Assessment of noise pollution at municipal economy objects in Pyatigorsk

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Abstract: People living in modern cities are always exposed to the influence of various factors of technology-induced or anthropogenic character. The investigations which have been carried out by the present time show that the resort cities of the Caucasian Mineral Waters (CMW) region are no exception. Nowadays, a particular attention is paid to the ecosystem of the existing urban development, where the resort cities of the CMW region are worth an increased focus on. A resort city with its attractive natural-and-resource parameters faces inherent problems of ecological character one of which is the noise pollution of the environment. For a city with non-industrial functional orientation, the main source of this pollution is its transport infrastructure. The development of the resort city of Pyatigorsk which started in the XIXth century did not provide for high traffic loads as well as for the source intensity typical of a modern city, therefore, today it is necessary to carry out an analysis of the noise loads and in the case of necessity to organize the work, aimed at restoring the favorable conditions in the resort city.

1. Introduction

In terms of the territory, the lands of the three constituent entities of the Russian Federation are included into the agglomeration region of the Caucasian Mineral Waters (CMW) with the area of more than 500 thousand hectares: the Stavropol Territory accounts for 58% of its area; the Republic of Kabardino-Balkaria – for 9%; and Republic of Karachay-Cherkessia – for 33%.

The cities of the Stavropol Territory occupying the largest part of the CMW region and forming its modern resort-and-recreation basis are of the highest interest for the comprehensive study in order to increase the level of the development of the touristic cluster which includes the recognized resort cities: Kislovodsk, Zheleznovodsk, Essentuki and Pyatigorsk.

Pyatigorsk holds a unique position among the resort cities of the Caucasian Mineral Waters group, since it is the oldest balneological and mud-cure resort of all-Russia importance. In addition to its achievements in the resort-and-recreation sphere, Pyatigorsk is the second largest city of the Stavropol Territory in terms of the population, and a commercial, industrial, scientific and cultural center of the CMW region. Nowadays, Pyatigorsk is the administrative center of the North-Caucasus Federal District (NCFD).

The environmental compatibility parameter is one of the most demanded at the present time in the contest of ensuring the comfort and improvements to inhabited localities. Despite all their
environmental attractiveness, the resort cities of the CMW region face ecological problems which require a special attention [1-13]. The pollution of the urban environment should be considered as an entire combination of factors exerting a negative influence on the human physiological or mental condition to a certain extent [14-18]. When analyzing the existing ecological situation in the CMW region, it is necessary to pay a special attention to Pyatigorsk since in addition to its role in the resort sphere the city performs various functions being the administrative center of the NCFD.

All types of the negative influence factors are inherent in the resort city of Pyatigorsk to this or that degree. The present article considers the issue of the noise impact of transport infrastructure on the ecological well-being of Pyatigorsk. The relevance of such investigations is rather high since trams, automobile vehicles and railway transport on suburban and long-distance routes run in the territory of the city. It should be noted that with the development and growth of the infrastructure, the increase in the noise loads is unavoidable due to the enhanced number of noise-generating sources, their enlarged intensity and power.

Noise pollution is typical for the majority of modern cities independently of their specialization and functional orientation. Due to the absence of large industrial objects, the main source of noise pollution for the resort cities of the CMW region is the transport infrastructure. In particular, for the largest resort city of Pyatigorsk, the problem of ecosystem disbalancing through acoustic vibrations is rather topical since automobile vehicles and railway transport as well as trams run in the territory of the city. The noise is a combination of sounds of various frequencies and intensity which differ in their spectral and time structures. The acoustic vibrations in the form of noise cause discomfort and negatively influence on human health, depending on the intensity and duration of the impact. A long-term and intensive noise impact leads to disorders in sound-sensing apparatus and results in changes in the central nervous system, the functional organization of the structures and systems of brains, it also negatively affects cardiovascular system, and exerts an integrated influence on human health and mental condition. Noise can cause nervous exhaustion, vegetative neurosis, psychological depression, endocrine system disorders, in addition it influences labour efficiency. In the course of medical investigations, the influence of various levels of noise on human organisms has been revealed.

Discomfort is caused by the noise of 50 dBA, and the higher values are of a threatening hazardous character for organisms. In order to prevent and reduce the negative influence of noise, the sanitary-and-hygienic standardization provides for the values of permissible levels (PL) of noise loads. The permissible levels differ depending on the locality of noise distribution. The normative technical documentation (The Code 51.13330.2011 Noise Control sets the following territorial values of noise level within the city borders (table 1).

| Intended purpose of the district of development, territory | Permissible levels of sound, dBA |
|----------------------------------------------------------|---------------------------------|
|                                                          | from 7 a.m. to 11 p.m. | from 11 p.m. to 7 a.m. |
| Resort and health-improvement districts (zones) | 40 | 30 |
| Territories of hospitals and health restoring centers (beyond the resort districts) | 45 | 35 |
| Territories and zones of mass recreation (beyond the resort districts) | 50 | – |
| New urban residential district under design | 55 | 45 |
| Residential district under reconstruction, residential district with the existing development | 60 | 50 |
| Industrial districts or zones, which include residential development | 65 | 55 |
This work presents the investigations carried out in Pyatigorsk and aimed at studying the noise loads which are formed in the district at the border of the resort zone and partially located in the territory of the industrial zone of the city, with a part of those occupied by residential development, educational institutions, buildings of administrative and public purposes. The sources of noise generation are divided into two groups [19-20]:

Industry and manufacturing. The given group includes the noise generated as a result of operation of machinery, manual power tools, electrical machines, generators, electric engines, lifting-and-transferring and auxiliary equipment.

Urban environment. This group combines noise sources located inside and outside buildings. Inside buildings, the noise is produced by the technical and technological equipment, sanitary lighting, working household appliances and music devices. Outside buildings, the noise sources can be mobile or stationary.

According to the investigations carried out, there is no stationary industrial manufacturing in the given territories, which could be a source of increased noise pollution. The main source of noise in these territories is their transport infrastructure. The selection of the functional zones of the territories under investigation is determined by the noise-generating sources and the data on the sanitary standardization of urban noise intensity.

In order to determine the noise load serving as the characteristic of permanent noise, as well as to examine the efficiency of the measures aimed at restricting its negative influence, the levels of sound pressure are adopted in decibels in octave band centre frequencies of 63; 125; 250; 1000; 2000; 4000 and 8000 Hz and the sound level is in dBA [1].

The results of the investigation in the industrial zone showed that the most loaded sections are located in Ermolov Street and Palmiro Togliatti Street.

Concerning the border of the resort zone, the most loaded section here is framed by Universitetskaya Street, Oktyabrskaya Street and Kalinin Avenue.

The graphical data of the equivalent and maximum levels of sound in the octave bands in Ermolov Street and Palmiro Togliatti Street are presented in figure 1.

![Figure 1. The data of the measurements of sound levels in octave bands.](image)

The graphical data on the equivalent and maximum levels of sound in octave bands at the section framed by Universitetskaya Street, Oktyabrskaya Street and Kalinin Avenue are given in figure 2.
Figure 2. The data of the measurements of sound levels.

Table 2 presents some results of the noise level investigation for these territories of Pyatigorsk in order to check their compliance with the PL. The investigations were carried out in the period from 7 a.m. to 11 p.m.

Table 2. The values of noise characteristics for various territories of Pyatigorsk.

| Territory name                                      | Territory description                                                                 | Sources of noise pollution              | Average levels of sound, dBA | Value of exceedance of PL, dBA |
|-----------------------------------------------------|----------------------------------------------------------------------------------------|-----------------------------------------|-----------------------------|--------------------------------|
| Industrial zone (Ermolov Street and Palmiro Togliatti Street) | the development is represented by commercial, warehouse and office facilities          | automobile and railway transport        | 75,1                        | 10,1                           |
| Border of the resort zone (Universitetskaya Street, Oktyabrskaya Street and Kalinin Avenue) | the existing residential development, cultural and social amenities for public         | automobile transport, trams             | 74,6                        | 14,6                           |
| Centre (Kalinin Avenue)                             | bus terminal, the existing residential development, cultural and social amenities for public | automobile transport                    | 69                          | 9                              |

It can be seen from table 2 that the noise pollution in the urban territories exceeding the permissible levels is observed at all the presented sections of Pyatigorsk. The average value of exceedance amounts to 11,23 dBA. Thus, the following conclusions can be drawn:
Despite all the environmental attractiveness, the CMW region faces ecological problems requiring a considerable attention. The noise pollution of the territories of resort cities belongs to these problems.

The main source of the noise pollution in the resort cities of the CMW region is the transport infrastructure, in particular for Pyatigorsk being the capital city of the NCFD it is automobile and railway transport and trams.

According to the performed investigations presented in this paper, the exceedance of the permissible levels of the noise characteristics in the city of Pyatigorsk is from 35,6 % to 36,5 % for the territories of urban development under investigation. It should be noted that, concerning the resort territories in which stricter requirements are applied to the ecological state, such level of noise pollution causes discomfort to the local residents and holidayers.

It is necessary to organize the same investigations for all the resort cities of the CMW region in order to determine the noise impact both on the local residents and the guests of the resorts.

In the authors’ opinion, for a higher quality analysis of the ecological condition of the noise characteristics in the resort cities, it is reasonable to organize a monitoring of the noise loads on a permanent basis, in the course of which it will be necessary to select the most “polluted territories” as well as the territories belonging to the resort infrastructure.

Based on the obtained results of the noise pollution, it is necessary to develop and implement measures of technical and organizational character which will be most suitable for the resort cities of the CMW region and will contribute to the protection of the territories and people against the negative impact of the noise loads.

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