Efficiency of Reducing Noise Pollution by Using the Greening System of Buildings

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Abstract. Noise pollution in the cities is a major factor jeopardizing health as well as human living environments. However, previous research mainly focused on the reducing noise from different human activities, especially in the construction. We consider the problem more comprehensively and study the various possible sources of noise and the possibilities for their reduction or disposal in general. This article presents the methods of reducing noise pollution by using the greening system of buildings. The purpose of the work is to analyse the main sources of noise pollution of buildings and their mitigation methods. We propose the innovative modular green roof systems in the environmental development of green buildings. Efficiency of reducing noise pollution by using the greening system is verified by a case study on a residential building project.

1. Introduction

Friedrich Engels said that life in continuous noise negatively affects health, but they only listened to it in the forties of the XX century when cities became sources of noise from automobile and railway transport and from the construction of the metro. Now many construction companies are trying to create acoustic comfort in buildings, taking into account the specifics of the location and based on the geographical structure [1-7].

So, norms of city noise according to EU standards is 55-75 decibels, while the most productive work and study is at 35-40 dB and sleep peacefully with a maximum of 30 dB. In Russia, the normal noise level, in accordance with the requirements of SP 51.13330.2011 [4], is considered to be no more than 55 dB during the day, which is comparable to a normal conversation or the operation of a washing machine, and 45 dB at night - the rustling of leaves in a gentle wind and whisper. But in practice, many have to put up with much louder noises.

According to the data of the World Health Organization for the European Union for 2018, approximately 40% of the population of Europe are exposed to excessive noise from traffic, of which 20% are above 65 decibels during the day, more than 30% are above 55 dB at night. The report of the Environmental Protection Agency on the impact of the environment on human health says that noise affects the condition of the people of Paris, Rome and London less than those who live in other European capitals. The global ratings of the noisiest cities include New York, Calcutta, Karachi, Moscow, Tokyo and others. For example, in Moscow, the main sources of noise are: highways, airports, ground sections
of the metro, electric trains and trains, thermal power plants, places where construction work is underway in construction (up to 80%).

Noise pollution studies have been carried out for a long time. It has long been known that excessive noise exposure can lead not only to headaches, but even to serious mental disorders. One of the most famous studies of noise pollution and its impact on the human psyche was carried out as far back as 1974 in New York in one of the schools that turned its east side to the subway. When the train passed, the class noise level increased from 60 decibels to 90 decibels, the teacher had to speak loudly than the train noise for 30 seconds every 5 minutes. Researchers compared the test results and reading skills of students studying in classes with the eastern noisy side and the western quiet side: on average, students who studied on the eastern side of the school building were 4 months behind the peers in terms of development.

2. Materials and methods
All methods for measuring noise are divided into standard and non-standard. Standard measurements are regulated by the relevant standards and provided by standardized measuring instruments. Non-standard methods are used in scientific research and in solving special problems. Measurement and assessment of noise pollution is traditionally carried out using instruments - sound level meters. All measuring instruments must be certified. The most effective is the express method. It consists in determining the most dangerous zones in terms of noise load and the number of people in them. The method is carried out using calculation and graphical schemes. In accordance with the readings of noise measurements, reproduce subsequent environmental protection.

Traditional architectural and planning methods of noise urban protection include:
- rational acoustic solutions for building plans and master plans for facilities;
- logical placement of technological equipment, machines and mechanisms;
- rational placement of working zones;
- efficient acoustic planning of zones and traffic patterns of vehicles and traffic flows;
- creation of noise-protected zones in various locations of human activities.

Organizational and technical methods of noise urban protection include:
- application of low-noise technological processes (change in production technology, a method of processing and transporting material, etc.);
- equipping noisy cars with remote control and automatic control;
- the use of low-noise machines, changing the structural elements of machines;
- improving the technology of repair and maintenance of machines.

Diagram on figure 1 summarizes estimated marginal urban highway noise costs for various vehicles.

![Estimated urban highways noise costs](image)

**Figure 1.** Diagram of estimated urban highways noise costs.
At present, noise screens are used to reduce noise, and active noise canceling devices based on the addition of sound waves are also used. The use of active blanking systems for protecting a person from exposure to intense acoustic fields is a more efficient solution. The use of this system reduces the noise load in high traffic areas and construction sites, thereby favorably affecting the health of the urban population. Also to reduce noise in residential houses and public buildings, during construction use soundproof materials.

New construction technologies, which forming the green spaces of a qualitatively new urban environment with the installation of greening systems on the walls and roofs of the buildings, are gaining popularity around the world [2,8,9]. We aimed to develop the methods to reducing air pollution and noise using harmonized installation of greening systems on the buildings (figure 2). Greening system refers to those noise protection measures whose effectiveness is most evident in large-scale design. Green spaces help to reduce the intensity of noise in those cases when they rise to their full depth with a sufficient width above the beam of the sound stream connecting the source and receiver of sound by at least 2-3 m.

![Figure 2. Implementation of the green wall technologies in the buildings.](image)

The assessment of noise is based on receiver point levels at 4 m above in front of building facades of residential buildings, this methodology is based on the German requirements of VBEB: Segments of a length of more than 5 m are split up into regular intervals of the longest possible length, but less than or equal to 5 m. Receiver points are placed in the middle of each regular interval (blue / green) (figure 3) [15].

![Figure 3. The assessment of noise of building facades of residential building with greening systems.](image)
These green wall technologies are improving noise quality and air quality environment [16-18]. The thing is the structure of wall panels: wave-like structural elements reliably absorb sound waves, preventing them from spreading. That is why such structures have a higher sound absorption coefficient than conventional walls. Our tests confirm that wall panels with a greening system with a thickness of only 27 mm, using a Texound 50 membrane and sealing tape, show an air noise insulation index of 57 dB, which corresponds to the standard sound insulation level for walls and partitions according to SP 51.13330.2011 "Protection against noise". We also based on studies and calculations of integral indicators of energy-saving measures at the stage of a feasibility study for the construction and reconstruction of real estate objects [19-22].

The ranges of measured levels (L) of noise exposure should be within \( L_D = 60 - 64 \) (dB), \( L_N = 55 - 59 \) (dB), for different measured points we got different values of the noise level, but in general they all comply with regulatory limits: \( L_D (1) = 63 \) (dB), \( L_N (1) = 58 \) (dB), \( L_D (2) = 64 \) (dB), \( L_N (2) = 59 \) (dB), \( L_D (3) = 63 \) (dB), \( L_N (3) = 58 \) (dB), \( L_D (4) = 63 \) (dB), \( L_N (4) = 57 \) (dB), \( L_D (15) = 63 \) (dB), \( L_N (15) = 56 \) (dB).

Decrease in sound level in dBA by green walls should be taken from the calculation of where the noise comes from and what is its source [23,10-12]. When planting strips of green space, the plants should be firmly adjacent to the panels and fill the space under them to the surface of the earth.

3. Results and discussions

The decrease in sound level by the green screen in dBA is determined depending on the difference in the length of the paths of the sound beam \( \delta \) in m at the accepted screen height.

The difference in the path lengths of the sound beam \( \delta \) in m should be determined by the formula:

\[
\Delta = (a + b) - s,
\]

where:
- \( a \) is the shortest distance between the geometric center of the noise source and the screen height of the screen in m, 15m,
- \( b \) is the shortest distance between the screen height and the upper point of the screen in m, 20m;
- \( c \) is the shortest distance between the geometric center of the noise source and the design point in m, 30m.

Decrease in sound level by the green screen \( \Delta L_{gs} \) (in dBA) should be determined from the value in dBA and angles (\( \alpha_1 \) and \( \alpha_2 \)) and at the accepted screen length. The amount of sound reduction by the green screen \( \Delta L_{gs} \) (in dBA) should be determined by the formula:

\[
\Delta L_{gs} = \Delta L_{gsa} + \Delta L
\]

where:
- \( \Delta L_{gsa} \) - the smaller of the values \( \Delta L_{gsa1} \) and \( \Delta L_{gsa2} \), in dBA,
- \( \Delta L \) - correction in dBA, determined depending on the difference in the values of \( \Delta L_{gsa1} \) and \( \Delta L_{gsa2} \).

In this case, the screen length should be taken twice as long as the noise source.

With the height of the protective green screen 10m and a length of 50m = 23 dBA.

4. Conclusions

Green wall panels of urban spaces should be provided from varieties of fast-growing plants that are resistant to air conditions in cities and other settlements and grow in the corresponding climatic zone. We had considered the methods of reducing noise pollution by using the greening system of the buildings and main sources of noise pollution in urban space were analyzed. We propose the innovative modular green wall systems in the environmental development of green buildings. Efficiency of reducing noise pollution by using the greening system is verified by a case study on a residential building project. This result is achieved by using of the device green screen. Decrease in sound level in dBA by green walls was taken from the calculation of where the noise comes from and what is its source. Also, as a protection against the effects of noise, people can use the system of green roof. Vegetable eco-tires are very popular, and there are several serious reasons for this.
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