741.155845.

[8] Swinburn, T.K., Hammer, M.S., Neitzel, R.L., (2015). An Economic Assessment of U.S. Environmental Noise as a Cardiovascular Health Hazard. American Journal of Preventive Medicine, 49(3): 345-353.

[9] Shu, S., Yang, P., Zhu, Y. (2014). Correlation of noise levels and particulate matter concentrations near two major freeways in Los Angeles, California. Environmental Pollution, 193: 130-137. DOI: 10.1016 / j.envpol.2014.06.025.

[10] Makarova, I., Khabibullin, R., Mavrin, V., Belyaev, E. (2016). Simulation modeling in improving pedestrians’ safety at non-signalized crosswalks. Transport Problems, 11(4): 139-150.

[11] GOST 20444-2014, (2014) Noise. Transport flows. Methods for determining the noise characteristic: Interstate Standard 20444-2014. (Shum. Transportnye potoki. Metody opredelenija shumovoj harakterictiki: Mezhgosudarstvennyj standart 20444-2014) Interstate Council for Standardization, Metrology and Correspondence Certification. Moscow: Standartinform, 24 p. (in Russian).

[12] Brinka, M., Schäffer, B., Pieren, R., Wunderli, J.M. (2018). Conversion between noise exposure indicators Leq24h, LDay, LEvening, LNight, Ldn and Lden: Principles and practical guidance. International Journal of Hygiene and Environmental Health, 221: 54–63. DOI: 10.1016/j.ijheh.2017.10.003.

[13] Wei-Jiang, Zhao; En-Xiao, Liu, Hee Joo, Poh; Binfang, Wang; Si-Ping, Gao; Ching Eng, Png; Kelvin Wenhui, Li; Shyh Hao, Chong (2017). 3D traffic noise mapping using unstructured surface mesh representation of buildings and roads. Applied Acoustics, 127: 297–304. DOI: 10.1016/j.apacoust.2017.06.025.

[14] Van Renterghem, T; Forssen, J; Attenborough, K; Jean, P; Defrance, J; Hornikx, M; Kang, J. (2015). Using natural means to reduce surface transport noise during propagation outdoors. Applied Acoustics, 92: 86 - 101. DOI: 10.1016 / j.apacoust.2015.01.004.

[15] Van Renterghem, T., Attenborough, K., Maennel, M. et al. Van Renterghem, T; Attenborough, K; Maennel, M; Defrance, J; Horoshenkov, K; Kang, J; Bashir, I; Taherzadeh, S; Altreuther, B; Khan, A; Smyrnova, Y; Yang, H.-S; (2014). Measured light vehicle noise reduction by hedges. Applied Acoustics 78 (2014) 19–27. DOI: 10.1016 / j.apacoust.2013.10.011.

DATA OF THE AUTHORS.

1. Irina V. Makarova. Kazan Federal University. Email: global@ores.su

2. Vadim G. Mavrin. Kazan Federal University. Email: Vadim_mmite@rambler.ru

3. Kirill A. Magdin. Kazan Federal University. Email: info@ores.su

RECIBIDO: 3 de noviembre del 2018. **APROBADO**: 17 de noviembre del 2018.