The use of noise maps of the city for selection of management decisions about the regulation of road traffic

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Abstract

The important problem is protection of population from high noise. This problem was discussed in the article. Also in the article was showed the necessity of the noise maps of the city for making correct management decisions is proved. There are presented data on the change in the number of vehicles on the territory of the European Union and Russia, information about noise levels in the territories along the roads in the cities of Russia, the algorithm for generating noise maps of the city. There were estimated noise levels generated by vehicles, in the Central part of the city of St. Petersburg for two scenarios: first on the basis of field studies on the composition and intensity traffic, second – on forecast of limiting vehicle traffic. Conclusion: restriction of movement of vehicles can reduce impact, noise, and values of the maximum concentrations near streets with restricted movement, but at the same time can increase the negative impact of the near streets, where will be redistributed transport stream. The decrease in the maximum ground level concentrations and levels of noise for such a big city like St. Petersburg will contribute to complex of environmental measures: improving fuel, classes environmental performance of vehicles, the development of the road network with traffic organization based estimate of environmental consequences of the proposed activities.

Key words: vehicles, intensity traffic, acoustic calculations, noise map of the city

Использование шумовых карт города для выбора управленческих решений по регулированию автотранспортных потоков

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Аннотация

Актуальность: в статье обсуждается актуальная проблема – защита населения от повышенного шумового воздействия. Цель: обоснование необходимости создания шумовых карт городов для принятия корректных управленческих решений. Материалы и методы: приводятся данные по изменению количества автотранспортных средств на территории Европейского Союза и России. Также представлена информация об уровнях шума на территориях вдоль автомобильных дорог, наблюдаемых в некоторых городах России. Приведен алгоритм создания шумовой карты города, который включает проведение натурных наблюдений состава и интенсивности автотранспортного потока, формирование электронной базы данных уровней звука от каждого автотранспортного участка, проведение

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акустических расчетов, анализ результатов расчетов с точки зрения соблюдения гигиенических нормативов. Результаты: оценены уровни шума в центральной части города Санкт-Петербург, создаваемого автотранспортом, как на основании натурных исследований о составе и интенсивности автотранспортного потока, так и прогнозные – при ограничении движения автотранспортных средств. Заключение: ограничение движения автотранспорта может способствовать снижению воздействия, как шумового, так и значений максимальных приземных концентраций вблизи улиц, на которых ограничено движение, но в то же время может привести к увеличению негативного воздействия вблизи улиц, на которые перераспределится автотранспортный поток. Снижению значений максимальных приземных концентраций и уровней шума для такого крупного мегаполиса, как город Санкт-Петербург, будет способствовать комплекс природоохранных мероприятий, направленных на улучшение топлива, класса экологичности автотранспортных средств, развитие улично-дорожной сети с организацией движения с учетом экологических последствий предлагаемых мероприятий при использовании шумовых карт.

Ключевые слова: *автотранспорт, интенсивность, акустические расчеты, шумовая карта города.*

Introduction

In the present time the noise impact is a topical ecological problem in cities. Motor vehicles are a major source of such impact. Roads are laid everywhere: in industrial areas and near apartment buildings. People who live near the roads are often subject to increased noise levels.

Noise pollution – is a form of physical pollution in which the noise level rises above the natural noise. The noise is disturbing, if it does not last long. But hearing organs may be damaged or the organism may die with prolonged noise exposure.

Noise not only affects hearing. Irritation of the noise transmitted to the central and vegetative nervous system through the fibers hearing nerve, and through them affects the internal organs. This leads to significant changes in the functional state of the body, affects the mental state, causes a feeling of anxiety and irritation. When there is pulse and irregular noise then the impact of noise increases.

Every year number of vehicles increased by more than 2 million units in the Russian Federation. In early 2014, Russia had more than 47 million vehicles (without trailers and semi-trailers). It is predicted that the number of vehicles by 2016 to increase by 11 million units. At the beginning of 2014 in Russia as a whole was 274 vehicles per 1000 people, in St. Petersburg – 308 cars per 1000 people in Moscow – more than 311 cars per 1000 people [1].

It should be noted that since 2007, when 15.5 million cars were registered, the number of new cars that are registered in the European Union, is reduced. In 2013, there were 11.8 million registered vehicles, this is 200,000 fewer units than in 2012. Approximately half of the countries of Europe the number of registrations decreased in 2013 compared with 2012, while in the other half of Europe, the number of registered vehicles has increased. The decrease registrations of new vehicle were in Cyprus (- 37%), the Netherlands (17 percent) and Romania (- 14%), whereas the highest growth of this indicator was recorded in the UK (11%), Portugal (10%) and Bulgaria (9.7%). The number of registrations of new vehicles decreased by 24% compared to 2007, by 80% in Greece, 54% in Spain, 48% in Portugal and 48% in Italy compared with 2007 [2].

However, despite some decline in newly registered cars, the number of cars per 1000 people of Europe is higher than in Russia. For example, the number of cars per 1000 inhabitants in France and Germany – 600, UK – 550, The Netherlands – more than 500 [3, 4]. The main findings of the European Environment Agency are presented below:

- noise pollution is one of the main ecological problems for health residents of Europe;
- road traffic is the most dominant noise source;

- every year in Europe not less than 10 000 cases of premature death are due to the noise in the environment;
- nearly 20 million adults had been irritated due to noise environment, and 8 million suffer from sleep disorders;
- every year environmental noise causes more than 900 000 cases of hypertension [5].

In the last decades the noise level has increased in the major cities by 10-15 dBA. In large urban the increase of noise is associated with increases of traffic intensity (up to 8,000 units/ hour), the power and capacity of transport, the introduction of new engines, etc. On the roads of Moscow, St. Petersburg and other large Russian cities the noise from traffic reaches 90-100 dBA during the day and even at night in some areas does not fall below 70 dBA. Excess noise levels are observed also in cities with smaller populations. In Arkhangelsk equivalent sound levels near residential buildings (12-18 meters from the road, traffic is about 2500 vehicles per hour) exceeded 11-18 dBA for daytime [6]. In Tyumen sound levels near the residential buildings, which are located at a distance of about 15 meters from the road, exceeded by 20,9 dBA for daytime [7]. Annual monitoring of measuring noise residential areas of Murmansk, near main transport routes, indicate a steady trend of increasing noise levels – in the daytime by 8-20 dBA during the night of 18-28 dBA. [8]

Sanitary standards for the territories of next to residential buildings are permissible equivalent levels of sound 55 dBA in daytime (from 7 to 23 h.), 45 dBA during the night (from 23 to 7 h.) [9].

In general, in Russia about 35 million people are exposed to significant of traffic noise.

In this connection currently protecting populations of high noise impact is important. According to the authors of one of the possible ways to solve the problem of high noise pollution – it is monitoring the situation on the basis of acoustic noise maps of cities, with a selection of the most effective measures to regulate noise pollution on the basis of model calculations of noise impact [10, 11].

1. The algorithm for generating noise maps of the city

This article describes an algorithm for creating a noise map of the city, based on data about structure and the intensity of road traffic flows, as well as the results of computational methods for assessing the changes of the noise pollution generated by road traffic in the city of St. Petersburg, taking into account certain restrictions of traffic in the central part cities.

The algorithm of the work was of the following stages:

- selection of the main roads with high traffic volume;
- monitoring structure and intensity of vehicular traffic with separate monitoring of trucks and diesel vehicles (including buses);
- exploring urban situation;
- the preparing of topographic map of the city in the geographic information system containing the following thematic layers: roads, buildings, taking into account the height, area with green spaces, hydrographic objects, etc.;
- stylization noise sources depending on sites with different intensity of vehicles and configurations of roads;
- set noise sources to the prepared topographic map;
- using specialized software, the creation of an electronic database of sound levels on each road section based on the parameters observing the intensity of motor vehicles;

- entry in the database of information about the buildings, their heights and sound absorption properties, which are barriers to sound propagation;
- acoustic calculations for two scenarios: the existing situation and taking into account activities;
- analysis of acoustic calculations and comparisons with hygienic standards.

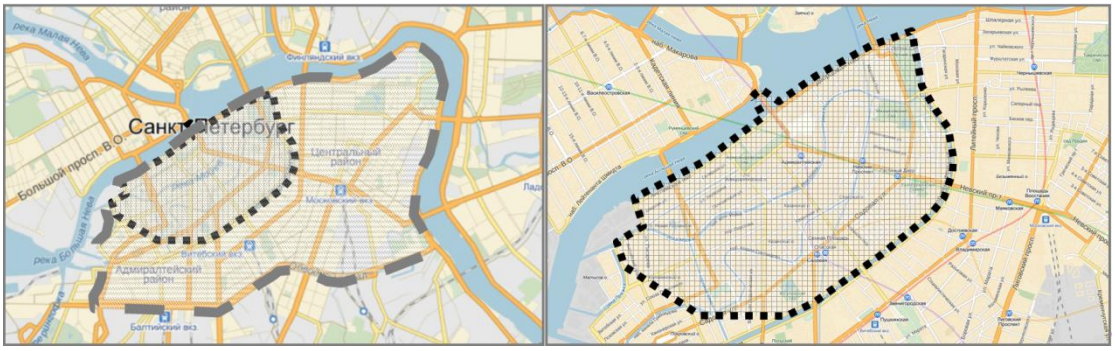
Development of project recommends various methods of noise protection for detailed planning of residential areas: a method of zoning – the removal of sources of noise from objects, shielding of noise sources, etc.

2. The results of calculations of noise levels when the vehicular traffic will be limited in the central part of the city Saint Petersburg

Recently the question of limiting vehicular traffic in the city center of St. Petersburg is debated. For a substantiation such a decision are often used environmental factor. Organization of foot zones in the central, historic part of St. Petersburg is an important task requiring study and assessment of such decisions. The results of such an assessment, conducted by the authors, are given below.

At the beginning of research the real urban development situation and the boundaries of the study area were analyzed and road traffic flows on the main roads, located in the central part of the city, were measured.

The central part of St. Petersburg is the territory of the city, situated in the two administrative regions – Central and Admiralty – which is bounded on the west, north and east of the Neva River, and from the south – by-channel (Fig. 1a). The situation was modeled: in the central part of the city, between the river Neva and Fontanka (Fig. 1b), traffic is limited. The size of this area is 7 km^2 or 30% of the entire territory of the central part of the city.



a) b)

Fig.1 The central part of the city

a) (▬ ▬) the central part of the city, b) (▪▪▪▪▪▪ **)** area of the city, which is supposed to limit the movement of vehicles

The maximum intensity of traffic in the central part of the city was 4,700 vehicles per hour – on the Nevsky Prospekt, the average rate – 2,150 vehicles per hour. Number of diesel cargo transport in the road transport stream was an average of 9%.

It was considered that the vehicles will move to nearby streets. It was also taken into account the maximum data throughput of streets. The model took into account the redistribution of traffic10 roads. The list of streets and data on changes in the characteristics vehicles traffic is given in Table 1.

Table 1
Changes in the average intensity and speed if it will be possible limitation movement in the central part of St. Petersburg

№	Street name	Changing of average intensity	Changing of movement speed
1	Fontanka river emb.	an increase of 26%	a decrease of 20%
2	English emb.	an increase of 65%	a decrease of 43%
3	Sadovaya str.	a decrease of 94%	an increase of 20%
4	Bolshaya Morskaya str.	a decrease of 85%	an increase of 71%
5	Nevsky pr.	a decrease of 98%	an increase of 100%
6	Gorokhovaya str.	a decrease of 94%	an increase of 71%
7	Admiralteyskaya emb.	an increase of 65%	a decrease of 33%
8	Dvortsovaya emb.	an increase of 65%	a decrease of 25%
9	Decembrists travel	a decrease of 96%	an increase of 50%
10	Liteyniy pr.	an increase of 13%	a decrease of 25%

Figure 2 shows the location of the surveyed streets, changing the intensity of vehicles and noise sources.

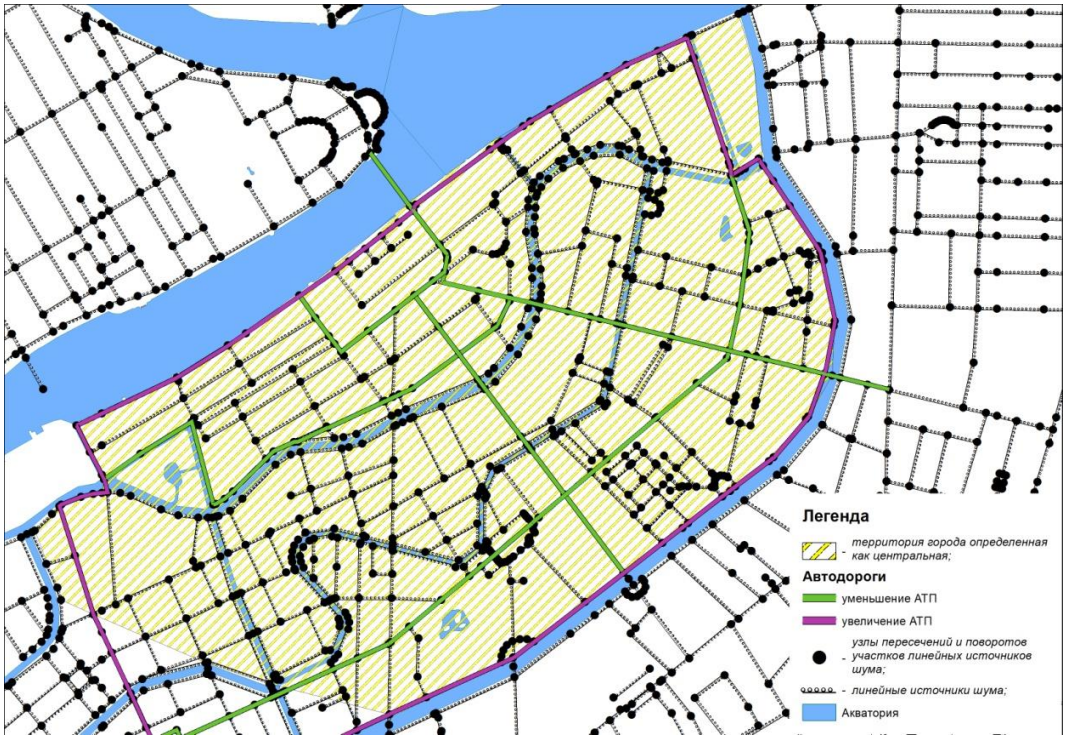


Fig.2 The location of the surveyed streets, changing the intensity of vehicles and noise sources

Table 2
Changes in the average intensity and speed, the noise characteristics of the example 2 streets

No	Object	Intensity, ed./hour	Average flow speed, km/h	Sound pressure levels (power, if R = 0), dB, in octave bands with geometric mean frequencys in Hz									La, dBA
				31.5	63	125	250	500	1000	2000	4000	8000	
1	Nevsky pr. (existing situation)	4719	30	72,3	78,8	74,3	71,3	68,3	68,3	65,3	59,3	46,8	72,7
2	Nevsky pr. (a decrease of number vehicle)	100	60	68,9	75,4	70,9	67,9	64,9	64,9	61,9	55,9	43,4	69,2
Changes		▼98%	▲10%	▼3,4	▼3,4	▼3,4	▼3,4	▼3,4	▼3,4	▼3,4	▼3,4	▼3,4	▼3,5
3	Fontanka river emb. (west side) (existing situation)	1338	40	72,0	78,5	74,0	71,0	68,0	68,0	65,0	59,0	46,5	72,3
4	Fontanka river emb. (west side) (an increase the number of vehicle)	1692	30	73,1	79,6	75,1	72,1	69,1	69,1	66,1	60,1	47,6	73,4
Changes		▲20%	▼25%	▲1,1	▲1,1	▲1,1	▲1,1	▲1,1	▲1,1	▲1,1	▲1,1	▲1,1	▲1,1

The noise maps as well as noise levels at the control points located in residential areas near roads and in yard territories were obtained for two scenarios: first on the basis of field studies on the composition and intensity traffic, second – on forecast of limiting vehicle traffic.

Results: The equivalent sound levels near residential buildings (buildings located at a distance of 5-10 m from the road) before conducting traffic restrictions higher sanitary standards at 10 - 19 dBA for the daytime [9]. Noise levels decreased by approximately 5 dBA after limit the movement of vehicle. But it's not enough. Hygienic standards for daylight hours are not complied with, the standards are exceeded by 3,7 - 16,7 dBA (Fig. 3 - 5). In the central part of the city are arranged low-rise buildings, width of pavement – about 3 - 6 meters high traffic vehicles. Noise occurring on the roadway highway extends not only to the territory of the residential buildings, but also deep into the residential area.

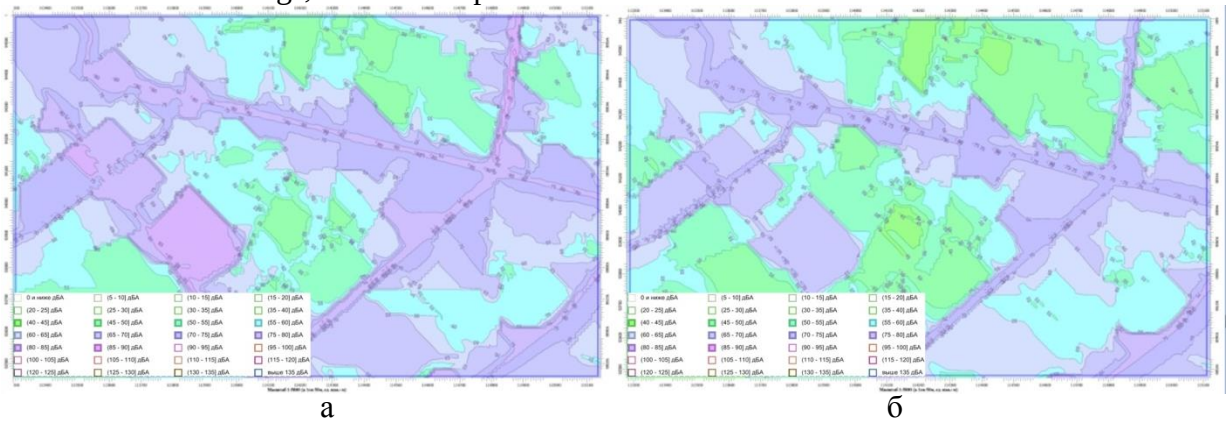


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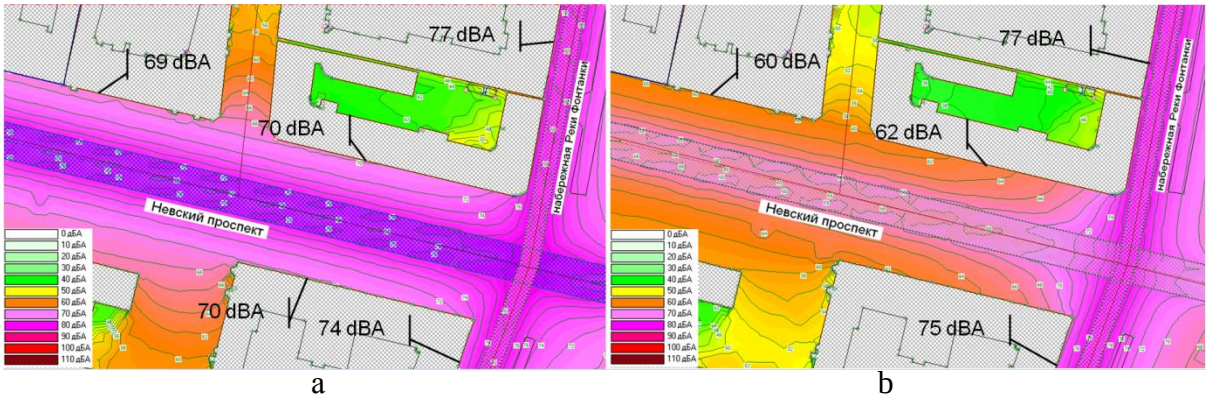
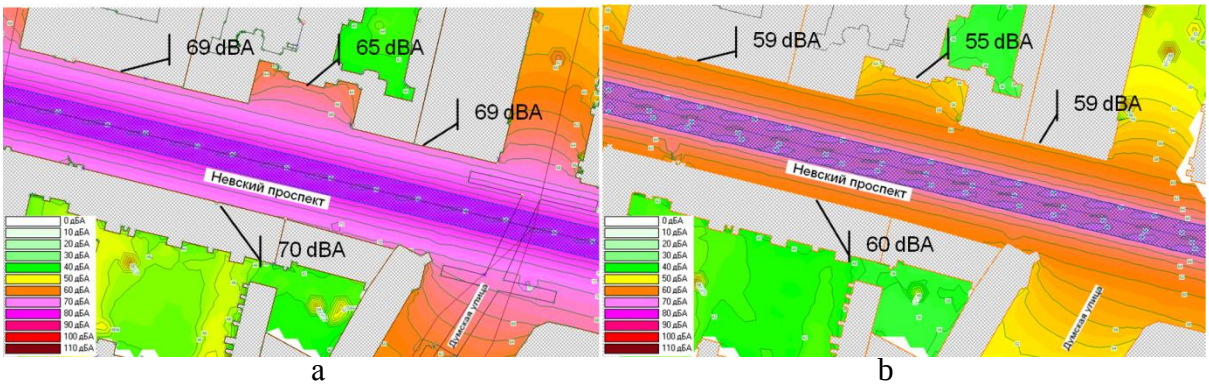
Fig. 3 Noise map of the downtown area
(a) the existing situation, (b) subject to the restrictions of movement



a b

Fig. 4 Fragment the noise maps near the Nevsky Prospekt and the Fontanka River (a) the existing situation (b) subject to the restrictions of movement



a b

Fig. 5 Fragment the noise maps near the Nevsky Prospekt (a) the existing situation (b) subject to the restrictions of movement

It should be noted that the calculation of the maximum ground-level concentrations of pollutants that come from the flue gases car, have been conducted also. Before the event the maximum ground-level concentrations of nitrogen dioxide reached near homes 2 - 3 of maximum permissible concentrations. After introducing limits traffic on the studied streets the maximum surface concentrations slightly decreased and made 1,5-2 of maximum permissible concentrations, which is the excess of the hygienic criteria of air quality. The traffic will increase on the streets where traffic will come. But the roads capacity of these streets are not changed, so the speed of movement will decrease and traffic jams can be on these roads. This leads to increased concentrations of carbon monoxide (CO).

Conclusion

The restriction of movement of vehicles can reduce impact, noise, and values of the maximum concentrations near streets with restricted movement, but at the same time can increase the negative impact on the near streets, where will be redistributed transport stream. In general, this measure is not enough to match hygienic and sanitary standards. The complex of environmental measures will contribute to decrease in the maximum ground-level concentrations and levels of noise for such a big city like St. Petersburg. Measures like an improving fuel, classes environmental performance of vehicles, the development of the road network with traffic organization based estimate of environmental consequences of the proposed activities.

Creating and using a noise map will promote the adoption of timely and correct management decisions for the territorial planning and development of the city, the introduction of modern technological means to reduce noise, creation and use of noise maps will promote the adoption of timely and correct management decisions for the territorial planning and development of the city, the introduction of modern technological means of reducing noise as vehicles and materials used in the construction of buildings to protect the public from exposure to high noise.

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12. Публикации Европейского Агентства по окружающей среде (ЕАОС) являющегося агентством Европейского Союза (The European Environment Agency (EEA) is an agency of the European Union).