

Geoecological assessment of acoustic pollution in the city of Shelekhov (Irkutsk agglomeration)

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Abstract. The work carried out a geoecological assessment of the acoustic pollution of the city of Shelekhov, based on the zoning of the territory according to the noise level. Field surveys were carried out and the number of vehicles registered on the city's road network was calculated. With the help of sound level meters, instrumental measurements were made in the daytime and at night, and the daily course of the distribution of the noise level on the main and secondary roads was plotted. In order to identify the propagation range of noise generated by motor vehicles, the sound pressure levels in the city were calculated for daytime and nighttime using the Ecologist Noise program. The results obtained were compared with the established sanitary standards. The result of acoustic monitoring was the creation of maps of the sound pressure level of the territory. Based on noise pollution maps, a set of measures is proposed to prevent and reduce noise impact on the urban environment.

1 Introduction

Shelekhov is an industrial and transport city of the Irkutsk agglomeration, through which the federal highway R-258 "Baikal" (Irkutsk - Ulan-Ude - Chita) passes, and therefore vehicles here are a round-the-clock source of noise pollution. In the traffic flow of Shelekhov there is a large number of transit trucks and buses. The city has a well-developed public transport system, which mainly operates fixed-route taxis. The Trans-Siberian Railway passes through the city of Shelekhov, there are two railway stations. As part of the development of the Irkutsk agglomeration and the Big Irkutsk program, it is planned to connect Shelekhov, Irkutsk and Angarsk with high-speed tram lines [1].

One of the main causes of acoustic pollution in the city of Shelekhov is the increase in the number of noise sources. In addition, the studies made it possible to establish that noise is an environmental risk factor that has a complex negative impact on public health in an urban environment [2, 3]. There is a problem of ensuring the acoustic safety of urban areas, including in the city of Shelekhov. risk factor that has a complex negative impact on public health in an urban environment. There is a problem of ensuring the acoustic safety of urban areas, including in the city of Shelekhov.

2 Materials and methods of research

In order to identify the noise load in the city of Shelekhov in the period 2016-2020, field observations of the composition and traffic intensity of vehicles during the day and night were carried out, as well as instrumental measurements of the sound pressure level were carried out using the "Testo 816" sound level meters. Noise level measurements were carried out according to the procedure [4]. Based on the results of the studies, a database of noise characteristics of the road network was formed and registered [5].

In order to identify the propagation range of noise generated by its main sources - motor vehicles, calculations were made of the sound pressure level in the city of Shelekhov for daytime and nighttime using the Ecologist Noise program (Integral company) [6]. The calculations were carried out taking into account obstacles and attenuation zones: the influence of foliage (parks, squares, green stripes), industrial facilities, and the height of buildings. The results of field surveys of the road network were used as input information for the Ecologist Noise program. To perform work on the creation of sound pressure level maps, the QGIS program was used. The layers of the OpenStreetMap mapping project acted as source spatial data. Noise level measurement data recorded at points, the coordinates of which were captured using the Garmin Dakota 20 GPS navigator, were used in the program. The result of the calculations was the zoning of the territory of the city of Shelekhov according to the level of acoustic pollution.

3 Results

As a result of the research, it was found that vehicles of all categories are recorded in almost the same number both in the morning and evening rush hours and in the daytime. In terms of traffic intensity, the sections of the central part of the city and the R-258 "Baikal" highway are the most loaded, the suburbs of the city turned out to be the least loaded. The results of the measurements of the noise level are presented in Table 1.

Table 1. Results of noise level measurements on sections of the road network in Shelekhov.

Noise level, dBA	Road section with fixed noise level
(80-85] – daytime (75-80] – night time	entrance to the city (Route R-258 «Baikal»), st. Cablemen – Highway R-258 «Baikal»
(75-80] – daytime (70-75] – night time	Central Avenue – Route R-258 «Baikal», Metallurgists Avenue – Avenue of Builders and Installers – Route R-258 «Baikal», st. Mira – st. Vokzalnaya – Highway R-258 «Baikal», st. Izvestkovaya – Highway R-258 «Baikal»
(70-75] – daytime (65-70] – night time	st. Ring - Central Avenue, st. Beloborodova – Central Avenue - Creators Boulevard, st. Industrial – st. Kabelshchikov, Metallurgov Avenue – st. Industrialnaya, Prospekt Builders and Installers – st. Industrialnaya, Prospekt Builders and Installers – Vostochny passage, st. Vokzalnaya – Station microdistrict (Goncharovo), st. Alexander Nevsky – st. Mira, 6 th quarter, st. Alexander Nevsky – st. Lenina, st. Orlovsky Komsomol – st. Sibiryakova, st. Lenin – st. Leonid Kulik, st. Ostrovsky – Highway R-258 «Baikal», exit from the city in the direction of Irkutsk (Kultuksky tract)

[65-70] – daytime [60-65] – night time	st. Ring – Boulevard of the Creators, st. Kabelshchikov – st. Energetikov, st. Energetikov – Central Avenue, st. South – railway, st. Labor – st. Lime, st. Ivan Kochubey – st. Oleg Koshevoy, st. Oleg Koshevoy – st. Kotovsky, st. Lenin – st. Panzhina, st. Lenin – st. Leonid Kulik, st. Leonid Kulik – st. Mira, st. Irkutnaya – st. Olkhinskaya – st. Kotovsky
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Note: (80-85] is the range of noise level values, where the round bracket denotes the interval boundary, if the interval does not include this boundary itself (> or <), and the square bracket denotes the interval boundary, which itself is included in this interval (>= or <=).

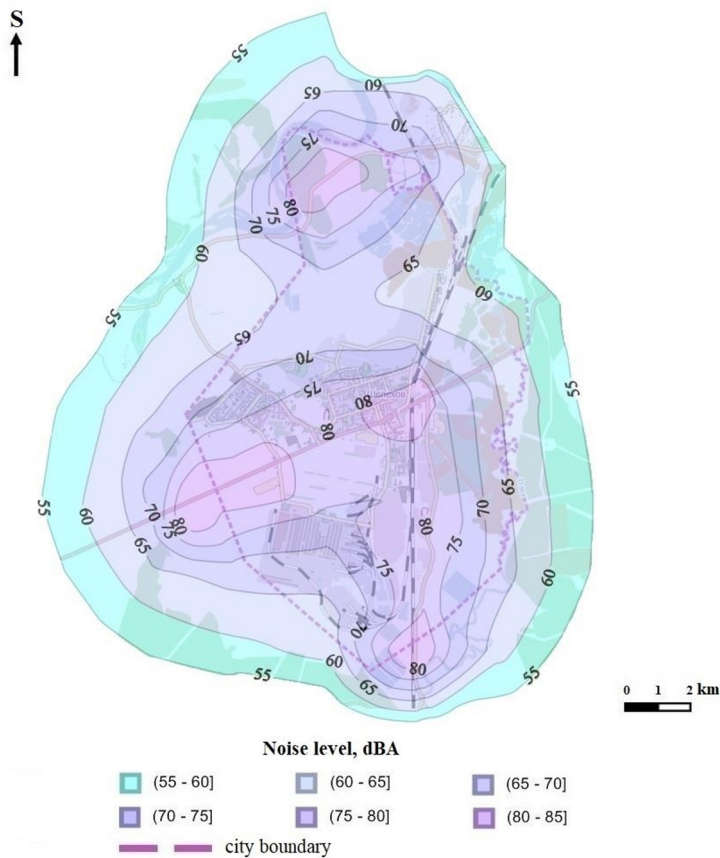


Fig. 1. Map of the noise level of the road network in Shelekhov (daytime)



Fig. 2. Noise level map of the road network in Shelekhov (night time)

Figures 3-4 show graphs of the daily distribution of the noise level on the main and secondary highways of the city of Shelekhov.

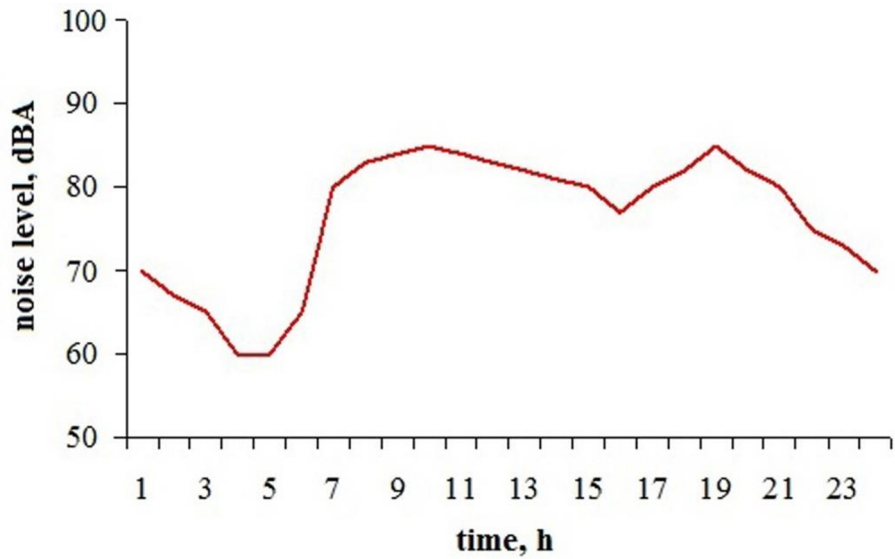


Fig. 3. Daily distribution of noise level on the main highways of Shelekhov

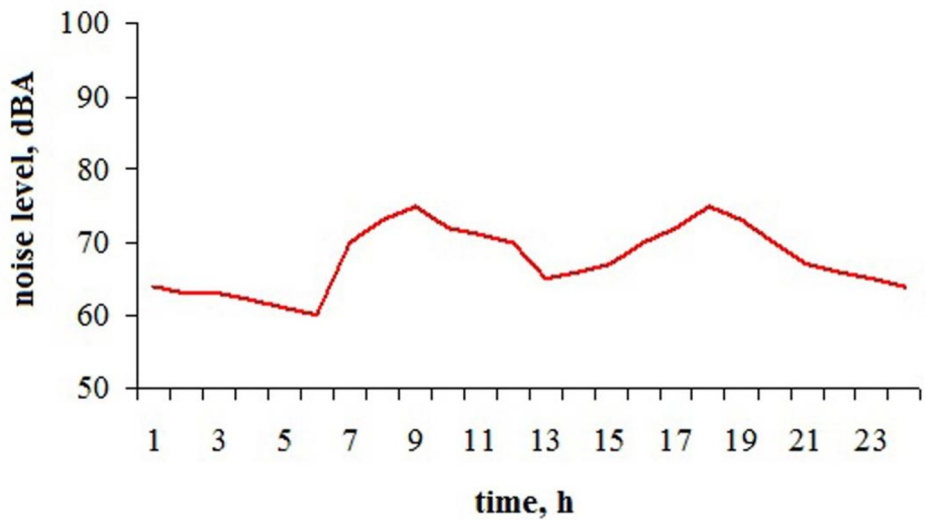


Fig. 4. Daily distribution of noise level on secondary roads of Shelekhov

4 Discussion

During the daytime in Shelekhov, the maximum noise level is created, which varies in the interval (80-85] dBA, the minimum - in the interval (65-70] dBA (see Table 1). The highest noise level recorded in the city at night varies in the interval (75-80] dBA, the lowest - in the interval [60-65] dBA (see Table 1). Such noise levels are recorded on the same road sections, which correspond to noise levels that change in the intervals (80-85] and [65-70] dBA, according to daytime measurements. According to the results of calculations carried out in the Ecolog Noise program, taking into account obstacles and attenuation zones, the maximum noise level of 80 dBA is created in Shelekhov in the daytime at the sites roads

and adjacent areas of residential development: Moskovsky tract - exit from Shelekhov in the direction of Angarsk, Route R-258 "Baikal" (Kultuisky tract) in the direction of Irkutsk, Izvestkovaya street, Kultuisky tract - Builders and Montazhnikov Avenue - Vokzalnaya street - Ivan Kochubey street - Izvestkovaya street (central part of the city). The average noise level to which residents of Shelekhov are exposed is 70 dBA (see Fig. 1).

At night, the maximum noise level of 75 dBA is created on the territory of Shelekhov. The average noise level to which Shelekhov residents are exposed is 65 dBA (see Fig. 2). The territory of the city is located in a zone of increased noise discomfort, both during the day and at night. An analysis of noise maps built in the Ecologist Noise program makes it possible to identify some features of the distribution of noise: its excess impact can spread over longer distances than other harmful factors (emissions of pollutants, etc.). This is due both to the high levels of noise generated by many sources in cities, and to specific sound attenuation conditions (only 3-5 dBA at twice the distance for traffic flows).

To compare the obtained results, Table 2 shows the maximum values of the detected noise level from traffic in residential areas of some countries of the European Union (EU) at night [7]. The noise level generated in the cities of the Irkutsk agglomeration as a result of the movement of vehicles at night exceeds the maximum noise levels in the EU member states, exceeding even the sound pressure values noted in France (see Table 2).

Table 2. The maximum values of the noise level recorded during the movement of vehicles in residential areas of the EU countries at night [7].

State	Sound pressure level, dBA
Netherlands	40
Latvia	40
Spain	45
Estonia	45
Finland	46
Germany	49
Austria	50
Switzerland	50
Sweden	51
Hungary	55
France	62

Thus, in the daytime on the territory of the city of Shelekhov, a maximum noise level of 80-85 dBA is created, at night - 70-75 dBA, which significantly exceeds the established sanitary standards [8]. The average noise level that Shelekhov residents are exposed to is 65 dBA. The territory of the city is located in a zone of increased noise discomfort, both during the day and at night. The standard set for the daytime was exceeded by 1.5 times, for the night time - 1.7 times [8].

In the daily distribution of the noise level on the main roads of the city, two maxima are distinguished: morning and evening, corresponding to the largest number of vehicles recorded on the roads during field video surveillance. On secondary roads (the least loaded), the maxima are not pronounced. So, in Shelekhov, on the main roads (the busiest), the sound pressure maxima equal to 85 dBA were noted at 10.00 and 19.00 h, on the secondary roads - at 9.00 and 18.00 h (75 dBA).

5 Conclusion

Carrying out important functions to ensure the life of urban residents, including intracity and intercity passenger and cargo transportation, vehicles in the city of Shelekhov are a constant source of noise pollution that exceeds the values of established sanitary standards.

In order to reduce excess noise and preserve acoustically safe areas of the city of Shelekhov, it is necessary to develop and implement an action plan that includes a set of architectural, planning and logistics solutions.

5.1 Architectural and planning solutions:

- taking into account the geomorphological features of the territory and the use of positive landforms as a natural screen or, on the contrary, laying new tracks in low relief areas (adjusting the longitudinal and transverse profiles of streets: leveling the longitudinal profile of the street allows you not to change the speed of the car along its entire length due to tracing using existing landforms);
- organization of territorial "gaps" between the residential area (with strict noise regulation) and motor roads - the main sources of external noise during the construction of new and reconstruction of old development areas;
- placement of residential buildings not along highways, but at an angle (taking into account the requirements of illumination and wind conditions on the territory of the city);
- planning "blind" facades near houses facing a highway with heavy traffic or placing non-residential premises on these sides with temporary stay of people in them;
- ring placement of buildings during construction with restriction of entry into the courtyard space;
- redevelopment of educational institutions, including preschool ones, located in zones of acoustic pollution, especially when walking areas in kindergartens are located almost on the sides of streets with heavy traffic (for example, Energetikov St., Kabelshchikov St., Timofey Panzhin St.);
- landscaping of areas adjacent to the carriageway and between oncoming traffic lanes should be carried out taking into account the optimal environmental protection function, climatic features of the territories, species composition and type of tree and shrub vegetation [9].

5.2 Logistic solutions

- modernization and expansion of the main infrastructure - redirection of transit flows outside the settlement; for example, in Shelekhov it is necessary to build a bypass road, which will allow transit transport to move around the city, and, consequently, reduce the load on intracity roads; the results of field surveys allow us to conclude that the transfer of roads from residential buildings and offices will reduce the noise level by an average of 8 dBA;
- redistribution of intracity flows, taking into account the species composition (a ban on the movement of freight transport on certain streets); on some roads there is already a ban on the entry of heavy vehicles at certain hours, but this is not enough;
- updating the public car park and increasing the level of comfort in using urban passenger transport.

Thus, the construction of bypass roads to pass part of the traffic flow, including transit, as well as bringing the parameters of the road network in line with traffic intensity is one of the important areas for the development of the transport hub of the city of Shelekhov and the Irkutsk agglomeration as a whole.

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