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EXPERIMENTAL RESEARCH OF ENVIRONMENTAL NOISE IN URBAN CONDITIONS BEFORE AND DURING COVID-19 PERIOD ON THE EXAMPLE OF SAMARA REGION OF RUSSIAN FEDERATION

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***Abstract**: Today the acoustical pollution is well monitored, especially in the urban environment, and in particular area it is still increasing. Environmental noise impact is increasing every year and may cause serious negative problems for inhabitants. Transport and industrial plants are making the most significant noise levels in the city environment. This paper presents the results of research of environmental noise in urban conditions before and during COVID-19 period on the example of Samara region of Russia. In Russia strong COVID-19 restrictions of traffic movement and industrial enterprises operation have caused significant variations of environmental noise generation and impact in conditions of urban territories. Comparison of results of environmental noise measurements in urban conditions before and during COVID-19 period is showing that transport noise level is reduced, but the industrial noise level is almost the same, especially in low frequency range.*

***Keywords:** noise, urban territory, industry, transport, COVID-19, low frequency*

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1. INTRODUCTION

For the time being acoustical pollution in modern cities is rapidly increased. Disturbing acoustical impact is appreciated by half of Earth population [4, 6-10, 13, 14, 18, 21-25, 27]. Environmental noise is produced by a variety of natural and man-made sources, but transport and industrial plants are making the most significant noise levels in the city environment [2, 3, 6, 12-17, 22-28].

It is well known, that noise is affecting to the human's central and vegetative nervous systems, influencing to the human's psychological condition etc. The most serious problems are caused by low frequency acoustic impact [20, 21, 25, 26].

COVID-19 period in the world is considered to begin in January-February 2020 [1, 5, 11, 19, 29, 30]. In Russia strong COVID-19 restrictions have been announced mainly in April 2020. Strong restrictions of traffic movement and industrial enterprises operation have caused significant variations of environmental noise generation and impact in conditions of urban territories.

The paper presents results of research of environmental noise in urban conditions on the example of Samara region of Russia.

2. RUSSIAN APPROACHES TO ENVIRONMENTAL NOISE RESEARCH AND ESTIMATION

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 [6, 12, 13, 21]. 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_{Aecv} and maximal sound levels L_{Amax}, 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_{Aecv} is no more than 40 dBA (day) and 30 dBA (night), the permitted value of L_{Amax} is no more than 55 dBA (day) and 45 dBA (night).

The most serious problems of noise pollution in cities are considered to be caused by transport, especially by vehicles. Evaluation of transport noise in Russia is carried out according to methodic recommended by Russian State Standards. Russian State Standard R 52231-2004 "External noise of motor vehicles. Permissible levels and methods of measurement" determines methods of automobile external noise measurement. As external noise indicator when checking the technical condition of the car the level of the automobile exhaust system is used. Measuring microphone is installed above the platform surface at the height of the location of exhaust pipe of muffler, but not lower than 0,2 m. Microphone is displaced at the distance (0,5±0,05) m from exhaust pipe cross section. The main axis of the microphone should be parallel to the sur-

face of the platform with the deviation of no more than ±15° and make up the angle 45°±15° with vertical plane passing through the axis of flow of exhaust gases coming out of the exhaust pipe of the muffler. For the automobile with vertical location of the exhaust pipe the microphone is installed at the height of the exhaust pipe cutoff at the distance (0,5±0,05) m in direction of the nearest side of the automobile. Microphone axis is directed vertically, the membrane is oriented upwards.

Results of measurements in every point are presented as measurements registration forms, usually including date, time and place of measurements, measuring points numbers and digital data of readings of noise levels in measured point. Noise of transport flows 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 most noisy 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_m in every point should be at least 30 minutes.

Measured values of noise level are rounded to the nearest whole number and are considered to be reliable during the difference in readings no more than 2 dBA. If the difference in readings is more, the measurements are repeated. Result of measurements is maximal reading of sound level meter, fixed during performing test cycles, which is comparing with admissible noise level. Measurements are considered to be valid if background noise is no less than 10 dBA lower than the level of measured noise.

Noise levels in industry in Russia are evaluated according to hygiene requirements, stated by valid sanitary norms (Sanitary Norms 2.2.4/2.1.8.562-96), Russian State Standards and Building Norms and Rules. Normative parameters for unstable noise are equivalent sound levels L_{Aecv} and maximal sound levels, L_{Amax} dBA. There are different noise values norms for different operational processes, but in any case noise levels must be lower than 80 dBA.

3. RESULTS OF RESEARCH OF ENVIRONMENTAL NOISE IN URBAN CONDITIONS BEFORE AND AFTER COVID-19 PERIOD ON THE EXAMPLE OF SAMARA REGION OF RUSSIAN FEDERATION

Analysis of environmental noise sources of the main towns of Samara region of Russia (Samara, Togliatti, Syzran) is showing that there is a number of large industrial enterprises and considerable automobile transport park, making significant acoustic impact to abutting dwelling territory. 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 [14, 23-25, 27].

For example, automobile transport is the main external noise source affecting to Togliatti city dwelling area. Specific city peculiarity is large automobile transport park, the most part of which consist of cars. This cause intensive transport flows at city's streets, which are generating significant noise impact.

Transport noise levels on the living territory of the Avtozavodsky, Central and Komsomolsky districts of Togliatti city was measured near to the city streets with intensive transport movement. In total over 250 points have been investigated. Measurements of noise levels in places of living territory of Togliatti city adjoining to noise dangerous zones have been conducted in strict correspondence with above mentioned requirements.

In years of 2014-2019 investigations of transport noise influence to the housing estates of the Central and Komsomolsky districts of Togliatti city have been carried out [23-25, 27]. Results of comparison of measured and calculated values for every point with normative requirements shows, that the most significant excess of standard equivalent noise levels is observed for the following points. Komsomolsky district, night time: point Matrosova Str., 60, the value of exceeding of normative requirements of equivalent noise level is 8 dBA, maximal noise level - 6 dBA; point Yaroslavskaya Str., 11: the value of exceeding of normative requirements of equivalent noise level is 5 dBA, maximal level - 8 dBA; day time: point Chaykina Str., 67, the value of exceeding of normative requirements of maximal noise level is 9 dBA; point Yaroslavskaya Str., 61, the value of exceeding of normative requirements of maximal noise level is 9 dBA. Central district, night time: point Lenina Str., 98, the value of exceeding of normative requirements of equivalent noise level is 10 dBA, maximal noise level - 5 dBA; point 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 Mira Str., 114, the value of exceeding of normative requirements of equivalent noise level is 4 dBA, maximal noise level - 3 dBA. . Central district, day time: the point of Mira street (near to bus stop) - 6 dBA; point Banykina street - 4 dBA; point Komsomolskaya street - 3 dBA.

Finally, in 2019 Avtozavodsky district living area was investigated. Again the zones with the exceeding of normative requirements of equivalent noise level were found: night time: point Dzerzhisky Street, the value of exceeding of normative requirements of equivalent noise level is 8 dBA, maximal noise level - 3 dBA; day time: point Topolinaya Street, 21, the value of exceeding of normative requirements of maximal noise level - 19 dBA; point Dzerzhisky Street, 31, the value of exceeding of normative requirements of equivalent noise level is 3 dBA.

In total from 250 points of measurements only 67 meets to the normative requirements of equivalent noise level and 71 - to maximal noise level. Values of more than half of measurements in night time are exceeding the normative requirements. Comparing with previous periods of noise measurements in any measurement point noise level reduction had not been obtained.

Spectral analysis of results of transport noise measurements is showing that the most significant noise levels are in low frequency range. Examples of presentation of spectral characteristic of low frequency noise and infrasound of the living terri-

tory of Komsomolsky district of Togliatti city near to transport roads are shown in figures 1 and 2. Example of presentation of spectral characteristic of low frequency noise and infrasound levels for point Makarova street, 47 is shown in Fog. 1, for point Chaykina Str., 67 – in Fig. 2.

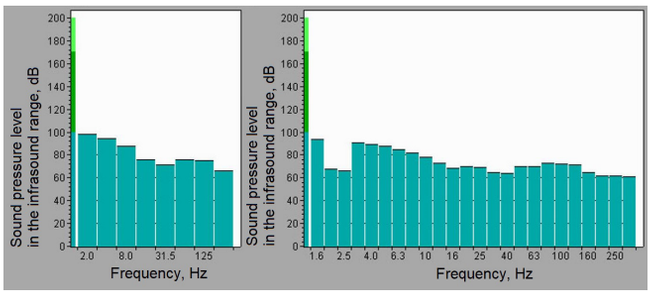

Fig. 1: The diagram of spectral characteristic of low frequency noise and infrasound levels (octave and 1/3 octave ranges) for point Makarova street, 47 of living territory of Komsomolsky district of Togliatti city (before COVID-19 period)

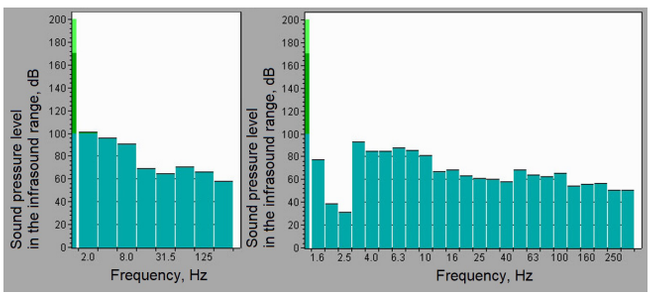

Fig. 2: The diagram of spectral characteristic of low frequency noise and infrasound levels (octave and 1/3 octave ranges) for point Chaykina Str., 67 of living territory of Komsomolsky district of Togliatti city (before COVID-19 period)

In the same points noise measurements were carried out during COVID-19 period in April and May of 2020. Results of measurements are shown in figures 3 and 4. Results of measurements of low frequency noise and infrasound levels during COVID-19 period are showing that practically in all spectral points we may see reduction of low frequency noise and infrasound levels.

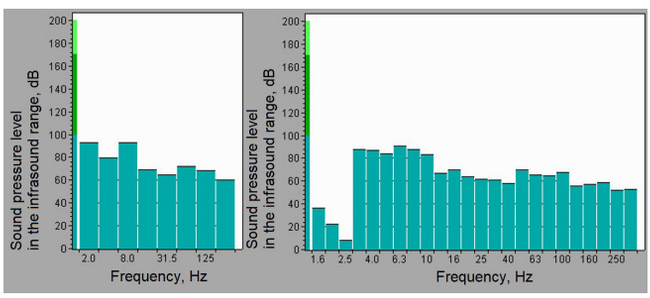

Fig. 3: The diagram of spectral characteristic of low frequency noise and infrasound levels (octave and 1/3 octave ranges) for point Makarova street, 47 of living territory of Komsomolsky district of Togliatti city (during COVID-19 period)

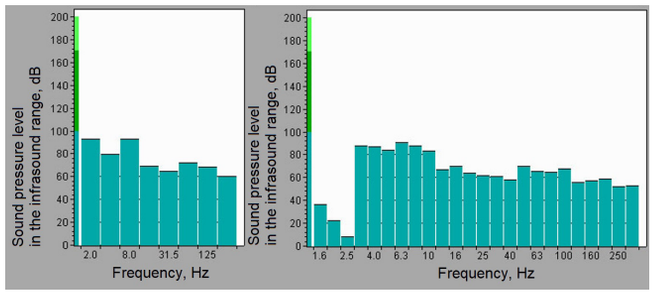

Fig. 4: The diagram of spectral characteristic of low frequency noise and infrasound levels (octave and 1/3 octave ranges) for point Chaykina Str., 67 of living territory of Komsomolsky district of Togliatti city (during COVID-19 period)

Industrial noise may also cause significant negative impact to population. Near to the living territories of the main towns of samara region of Russia there are a number of industrial enterprises. For, example, in Central district of Togliatti city it is situated so called „North Industrial Unit" of industrial enterprises.

Noise estimation and monitoring of North Industrial Unit enterprises for further determination of sanitary zone have been also carried out. Measurements have been carried out before COVID-19 period in daytime in weekdays mainly in rush hours and during the lunch-time; and in night time (since 23.00 till 6.00). Results of measurements in every point have been presented as measurements registration forms, which including date, time and place of measurements carrying out, measuring point number and digital data of readings of noise levels in measured point.

The results of measurements of sound levels in some points of North Industrial Unit zone are shown in Table 1. We may see that in all measuring points there are some exceeding values compared with Russian Sanitary Norms requirements (65 dB). The most significant values of equivalent and maximal noise level are in the points 1, 4, 6.

Measurement results of noise characteristic directly in the territoris 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 5 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 is shown. We may see significant noise values in low frequency noise spectrum.

N p/p	Displacement of points of measurements	Time of measurement	Equivalent sound levels, L_{Aeqv} dBA	Maximal sound levels, L_{Amax} dBA
1	Larina Street (Crossing with Mira Street)	9:00	71	83
2	Larina Street (200 m from the Mira Street)	9:58	68	75
3	Larina Street (400 m from the Mira Street)	11:10	69	78
4	Larina Street 170	12:26	69	82
5	Larina Street 153	12:03	69	77
6	Larina Street 147	13:15	71	82
7	Larina Street 143	14:31	69	78
8	Larina Street 139a	15:44	68	76
9	Komsomolskaya Street 175	13:00	67	75
10	Komsomolskaya Street 170	14:08	67	73
11	Komsomolskaya Street 163	15:35	67	75
12	Novozavodskaya Street 49	9:58	70	96
13	Novozavodskaya Street 55	11:05	68	75
14	Novozavodskaya Street (Vogla Cement Plant Administration)	12:16	69	78
15	Novozavodskaya Street (crossing with 50 years of October Street)	11:17	69	74
16	Novozavodskaya Street (Trolleybus deport)	12:27	69	78
17	Novozavodskaya Street	13:40	69	78
18	Industrialnaya Street 5	8:56	68	76
19	Industrialnaya Street 16	10:15	66	74

Tab. 1: Equivalent and maximal noise level values in North industrial unit zone taking to account correction levels

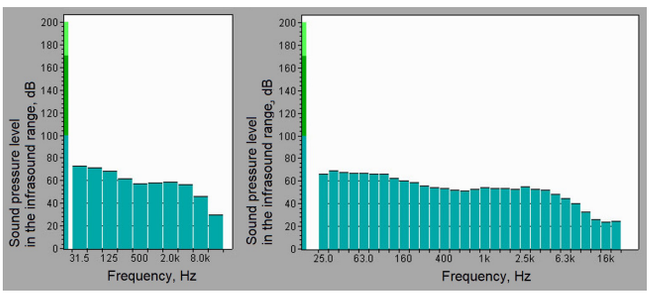

Fig. 5: The diagram of spectral characteristic of equivalent sound levels (octave and 1/3 octave ranges) for industrial site of shop 38 of "KuibyshevAzot" Company of Togliatti city of Russia (before COVID-19 period)

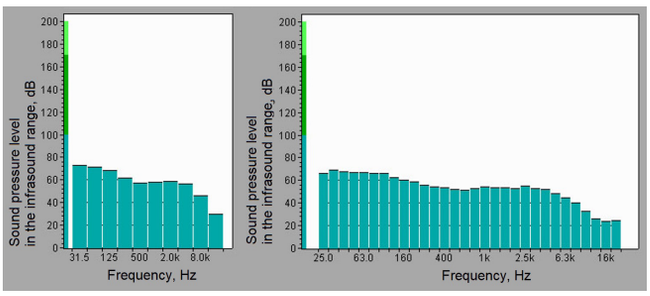

Fig. 6: The diagram of spectral characteristic of equivalent sound levels (octave and 1/3 octave ranges) on the border of the sanitary protective zone of North industrial unit zone of Togliatti city of Russia (during COVID-19 period)

Measurements have been carried out during COVID-19 period in the same points and practically at the same time. Analysis is showing that the results of measurements show that noise level values were practically the same as before COVID-19 period, and again significant noise values were in low frequency range. The diagram of spectral characteristic of equivalent sound levels (octave and 1/3 octave ranges) on the border of the sanitary protective zone of North industrial unit zone of Togliatti city of Russia during COVID-19 period is shown if Fig. 6. We may see that again significant noise values were obtained in low frequency noise spectrum.

4. CONCLUSIONS

Analysis of measurement results of external noise levels in living territory of Samara region of Russia shows, that there are noise dangerous zones of dwelling territory. The most serious problem is noise impact from transport and industry.

Transport noise levels on the living territory of the Avtozavodsky, Central and Komsomolsky districts of Togliatti city was measured near to the city streets with intensive transport movement. In total over 250 points have been investigated. In total from 250 points of measurements only 67 meets to the normative requirements of equivalent noise level and 71 - to maximal noise level. Values of more than half of measurements in night time are exceeding the normative requirements.

Results of noise measurements in the zone of North Industrial Unit during enterprises operation are discussed. In all measuring points there were exceeding values compared with Sanitary Norms requirements. The most significant values of equivalent and maximal noise level were in the points 1, 4, 6.

Measurements of environmental noise characteristic in urban conditions before and during COVID-19 period on the example of Samara region of Russia have been carried out. Strong restrictions of traffic movement and industrial enterprises operation have caused significant variations of environmental noise generation and impact in conditions of urban territories. For the territory of Samara region of Russia it is possible to conclude that for transport noise impact estimation the results of measurements show that noise level values during COVID-19 period were lower than before. But industrial noise estimation results are showing that noise level values during COVID-19 period were practically the same as before COVID-19 period, and significant noise values were in low frequency range. It was determined that power plants (compressors, fan systems, pumps etc.) are may be considered as one of the main sources of industrial noise. Therefore it is necessary to develop the measures of power plants noise reduction, especially in low frequency range.

In total, it is possible to speak about the existing of real problem of noise safety of urban territories provision.

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