Research of industrial noise impact to the urban environment on the example of enterprises of north industrial unit of Togliatti city of Russia

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Abstract. Environmental noise impact is increasing every year and may cause serious negative problems for inhabitants of urban territories and for specially protected natural areas. Industrial noise is one of the main noise sources of the urban territories of modern towns. On the territory of Togliatti city of Russia the part of the Middle Volga Integrated Biosphere Reserve is located. Results of analysis of environmental noise sources on the territory of north industrial unit of Togliatti city are considered. Methods of analysis of environmental noise in Russia are analysed. Results of measurements of environmental noise in the zone of north industrial unit of Togliatti city are presented. Practically in all noise measuring the exceeding noise values were determined. Measurement results of noise characteristic directly in the territories of industrial enterprises are showing that the main noise sources, especially in low frequency range, are power plants. Noise map of the territory of the north industrial unit of Togliatti city have been developed. In total, it is possible to make a conclusion about the existing of real problem of increased noise impact of industrial enterprises to the population.

1. Introduction
For the time being the impact of physical pollutions to the population is rapidly increasing. One of such physical pollutions is noise. Environmental noise impact is increasing every year and may cause serious negative problems for inhabitants. More than 60% of population of large cities is living in exceeding noise conditions [1, 9-12]. Disturbing acoustical impact is appreciated by half of Earth population. Among of the main noise sources of urban territories and of specially protected natural areas are transport and industrial enterprises.

The problem is intensified by the fact that some industrial enterprises and highways are closely adjoining to city's dwelling area. As result significant part of city's population is affected by increased noise level [1, 5, 6, 8-12]. As a typical industrial city Togliatti has as a number of large industrial enterprises as considerable automobile transport park, making significant acoustic impact to abutting dwelling territory. On the territory of Togliatti city of Russia part of the Middle Volga Integrated Biosphere Reserve is located. Near to the Central district of Togliatti city it is situated a number of industrial enterprises united into so called "north industrial unit".

In order to calculate the sanitary zone of north industrial unit it was decided to measure noise levels and to create the noise map.

This paper is devoted to the results of environmental noise estimation, monitoring and mapping of north industrial unit enterprises of Togliatti city for further noise reduction.
2. Analysis of noise sources of the territory of north industrial unit of Togliatti city

Specific peculiarity of Togliatti city is large automobile transport park and a number of large industrial enterprises. This causes significant noise impact to the population. There are a lot of industrial enterprises situated not far from the dwelling area. As result are increased noise levels for some dwelling houses.

In the zone of north industrial unit enterprises there are two main environmental noise sources affecting to Togliatti city dwelling area: industrial noise and transport noise.

Let us consider the main noise sources which are generating during industrial enterprises operation on the territory of north industrial unit.

**Compressors.** Depending on the kind of compressor mounts, conditions of operation and of noise and vibration generation compressors have different acoustical characteristic. E.g., in the intake spectrum of turbo-compressors (high-speed aggregates) high frequency sound harmonic are dominating. Volume compressors are subdivided as piston, rotor and membrane types. In the intake spectrum of rotor compressors, the frequency of shaft rotation and it harmonic are dominating. Due to the fact that rotation speed of rotor compressors usually is high, again we have high frequency sound domination. The most of piston and membrane type compressors are low-rotating machines, so in its spectra low frequency sound harmonic are dominating.

**Pumps.** Pumps are machines using for transportation of liquids and for transmission of energy to it. Pumps are subdivided to blade (centrifugal, vortex, axial, diagonal), volume (piston and rotor), pneumatic, stream. The most often used are blade pumps. Noise spectra of pumps are widely different and complicated.

**Engines.** Engines are devices transforming some kind of energy to mechanical operation. The most often used kind of engines is heat engines, transforming heat energy to mechanical operation. Engines are subdivided to stationary and moving kinds. Moving machines are often using in industrial cites of chemical enterprises. Noise spectra of engines are widely different and complicated.

**Chemical processes.** In chemical production there are some specific processes (e.g. oxidation, ammonia production, carbon dioxide production etc.), causing the significant noise impact.

3. Methods of analysis of environmental noise in Russia

There are legal, normative and technical documents, determining the procedure of research of acoustic pollution of environment and noise impact in conditions of urban territories [1-5, 7, 8, 9-12]. There are international and national standards of environmental noise assessment. In Russia noise levels in living area are evaluated according to hygiene requirements, stated by valid sanitary norms, Russian State Standards, Building Norms and Rules etc. Normative parameters for unstable noise are equivalent sound levels $L_{A_{eq}}$ and maximal sound levels $L_{A_{max}}$, dBA. There are two periods of evaluation: day (7.00-23.00) and night (23.00-7.00). If noise level is measured inside of building, the permitted value of $L_{A_{eq}}$ is no more than 40 dBA (day) and 30 dBA (night), the permitted value of $L_{A_{max}}$ is no more than 55 dBA (day) and 45 dBA (night). It should be noted that Russian noise standards are differing from the European standards [4].

Industrial noise is unstable, oscillating in time. For this kind of noise there are some main requirements to carrying out the measurements:

- Time of noise evaluation $T$ in dwelling houses, public buildings and in living territory should be accepted in the day-time - continuously during 8 hours, at night - continuously during 0,5 hour (in the noisiest periods of day).
- Measurement of unstable noise should be carried out at the periods of time of noise evaluation $T$, which include all typical variations of noise regime in evaluated point. Duration of every measurement of unsteady noise $T_{mi}$ in every point should be at least 30 minutes.
- Reading of sound levels of interrupting noise, which are remaining stable in the intervals with duration less than 0,5 minute, and also of oscillating and impulse noise should be carried out with intervals
from 5 to 6 seconds. In every point during the period of noise $T_m$ should be conducted 360 readings of sound levels etc.

4. Results of measurements of environmental noise in the zone of north industrial unit of Togliatti city of Russia

Measurements of noise levels in north industrial unit zone adjoining to the living territory of Togliatti city have been conducted in strict correspondence with normative requirements. Measurements were conducted during weekdays’ daytime mainly in rush hours and also during to the lunchtime. In total, over 30 points have been investigated. Measured noise levels evaluated according to hygiene requirements, stated by valid Russian sanitary norms 2.2.4/2.1.8.562-96, according to requirements of which normative parameter for unstable noise are equivalent sound levels $L_{Aecv}$ and maximal sound levels $L_{Amax}$, dBA. $L_{Aecv}$ value is determined according to the equation $L_{Aecv} = \Delta L_A + 10$. $L_{Amax}$ value is determined as the highest noise level for the all period of measurements in the point.

For evaluation of obtained results following normative values of equivalent and maximal sound levels were used:

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L_{Aecv \text{ norm}} = 55 \text{ dBA} + 10 \text{ dBA} = 65 \text{ dBA},
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\[
L_{Amax \text{ norm}} = 70 \text{ dBA} + 10 \text{ dBA} = 80 \text{ dBA},
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The results of measurements of sound levels in some points of North Industrial Unit zones are showing that in all measuring points there are some exceeding values compared with Sanitary Norms requirements (65 dB). The most significant values of equivalent and maximal noise level are in the points of measurements situated near to the Larina and Novozavodskaya streets of the Central district of Togliatti city.

Measurement results of noise characteristic directly in the territories of industrial enterprises are showing that the main noise sources, especially in low frequency range, are power plants (compressors, ventilators, pumps etc.). As example of noise measurements results in industrial sites, on the figure 1 the diagram of spectral characteristic of equivalent sound levels (octave and 1/3 octave ranges) for industrial site of of “KuibyshevAzot” company of Togliatti city of Russia is shown. We may see significant noise values in low frequency noise spectrum.

5. Environmental noise mapping of the zone of north industrial unit of Togliatti city of Russia

Using software «Physic City Test» and sub-program «Sound City Test», noise maps are created during operation of the enterprises of the north industrial unit zone of Togliatti city and in abutting living areas of Central district of Togliatti city.

Noise map of the north industrial unit zone of Togliatti city (figure 2) have been developed taking into account the fact of exceeding of sanitary norms in the points of measurements. Orange color was used for the points with equivalent noise level in the range from 65 to 70 dBA, red color – points with equivalent sound levels over 70 dBA.

In figure 3 noise map of the external border of “KuibyshevAzot” company situated in the north industrial unit zone of Togliatti city is shown. In some points of measurements noise level is exceeding 65 dBA value.
Figure 1. The diagram of spectral characteristic of equivalent sound levels (octave and 1/3 octave ranges) for industrial site of shop 38 of “KuibyshevAzot” Company of Togliatti city of Russia. Vertical direction - equivalent sound levels, dBA; Horizontal direction - octave and third-octave frequency spectra, Hz

Figure 2. Noise map of the north industrial unit zone of Togliatti city
6. Conclusions
Results of noise measurements in the zone of north industrial unit during enterprises operation are discussed. Practically in all noise measuring points the exceeding noise values compared with valid Russian sanitary norms requirements were determined.

Measurement results of noise characteristic directly in the territories of industrial enterprises are showing that the main noise sources, especially in low frequency range, are power plants (compressors, ventilators, pumps etc.).

Using software «Physic City Test» and sub-program «Sound City Test», noise map of the territory of the north industrial unit zone of Togliatti city have been developed.

In total, it is possible to make a conclusion about the existing of real problem of increased noise impact of some industrial enterprises situated in the zone of north industrial unit to the population of Togliatti city. It is necessary to develop the measures of industrial noise reduction.

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