Assessment of the Additive Impact of Transport Flows on the Acoustic Environment of Residential Areas

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Abstract: Based on the analysis of measurements of noise levels generated by railway, tram and motor traffic flows, an assessment and development of methods for reducing the noise additive effect of traffic flows on residential area is given.

1 INTRODUCTION

1.1 Relevance of the Research Topic

Due to the urbanization of the area and the simultaneous increase in traffic in the urban infrastructure, more and more people are feeling the negative effects of noise of varying intensity.

Noise, whose influence on people continues to increase in conditions of dense development, is considered to be particularly significant of the physical factors affecting the human environment. The share of noise measurements in residential buildings that do not comply with sanitary standards in 2019 was 13.4% (in 2018 – 19.8%, in 2017 – 19.2%, in 2016 – 16.6%). The main source of noise in populated areas is still traffic. (Federal Service for Supervision of Consumer Rights Protection and Human Well-Being. 2020)

In 2019, 28 thousand complaints were recorded about the negative impact of physical factors, of which 3.8% accounted for the Sverdlovsk region. The share of the acoustic factor continues to be overwhelming from year to year – Figure 1. (Federal Service for Supervision of Consumer Rights Protection and Human Well-Being. 2020)

Over the past five years, the increased noise load in the structure of complaints of the population has increased by more than 8% (Sherstyuchenko, 2015). In the largest cities, up to 60% of residents are under the influence of acoustic discomfort, since noise protection measures in the conditions of the current development are quite expensive and technically complex (Bershadsky, 2012).

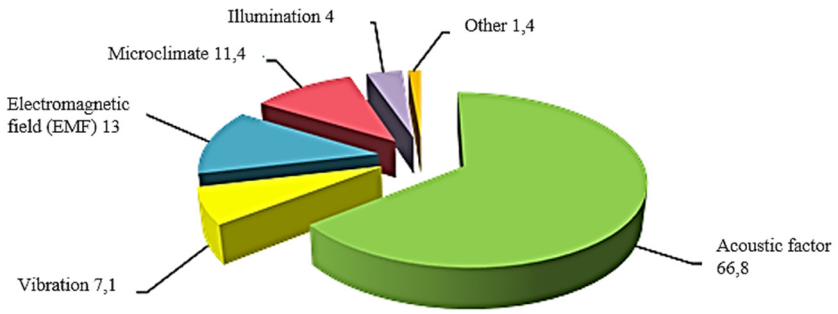

Figure 1: Structure of complaints of the population related to the influence of physical factors in 2019, %.

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Living along urban highways entails an increase in the overall incidence (Vasiliev, 2004). New data show that every year in Europe, at least 1 million years of a healthy lifestyle are lost due to noise coming from just one street traffic (World Health Organization, 2014).

According to AUTOSTAT (Autostat, https://www.autostat.ru) Yekaterinburg occupies one of the leading places in Russia in terms of car availability for 2019. On average, there are 315 cars per one thousand inhabitants, which entails an increase in traffic intensity, traffic density and, as a result, an increase in acoustic pollution of the city. Even with the level of motorization of 300 units, the equivalent sound level calculated for one of the microdistricts of Yekaterinburg (Zarechny) is more than 70 dB, which significantly exceeds the standard value (Sherstyuchenko, 2015).

The highest noise levels are determined on urban highways in the area of their intersections, which affects the formation of the acoustic environment of the nearby area, especially in conditions of dense development.

The general acoustic background of the city is formed not only by road transport and trams, but also by railway tracks, often passing directly through the city, without observing the necessary boundaries of sanitary protection zones. This is clearly illustrated by measurements carried out along Cherepanova Street (Zarechny microdistrict) (Lachimova, 2014; Lachimova, 2013), where noise from railway and automobile transport was taken into account.

Despite a fairly large number of studies conducted on the problem of assessing and reducing noise pollution in cities, we can say that most of them considered one type of transport: motor transport, rail, aviation or others. Little attention has been paid to the study of additive effects from different modes of transport, so it is quite relevant.

The purpose of the study is to evaluate and develop methods for reducing the noise additive effect of traffic flows on residential territory. To achieve this goal, it was necessary to solve the following tasks:

1. Near the Pervomayskaya station in Yekaterinburg, measure the noise levels generated by railway, tram and motor traffic.
2. Assess the additive effects of all traffic flows.
3. Develop recommendations to reduce the level of noise pollution of the urban environment.

The object of the study is traffic flows moving in the conditions of the existing infrastructure of the city.

The subject of the study is the additive noise effect from all traffic flows.

Scientific novelty:

1. An assessment of the impact of traffic noise on the residential area was carried out.
2. The dependences of the noise level change on the distance from the source are obtained.
3. Noise level studies have been carried out depending on the type of traffic noise.
4. An assessment of the additive effect of transport noise has been carried out.

The theoretical and practical significance of the work lies in the fact that on the basis of noise load measurements, the values of noise levels in the area of Pervomayskaya station were obtained, measures were also developed to reduce the transport noise load on the residential territory.

The reliability and validity of the results obtained is ensured by the theoretical validity, the logic of the study, the use of fundamental works on the study of noise load in residential areas.

2 MATERIALS AND METHODS

The research methods were based on the assessment of the noise load of the existing traffic flows in the residential area.

The study uses materials presented in scientific publications on the problem of the negative impact of the acoustic environment from the traffic flow on residential areas. The following sources served as research materials:

- scientific developments of scientists presented in books and articles;
- the author's own experience in the development of load assessment of acoustic systems;
- empirical methods;
- theoretical methods.

Own observations: measurements of the noise level in the urban environment (63 measurements).

Used materials and research methods:

- A satellite image of the city was used to compile a map of the road and street network that characterizes the degree of noise load on the population living or located near the Lenin-Vostochnaya transport hub.
- Comparison of experimental indicators of noise levels with the maximum permissible values at workplaces and in residential areas was carried out in accordance with SanPiN 1.2.3685-21 "Hygienic standards and

requirements for ensuring safety and (or) harmlessness of environmental factors for humans".

3 RESEARCH METHODS

Measurements of the noise generated by traffic flows on city streets were carried out according to GOST 20444-2014 "Noise. Traffic flows. Methods for determining the noise characteristic".

The noise characteristic of traffic flows is the equivalent sound level, dBA.

Measurements of sound characteristics were made in accordance with the basic requirements prescribed by regulatory documents for the definition of traffic noise: the microphone was located in a cramped building environment no closer than 1 m from the walls of buildings, solid fences, as well as other buildings or relief components that reflect the sound.

4 RESULTS AND DISCUSSION

Studies were conducted on the propagation of traffic noise at the Pervomayskaya railway station in Yekaterinburg. The noise measuring instrument was a Class 1 noise meter and an Octave-101A spectrum analyzer. It is intended for field and laboratory professional measurements of sound and infrasound, mainly for sanitary and epidemiological studies, occupational safety and conformity assessment. It has a single measurement mode. Measurements of all sound pressure parameters, both in the audible and infrasound ranges, are carried out simultaneously.

Field observations of noise levels were carried out in dry, windless weather on a weekday. In the morning – in the interval from 8 to 9 o'clock, at lunch – from 12 to 13 o'clock, in the evening – from 17 to 18 o'clock.

The acoustic situation on the roads and streets in different parts of the city of Yekaterinburg varies. It is obvious that the Lenin-Vostochnaya transport hub is experiencing a lot of noise pressure. After all, it combines several sources of traffic noise:

- passenger vehicles,
- trams,
- railway transport,
- cargo vehicles,
- public transport (the Vostochnaya bus station is located nearby).

It was necessary to obtain acoustic characteristics and evaluate them in accordance with sanitary standards.

Automobile, railway and tram tracks run in close proximity to residential buildings, therefore, residents of nearby buildings are exposed to the greatest negative noise impact.

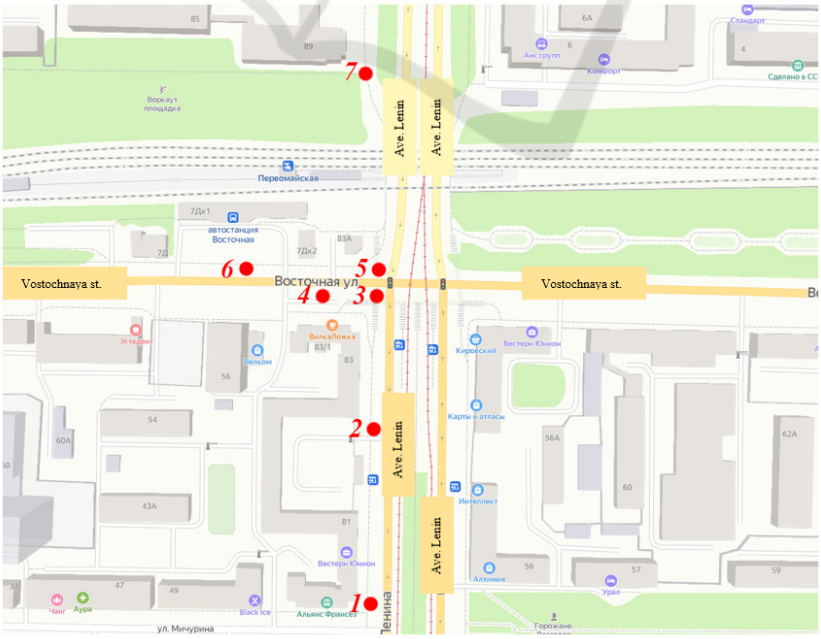


Figure 4: Map of measurement points.

The noise level for residential areas according to SanPiN 1.2.3685-21 in the daytime is 55 dBA. The normalized noise parameters in our case can be taken 10 dBA higher.

Enclosing structures of railway tracks are mostly absent in the area of Pervomayskaya station. Green spaces are a natural barrier. Green spaces also act as a natural barrier between the motorway and residential buildings at the Lenin-Vostochnaya intersection. Therefore, in our studies, 55 dBA is taken as the hygienic noise standard.

For noise measurements, 7 points were selected in the area of Pervomayskaya station – Figure 4.

Since measurements of equivalent noise levels at the same points were carried out repeatedly, ranges of average values of these characteristics were taken. The total number of observation stations is 7. The total number of measurements performed is 63.

The highest equivalent noise levels are noted in the morning and evening at points 5 and 6. The excess of the remote control at these points is 15.5-21.9 dBA.

The quietest place was the territory near the Polytechnic College. The highest maximum sound level was recorded at point 5 in the evening – 82.5 dB.

As we can see from the measurement results, the highest noise levels are observed at points 3, 5, 6 throughout the day. At points 3 and 5, this is due to the proximity of three types of transport highways at once – railway, tram and motor transport. In addition, there are no noise-proof structures and a sanitary gap zone at these points. Point 6 is located in the immediate vicinity of the Vostochnaya bus station, which is also not separated from residential development.

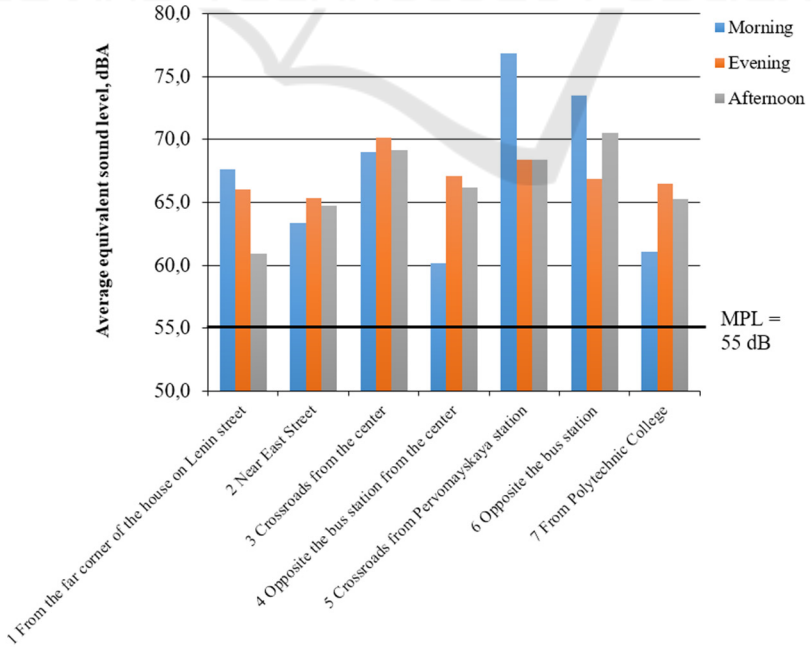
According to the results of the study, moving away from the transport hub, the noise load levels decrease proportionally – points 1, 2, 7. Houses 83 and 81 on Lenin Street (points 1 and 2) are separated from tram tracks and highways by green spaces, which reduces the noise load on the residents of these houses. The Polytechnic College (point 7) is also separated from the railway track and the highway by green spaces.

If we consider the dependence of noise levels on the time of day, we will not see an unambiguous pattern, but we can notice that peak values occur in the morning and evening hours, corresponding to the greatest traffic congestion in the city.

High levels of noise pollution in the considered transport hub of the city of Yekaterinburg appear due to several factors.

Firstly, the absence of noise barriers along the transport highway along Vostochnaya Street.

Secondly, a large number of freight vehicles moving along Vostochnaya Street, which at the same time overcome the transverse tram tracks



Graph 1: Average equivalent sound level depending on the measurement station and time of day.

passing along Lenin Street.

Thirdly, the noise from the brake pads of trains stopping at Pervomayskaya station and from freight trains in transit.

Fourth, the noise from the movement of trams. On some sections of the trackbed, trams provoke much more noise than on others.

Fifth, the noise from public vehicles at the Vostochnaya bus station. Many buses create a high noise load due to their already long service life.

5 CONCLUSIONS

According to the results of the conducted research, we get that in the area of the Lenin-Vostochnaya transport hub, the noise load on the population exceeds the standards throughout the day. With regular exposure to noise above 55 dB, a person has an increased risk of chronic disorders of physiological functions, which can subsequently lead to diseases. The prolonged effect of increased noise levels on the human body can lead to an increase in blood pressure or disruption of the cardiovascular system. Elderly people and children are at risk.

High noise levels in the area of Pervomayskaya station are due to a number of reasons:

1. Partial absence of noise screens along railway tracks;
2. High intensity of traffic flow in the area of the transport hub:
   - tram line along Lenin Street;
   - railway tracks on the second level along Vostochnaya Street;
   - the movement of passenger vehicles along Lenin and Vostochnaya streets;
   - the movement of freight transport on Vostochnaya Street;
   - movement of public vehicles along Lenin and Vostochnaya streets;
   - increased public transport traffic near the Vostochnaya bus station.
3. A small number of green spaces for noise screening at the Lenin-Vostochnaya intersection.

The practical results obtained during the study can be used in the organization of environmental monitoring of noise load in the city of Yekaterinburg.

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