

Approaches to acoustical planning of towns (Russian experience)

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Summary

Noise impact in towns may cause significant discomfort and health damage of population. That is why it is necessary taking into account noise factor during environmental planning of towns. Noise sources of urban territories are considered on the example of towns of Russia. Methods of acoustical planning and assessment in town conditions are discussed. Peculiarities of noise assessment and control in low emissions zones are described. It is pointed out that in many Russian towns the living areas are situated close to transport highways and to industrial enterprises. Results of noise measurements in the territory of towns of Samara Region of Russia are presented. It was shown that there are exists the zones of urban territories with increased noise levels. Peculiarities of cities environmental planning taking to account transport noise impact are considered on the example of Togliatti city of Russia. Approaches to acoustical planning of existing and new districts of towns of Samara region to provide the required sanitary norms of noise impact are suggested, including architect solutions, sanitary-protective zones provision, different kinds of noise barriers installation, restriction measures of high traffic movement near to the hospitals, schools etc.

PACS no. 43.50.Sr

1. Introduction

Presently in towns conditions there are many ecological problems. Among of them are air, water and soil chemical pollutions, energy consumption growth, rapid growth of domestic and industrial wastes etc. Environmental pollutions are causing significant negative influence to the man's health and to environment. Therefore during towns planning it is necessary to take into consideration ecological issues.

The problem of acoustical pollution of towns is coming more important every year. Approximately half of inhabitants of towns are presently affected by increased noise levels. And the town's noise level is trend to be increased. Noise level in large cities is growing every year approximately up to 0,5 dBA. Increased noise impact may cause significant discomfort for inhabitants and health damage. Damaging influence of intensive noise to the human's health is not restricted only by impact to ears. It is known, that noise is affecting to the human's central and vegetative nervous systems, influencing to the human's psychological condition etc. That is why it is especially important take into account noise factor during environmental planning of towns.

This paper is devoted to the questions of acoustical planning of towns on the example of Samara Region of Russia.

2. Analysis of noise sources of urban territories

Noise sources of urban territories may be subdivided into two main groups: separate noise sources and complex noise sources. As separate single vehicles, exhaust systems of ventilation, single mounts of industrial enterprises etc. may be considered. Complex sources are transport flows, industrial enterprises, stadiums etc.

As the main noise sources of urban territories the following sources may be pointed out:

- noise from separate automobiles, motorcycles;
- noise of automobile transport flows;
- noise of railway transport;
- noise of aviation;
- noise of trams;
- noise of open lines of subways;
- noise from industrial enterprises and transformer substations;
- noise from different kinds of building works;
- noise inside of residential settlements (waste-transportation machines, sport games etc.).

The degree of impact of different noise sources to inhabitants depends on the number of factors: mutual dislocation of noise sources and living area, intensity and kind of moving transport flows etc.

For example, in Hong Kong living areas are located near to airport and aviation noise here is very significant. In many towns impact of railway noise is also significant.

In big towns of Russia automobile transport is considered as the main noise source creating 60-80% of total acoustical pollution impacting to the town's population and giving up to 90% from all population complaints to negative noise influence. Transport noise level is increasing together with the cities growth. When the scale of city transport flows is bigger, acoustic discomfort zones are considerably increased. Transport number in towns is increasing with every month. Therefore the problem of transport noise reduction in towns is so important.

Samara region is one of the leading industrial regions of Russia. The biggest towns of Samara region are Samara (the capital of region), Togliatti (automobile capital of Russia), Syzran and Zhigulyovsk.

As typical industrial towns Samara, Togliatti and Syzran have as a number of large industrial enterprises as considerable automobile transport park, making significant acoustic impact to abutting dwelling territory. Samara also has railway transport, trams and metro; Syzran - railway transport. The problem of noise impact in these towns is intensified by the fact that some industrial enterprises and highways are closely adjoining to cities dwelling areas. As result significant part of cities population is affected by increased noise level [1-3, 9]. The peculiarity of Zhigulyovsk town is that it is situated near to the Zhigulyovsky reserve and Russian national park Samarskaya Luka. In a meantime Zhigulevsk has transport roads with intensive traffic and some industrial noise sources.

Thus, there are several main noise sources on the territory of Samara region. But the most important source of disturbing noise for the population of Samara region is automobile transport. Noise of moving automobile is induced by the noise from the engine and its systems, automobile aggregates, oscillating body, tires, noise of auxiliary equipment etc. Taking to account continuous growth of transport number of the region, the problem of transport noise impact to the inhabitants is coming more significant with every year.

The problem is intensified by the fact that some industrial enterprises and highways of towns of Samara region of Russia are closely adjoining to

city's dwelling area. As result significant part of city's population is affected by increased noise level. It should be noted that such situation is typical not only for towns of Samara region of Russia, but also for many other towns of Russia and West Europe, especially for towns with ancient history.

The other main source of town's acoustical discomfort is industry.

It is also should remember about some other noise sources in towns like sport and cultural objects, food industry etc.

3. Russian approaches to acoustical planning and assessment of towns

In total ecological state of towns of Russia is estimated by the complex of factors. Among of them are volume of negative emissions to atmosphere and to water reservoirs, soil pollutions by chemical substances, levels of physical factors, indexes of atmosphere pollutions etc. Taking to account ecological conditions, all towns of Russia are subdivided into 5 categories of ecological state: 1 - problem-free, 2 – satisfactory, 3 – moderate-intensive, 4 – intensive, 5 – critical. Approximately 100 towns of Russia are having 5th category. Almost all large towns of Russia are having intensive and critical ecological state.

Significant parameter is the presence of zones of ecological impact of towns which are differs depending on the concentration and kind of industry and geographical position. These zones are especially large in major industrial agglomerations with combined impact of industrial and transport pollutions: Moscow agglomeration with more than 200 km length, Saint-Petersburg agglomeration with more than 150 km length. Some industrial & transport regional centers of Russia are also have distinguished zones of ecological impact. E.g., large towns of Volga region are traditionally have significant zones. Samara region is one of the industrial centers of Russia having the zone length more than 100 km.

In Russia every town must have 3 kinds of planning documentation: general plan of development (reconstruction); projects of planning and of building of total towns and of its separate parts; plan of land-economical gradation of town's territories.

General plans of development (reconstruction) of towns are having significant meaning for provision

of the required state of environment in long-term prospect. General plans are developing for the period of 25-30 years. General plans of construction and reconstruction of Moscow, Saint-Petersburg, large regional centers are утверждается by Government of Russian Federation. Every 5 years general plans are précised according to variation of conditions of development of towns.

There are three main principles used during development of general plans of towns: zoning principle, ecological safety principle, rational territory organization principle.

Zoning principle means division of all the territory of town to four parts – industrial, living, culture-domestic and recreational. Requirements of ecological safety are admitting taking into consideration of norms of roads displacement, of living and administrative buildings, rest zones, fitting to the requirements of sanitary norms of maximal permissible concentrations and exhausts, for the displacement of sanitary-protective zones, waste disposal etc.

General plans of towns are the basis for development of projects of planning and building of town and of it separate parts. According to the requirements of Russian legislation planning and building of towns must foresee creation of the most favorable conditions for life, rest and health of population. The main task determining the order of complex improvement of towns is prevention and liquidation of harmful and dangerous influence of environmental factors to the living conditions of man.

Before to allow to make the construction of living houses or industrial objects it is necessary to receive positive conclusions of Russian State organizations of ecological and sanitary-epidemiological control and oversight for organizations of all forms of propriety. It is one of the guaranties of provision of ecological safety of population.

Plans of land-economical gradation of cities are considering dislocation of communications for energy, water and heat supply, as well as waste management, rainwater escape etc. Plans are developing and realizing according to the sanitary norms and rules under control of sanitary-epidemiological organizations.

It is especially important to protect low emission zones near the schools, hospitals etc. In Russian Sanitary Norms CH 2.2.4/2.1.8.562-96 there are special strict requirements for noise levels on the territories adjoining to the hospitals and sanatoria: equivalent sound levels L_A 45 dBA (day period) and 35 dBA (night period) and maximal sound

levels L_{Amax} 60 dBA (day period) and 50 dBA (night period).

During acoustical planning of towns it is necessary to take into consideration a number of architecture-planning solutions. Some of them are:

- rational acoustical solutions of plans of industrial areas and of general plans of objects;
- rational dislocation of technological equipment;
- rational displacement of working places in enterprises;
- creation of noise-protective zones etc.

The most noisy transport highway streets of towns may be considered as «transport corridors» with the main task of transportation of people and of loads. Transport highway streets are causing significant influence to the environment (not only noise but also air and soil chemical pollutions etc.) and should be isolated form the living areas. This requirement is necessary to take into consideration in architecture-planning decisions of building of living areas.

For provision of acoustical comfort it is reasonable to use first of all the solutions deciding not only noise-protective, but also architecture-planning questions. Earth mounds and artificial hills protecting the living area from transport noise should look as landscape elements and to have pictorial form.

During towns planning it is necessary to take into consideration correct zoning of territories surrounding the traffic interchanges which are traditionally the most noisy part of highways. In the zone near to transport highway it is not reasonable to dislocate living and social buildings of high floors, because to protect it from negative noise impact it is necessary to erect noise barriers of high height.

Among of town planning solutions for noise reduction it should to point out the following measures:

- observing of the principle of zoning, giving the separation of noisy sources from urban territories;
- transferring of noisy enterprises beyond the bounds of living area;
- construction of special noise-protective living buildings.

Values of admissible gaps between single noise source and the object to be protected may vary in very wide range: from 8-10 up to 500-1000 meters. In zone of gaps auxiliary buildings and areas (garages, car parks, storehouses etc.) are dislocated. For many cases the gaps are should be considered as auxiliary measure.

4. Results of noise measurements on the territory of Samara region of Russia

In recent 20 years under supervision of author of paper acoustical pollutions on the territory of Samara region have been investigated. Measurements were carried out by using of "Octava 101 AM" sound level meter and other equipment.

As a measuring parameters equivalent sound levels L_A and maximal sound levels L_{Amax} (dBA), octave and 1/3 octave spectra of sound pressure (dB) were used. Measurements have conducted in daytime in weekdays mainly in rush hours and during the lunch-time; and in night time (since 23.00 till 7.00). Measured noise levels were evaluated according the requirements of Russian Sanitary Norms CH 2.2.4/2.1.8.562-96. Requirements of Russian Building Norms and Rules were also taken into consideration.

Results of measurements in every point have been presented as measurements registration forms, which including date, time and place of measurements carrying out, measuring points numbers and digital data of readings of noise levels in measured point, as well as in form of spectral presentation of sound pressure levels [1-3].

In Samara city noise levels were measured in some of the most important streets. The most significant exceeding values of sanitary norms requirements were obtained in Kuibyshev Street, Stara Zagora Street, Stavropolskaya Street and Moskovskoye Highway. In Zhigulevsk town the most significant noise levels were fixed near to the living houses situated near to railway station and highway Moscow-Chelyabisk. The most significant noise levels in Syzran city were measured near to the Central Supermarket and railway station.

For Togliatti city comparatively homogeneous composition of transport flows is typical - rail city transport is absent, impact of aircraft noise is excluded. Transport and industrial enterprises are the main noise sources for Togliatti city. As object of study living territory of the Avtozavodsky, Central and Komsomolsky districts of Togliatti city was selected near to the streets with intensive transport movement and near to industrial zones. In total over 150 points have been investigated [4-8].

Near to the Central and Komsomolsky districts of Togliatti city it is situated a number of industrial

enterprises united to so called "North Industrial Unit". Noise estimation and monitoring of North Industrial Unit enterprises for further determination of sanitary zone have been also carried out. Measurements have conducted in daytime in weekdays mainly in rush hours and during the lunch-time; and in night time (since 23.00 till 7.00). The most significant values of equivalent noise levels have been observed for the following points of the territory. Komsomolsky district, night time: point K-07, Matrosova Str., 60, the value of exceeding of normative requirements of equivalent noise level is 8 dBA, maximal noise level - 6 dBA; point K-12, Yaroslavskaya Str., 11: the value of exceeding of normative requirements of equivalent noise level is 5 dBA, maximal level - 8 dBA; day time: point K-10, Chaykina Str., 67, the value of exceeding of normative requirements of maximal noise level is 9 dBA; point K-13, Yaroslavskaya Str., 61, the value of exceeding of normative requirements of maximal noise level is 9 dBA. Central district, night time: point C-18, Lenina Str., 98, the value of exceeding of normative requirements of equivalent noise level is 10 dBA, maximal noise level - 5 dBA; point C-23, Mira Str., 60, the value of exceeding of normative requirements of equivalent noise level is 12 dBA, maximal noise level - 12 dBA; day time: point C-24, Mira Str., 114, the value of exceeding of normative requirements of equivalent noise level is 4 dBA, maximal noise level - 3 dBA. Avtozavodsky district, night time: point A-32, Dzerzhinskogo Str., the value of exceeding of normative requirements of equivalent noise level is 8 dBA, maximal noise level - 3 dBA; day time: point A-04, Topolinaya Str., 21, the value of exceeding of normative requirements of maximal noise level - 19 dBA.

It should be noted that not only living areas, but also industrial sites of territory of Samara region were estimated. For example, noise and vibration at industrial sites of chemical production of Russia were estimated. Example of noise estimation at industrial site of construction of carbon dioxide production of "Khimteco" joint stock company is shown at the figure 1.

Analysis of measurement results of external noise levels in living territory of Samara region shows, that there are noise dangerous zones of dwelling territory. The most serious problem of noise influence is for the dwelling territories of Samara region adjoining to transport highways.

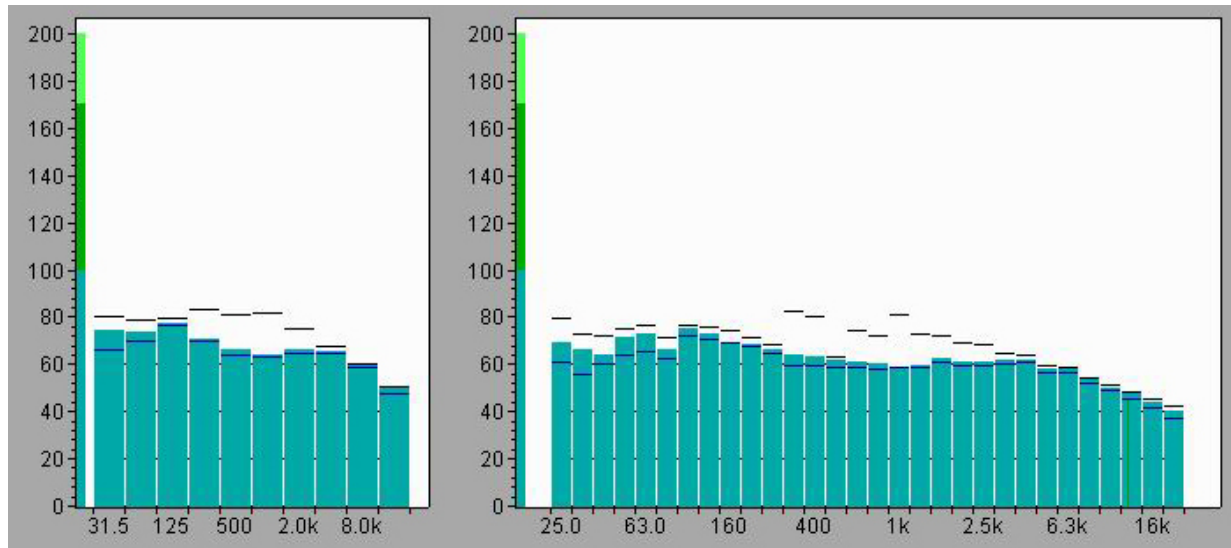


Figure 1. Diagram of spectral characteristics of sound levels estimation at industrial cite of construction of carbon dioxide production of "Khimteco" joint stock company for point 1 of measurements (octave and 1/3 octave bands)

5. Some approaches to reduction of acoustical pollution in towns

Reduction of acoustical pollution of urbanized complexes up to admitted hygiene requirements in present conditions is sophisticated scientific-research problem, which may be decided only by complex measures.

In whole all measures of noise reduction in the dwelling territories may be conditionally divided into several big groups:

1. Urban development and building-acoustic methods of noise control: rational acoustic planning of neighbourhood units, industrial enterprises and highways, erection of noise-protecting shields, noise-protecting planting trees and shrubs, increasing of sound-insulating qualities of buildings, development of noise-protecting screens constructions, foaming of the systems of settling groups on the basis of mass velocity passenger transport with definite functional zoning of the territory, removal of dwelling areas from intensive noise sources, using of compositional grouping of buildings etc.
2. Administrative-organizing measures of noise reduction: noise levels reduction due to decreasing of intensity and noise of transport flows; improvement of roads quality, using of road surface with lower noise; provision of rational velocity of movement; provision and even exclusion of automobile (especially lorry) transport traffic in central parts of town and in living area

streets, restriction measures of high traffic movement near to the hospitals, schools etc.

3. Legal acts, technical norms, prohibitions of noise generation in living zones etc.

4. Using of the technical means of acoustical radiation reduction.

Measures to reduce transport noise may be widely divided to two groups: reduction of transport noise levels in the source of its generation and on the ways of noise propagation.

Many scientists are supposing that the most efficient measure is transport noise reduction in the source of its generation. Design and exploitation of noiseless automobile constructions, especially in low frequency range, is one of the most efficient and economically reasonable ways of noise levels reduction in the living area. At city's level it is necessary to unite the efforts of scientists, designers of cars perspective constructions, specialists of transport department of administration. It is necessary to restrict responsibility for noisy automobiles using. While toxins of automobiles exhaust are strictly controlled by state automobile inspection, noise control of automobiles during exploitation is completely absent.

Some other measures of noise reduction should be used: rational organization of transport flows, prohibition of transport movement at some districts etc. It is necessary to reduce intensity and noise of transport flows. It is required to exclude lorry transport traffic.

Secondly, it is recommended to use noise-damping road surfaces. Such surfaces have been developed presently by many foreign companies. For example, there is road surface "Viaphone", having reduced granulation and insignificant thickness of layer (2-3 sm). Other type - porous draining road surfaces. For example, "Gerland Routes" company suggests road

surface Epsibel. "Colas" company is using in "Golsoft" mixtures recycled rubber from the automobile tires in two layers, providing noise reduction 8 dBA.

High efficiency measures of transport noise reduction are development and using of alternative transport as well as more intensive using of public transport. As alternative to automobile transport using of bicycle transport may be suggested. In this case during the planning of town's territory it is necessary to foresee special bicycle roads, places for bicycles parking etc.

In many towns noise protective barriers are using for noise reduction. But the installation of noise barriers in towns may significantly change external look of town, that is why before to make the decision to install noise barrier (even the acoustical effect is good) it is necessary to have the detailed consultations with architects.

6. Conclusions

Analysis shows that for the towns of Russia transport noise is the main source of acoustical pollution of the territory [4-9].

Methods of acoustical planning and assessment in town conditions are discussed. Peculiarities of noise assessment and control in low emissions zones are described. It is pointed out that in many Russian towns the living areas are situated close to transport highways and to industrial enterprises.

Analysis of measurement results of external noise levels in living territory of Samara region shows, that there are noise dangerous zones of dwelling territory. The most serious problem of noise influence is for the dwelling territories of Samara region adjoining to transport highways.

Results of noise measurements in the territory of different towns of Samara Region of Russia are shows that there are exist some zones of urban territories with increased noise levels. Thus, it is possible to speak about the existing of real problem of noise safety of Samara region provision.

Some approaches to noise reduction in urban areas are suggested, including architect solutions, sanitary-protective zones provision, different kinds of noise barriers installation etc.

In total, effective noise reduction in living areas may be achieved by provision of complex administrative-organizing, urban development and building-acoustic.

Acknowledgement

The author would like to express many thanks to Russian Ministry of Education and Science for the support of work in framework of State task N 5.7468.2017/BCh for topic of research "Development of scientific foundations and of generalized theory of monitoring, estimation of risks and reduction of impact of toxicological pollutions to biosphere".

References

- [1] S. Luzzi, L. Alfinito, A. Vasilyev: Action planning and technical solutions for urban vibrations monitoring and reduction. Proc.: 39th International Congress on Noise Control Engineering 2010, INTER-NOISE 2010, 2508-2515.
- [2] S. Luzzi, A.V. Vassiliev: A comparison of noise mapping methods in Italian and Russian experiences. Proc.: Forum Acusticum Budapest 2005: 4th European Congress on Acoustic 2005. pp. 1051-1056.
- [3] S. Luzzi, A.V. Vasilyev: Noise mapping and action planning in the Italian and Russian experience. 8th European Conference on Noise Control 2009, EURONOISE 2009 – Proceedings of the Institute of Acoustics 2009.
- [4] A.V. Vassiliev: Recent approaches to environmental noise monitoring and estimation of its influence to the health of inhabitants. Proc.: 14th International Congress on Sound and Vibration 2007, ICSV 2007, 3242-3249.
- [5] A.V. Vasilyev: Ecological Monitoring of Physical Pollutions on the Territory of Samara Region. Reduction of Impact of Sources of Physical Pollutions // Book. – Edition of Samara Scientific Center of Russian Academy of Science, Samara, Russia, 2009. 140 p., 36 ill.
- [6] A.V. Vasilyev, V.O. Bukhonov, V.A. Vasilyev: Approaches to Environmental Impact Assessment of Physical Pollutions of Territories During Design and Construction of Industrial Objects and it Realization in Samara Region of Russia. Proc. of the International Scientific Conference (XI International Forum) Heritage. Architecture. Landesign Focus on Conservation, Regeneration, Innovation "Le vie dei Mercanti", June 13th – 15th 2013, Aversa-Capri, Italy, Edition of La scuola di Pitagora, Naples, Italy. - pp.1183-1190.
- [7] A.V. Vasilyev, G.S. Rozenberg: Monitoring of Noise Pollution in Living Area of Togliatti City and Estimation of It Influence to the Health of Inhabitants // Proc. of Scientific-Practical Journal "Safety in Technosphere", No 3, 2007, pp. 9-12.
- [8] A.V. Vasilyev, V.V. Zabolotskikh, O.V. Bynina, J.P. Tereshchenko: Experience And Prospects Of Environmental Planning Of Towns Of Russia Taking To Account Noise Factor. Proc. of the international scientific conference (X International forum) Architecture. Design. Landscape "Le vie dei Mercanti", 30 May – 4 June 2012, Aversa-Capri, Italy, pp.1253-1260.
- [9] A.V. Vasilyev, V.V. Zabolotskikh, V.A. Vasilyev: Development of Methods of Estimation of Physical Factors Impact to the Health of Population. Safety of Technogenic Environment, Riga Technical University, Riga, Latvia, 2013, vol. 4, pp. 42–45.