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ON DEVELOPMENT OF SYSTEM FOR ENVIRONMENTAL MONITORING OF ATMOSPHERIC AIR QUALITY

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The article suggests the directions for development of the system of environmental monitoring of atmospheric air quality in the Russian Federation, namely: an increase in the number of stationary control posts for atmospheric pollution in each specific city; expansion of the list of cities where constant measurements of pollutant concentrations are conducted; expansion of the list of controlled impurities through the introduction of automated air quality monitoring systems, the development of computational methods for monitoring air quality, including not only information on pollution levels in terms of compliance with hygienic standards, but also assessment of pollution levels from the perspective of environmental risk to the health of the population. There is a great sensitivity of plants to the low quality of atmospheric air in comparison with the sensitivity of animals and humans. The air quality standards for vegetation are given. It is proposed to evaluate the quality of atmospheric air not only from the point of view of the impact on human health, but taking into account the impact on vegetation, to include in the program route observations carried out by mobile atmospheric air monitoring laboratories, territories with public green areas, which will increase the information content of atmospheric air monitoring and the state of green spaces. In connection with the increasing noise level in large cities and the lack of a permanent noise monitoring system, it is proposed to equip existing and new monitoring stations with noise level meters to provide reliable information for the development of relevant environmental measures.

Key words: air quality monitoring, automated monitoring systems, noise level measurement, state of green areas, health risk assessment of the population

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Introduction. The quality of atmospheric air in the cities of many countries is one of the most acute environmental problems of our time. Deterioration of the air condition of cities due to emissions of energy, industry and transport complex has a negative impact on both public health and the environment as a whole. The quality of the components of the environment is estimated from the monitoring data carried out within the framework of state environmental monitoring. In this regard, there is a need for constant control of the quality of atmospheric air.

State environmental monitoring (state ecological monitoring) is a comprehensive system for observing the state of the environment, estimating and forecasting changes in the state of the environment under the influence of natural and anthropogenic factors [19].

Currently, they general conduct the monitoring of the atmospheric air condition at the territory of the cities of the Russian Federation, but not in every city. According to the FSEEM «Voeikov Main Geophysical Observatory» information, a regular network of the state service for monitoring atmospheric pollution in the Russian Federation in 2013 consisted of 694 stationary observation stations for checking the level of atmospheric pollution, and the number of monitored cities is 252. Depending on the scope of work at the Territorial Administrations for Hydrometeorological and Environmental Monitoring they control the level of 14 – 34 impurities [7].

Thus, the increase in the number of stationary control posts for atmospheric pollution in each specific city, the expansion of the list of cities where constant measurements of pollutant concentrations are being conducted, and the increase in the list of controlled impurities is one of the urgent tasks of developing environmental monitoring.

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Directions of development of the system of environmental monitoring of atmospheric air quality. One of the first tasks is the introduction of automated systems for monitoring the quality of atmospheric air, since up to now the acquisition of information on atmospheric air pollution on Roshydromet networks was mainly focused on taking samples of air in the absorption devices and aerosol filters – manual methods for determining the chemical composition of the atmospheric air. At present, air quality assessment using an automated continuous monitoring system is performed in single cities of the Russian Federation [1, 2]. It should be noted that the development of automated systems (AMS) is one of the main directions of the strategy of activities in the field of hydrometeorology and related areas for the period until 2030 [17].

Automatic stations for atmospheric air monitoring function continuously and allow regular input of latest and immediate information on the concentration of pollutants, in contrast to the use of manual sampling. The technical support of the AMS consists of pavilions of stations, a measuring complex (analyzers, air sampling systems, meteorological sensors), data processing and transmission systems (modems, computers), «life support systems» for stations (power supply, heating and air conditioning, security alarms, and lighting).

With all the positive aspects of the existing approaches to the organization of laboratory (instrumental) atmospheric air monitoring of industrial cities, such systems have a number of shortcomings, primarily related to the limited information component both in the set of tested substances and the number of sampling points. For example, in Saint-Petersburg there are three systems for measuring atmospheric air, implemented by Rospotrebnadzor, the Hydrometeorological Service and the Committee for Nature Management, Environmental Protection and Ensuring Environmental Safety of the Government of Saint-Petersburg, which cover (together) about 90 posts and three dozen substances. At the same time, according to the inventory and calculations of industrial emissions received in the course of environmental design work in the city, more than 450 substances should be considered relevant for hygienic and environmental analysis, and since Saint-Petersburg is located on an area of 1439 km^2, the existing observation posts are not able to provide adequate information on air pollution with spatial detail required by modern standards for spatial details [4, 16].

At the same time, not sufficient amount of attention is paid to calculation methods of air pollution monitoring in the set of means for monitoring atmospheric air, although in some areas (for example, determining the required size of the sanitary protection zones of industrial enterprises, developing environmental documentation), positive experience has been accumulated. Calculation methods based on approved initial information and calculation methods allow to conduct a correct analysis of the current, retrospective and prospective situation with the required spatial detail and meet the objectives of risk-based technologies of sanitary and environmental supervision.

It should also be noted that in the system of assessment criteria for the level of atmospheric air pollution, the leading place is given to hygienic standards (MAC and SRLI), which indicates the established anthropocentric trend of standardizing environmental factors. However, hygienic standards cannot fully be the criteria for environmental and sanitary and epidemiological well-being, since their values are often the result of a management decision based on a compromise that takes into account the real capabilities of the business community and scientific research data on the health hazards of different factors, entering the human habitat. That is why compliance with hygienic standards does not guarantee environmental and sanitary-epidemiological well-being, but only characterizes the level of compliance of the habitat with established requirements, and to assess the effectiveness of environmental tasks and the state of the sanitary-epidemiological population, it is necessary to clearly maintain hygienic standards from the standpoint of environmental risk to the health of the population.

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According to the current legislation, the use of the methodology for risk assessment is described in the Resolution of the Chief State Sanitary Doctor of the Russian Federation of 10.11.97 N 25 and the Chief State Inspector of the Russian Federation for Nature Protection of 10.11.97 N 03-19/24-3483 «On the use of risk assessment methodology for quality management of environment and health of the population in the Russian Federation» and developed in the official «Guidelines for assessing the health risks of the population when exposed to chemicals that pollute the environment «(Guidelines R2.1.10.1920-04).

Assessment of the risk to public health in the analysis of environmental quality implies, as it is done in international practice, the implementation of four main stages:

- hazard identification;
- exposure assessment;
- assessment of relation «dose-effect»;
- risk profile.

At present, this logic of stages has been used since 2009 by the Committee for Nature Management, Environmental Protection and Ensuring Environmental Safety of the Government of Saint-Petersburg, where data on 36124 sources of emissions taken as priority, 72 % of which are organized, are used as the reference database. At the same time, it was found that 455 substances are supplied to the atmospheric air from these sources. The calculated grid is defined with a step of 500 m and covers the territory in 5041 km^2. In the course of this monitoring, calculations are made of the maximum one-time and average annual concentrations for emission of all substances, and carcinogenic and non-carcinogenic (acute and chronic) risks are assessed, and contamination is assessed according to the olfactometric criterion (the odor threshold) [8, 14].

It should be noted that there is no comprehensive assessment of air pollution on the quality of green areas in our country. Analysis of the results of air monitoring taking into account the criteria for maximum permissible air pollution for green spaces will allow developing a system for monitoring the state of green areas in cities. The inclusion in the program of observations, which are carried out by mobile air monitoring laboratories, public green area territories, will increase the information content of monitoring of atmospheric air and the state of green areas. In this regard, it is advisable to develop mobile atmospheric pollution control laboratories, in addition to stationary atmospheric pollution stations, which can carry out measurements in various parts of the city, taking into account the current environmental situation, to carry out measurements not only in residential areas, but also in recreation areas, parks, gardens and etc. The development of computational monitoring will allow to assess the quality of atmospheric air anywhere in the city, including parks, gardens, green areas in terms of compliance with environmental standards.

Discussion on the introduction of environmental standards in the practice of atmospheric protection activities has been conducted in our country since the end of the last century [6, 11, 12]. The Law of the Russian Federation «On the Protection of Atmospheric Air» [19] introduced a definition of the environmental quality standard for atmospheric air (Article 1) and defined the objectives of establishing environmental standards for the quality of atmospheric air (Article 11).

The environmental quality standard of atmospheric air is a criterion for the quality of atmospheric air, which reflects the maximum permissible content of harmful (polluting) substances in atmospheric air at which there is no harmful effect on the environment. Environmental quality standards for atmospheric air include the maximum one-time, average daily and average annual concentrations of pollutants in the air, which are established based on the sensitivity of various elements of the ecological system [19].

Environmental standards for air quality should be aimed at preserving natural ecological systems, natural landscapes and natural complexes, green areas of cities, which on the one hand are the «lungs» of cities, on the other hand they themselves are exposed to negative air quality.

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Table 1

Maximum permissible air pollution for green areas on the territory of Moscow

Harmful substance (pollutant)	Phytotoxic MAC, mg/m^3	
	One-time maximum	Average daily
Sulphur dioxide	0.100	0.05
Nitrogen dioxide	0.09	0.05
Ammonia	0.35	0.17
Ozone	0.47	0.24
Hydrocarbons	0.65	0.14
Carbon monoxide	6.7	3.3
Benz(a)pyrene	0.0002	0.0001
Benzene	0.1	0.05
Suspended substances	0.2	0.05
Hydrogen sulfide	0.008	0.008
Formaldehyde	0.02	0.003
Chlorine	0.025	0.015

The vegetation is the most sensitive element of the ecological system subjected to air pollution, its sensitivity exceeds the sensitivity of animals and humans, having a low ability to detoxify absorbed pollutants and a specific response to specific pollutants. The high sensitivity of plants to harmful impurities in atmospheric air is due to a significant difference in metabolism in higher plants and animals [9, 15]. All green plants are autotrophs, i.e. organisms synthesizing from inorganic compounds (mainly from water, carbon dioxide, inorganic nitrogen compounds) all the organic substances necessary for life, using the energy of photosynthesis. All animals and humans use ready-made organic substances for their food, i.e. are heterotrophs. It is the presence of photosynthetic apparatus in plants that explains the greater sensitivity of plants to the low quality of atmospheric air [11].

For the territory of the Russian Federation, there are no approved environmental quality standards for atmospheric air, but for some regions such regulations have been approved. The standards of maximum permissible air pollution for green areas on the territory of Moscow [10] are given in Table 1.

In many foreign countries, environmental legislation has been developed and is currently in effect, including the establishment of air quality standards for both humans and the environment.

In foreign countries, air quality standards have been established for pollutants recognized as the most dangerous. At the same time, the standards are set for different time intervals, which is probably adapted to air quality control systems currently acting in each country.

In international environmental activities, they use the term «critical level» (CLE) – the concentration in the atmosphere of a pollutant above which unfavorable effects on individual plant species and the ecological system as a whole occur. The goal of the critical levels is to protect the functioning of the plant community.

The critical levels of SO_2, NO_2, NH_3 for different vegetation types were adopted by the World Health Organization in 2000 [21]. For example, for lichens, the annual critical level of SO_2 is 0.01 mg/m^3, for forest ecological systems it is 0.02 mg/m^3, for agricultural crops – 0.03 mg/m^3.

In the European Union, the critical values of the content of pollutants in the ambient air for the protection of human health and for the protection of the environment (vegetation) are established to normalize the quality of atmospheric air.

For vegetation the critical values of SO_2 content are 0.020 mg/m^3, ozone – 0.006 mg/m^3, NOx – 0.030 mg/m^3.

In the United States, primary and secondary air quality standards have been established to normalize the quality of atmospheric air. Primary standards are aimed at protecting human health, including vulnerable groups of population such as children, the elderly and people suffering from respiratory diseases. Secondary air quality standards are designed to protect public welfare (for example, building facades, crops, and domestic animals). The values of primary and secondary national air quality standards for different time intervals are given in Table 2.

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Given the urgency of urban improvement, namely, the conservation of existing and newly planted green spaces in the city, it is advisable to assess the quality of atmospheric air in terms of impact not only on human health, but taking into account the impact on vegetation.

Table 2

Values of national quality standards of atmospheric air in the USA, mg/m^3

Harmful substance, mg/m^3	Averaging time, h	Primary standards	Secondary standards
SO_2	24	0.365	–
	Yearly	0.08	–
	3	–	1.30
Solid particles (SP_{10})	24	0.15	0.15
Solid particles ($SP_{2.5}$)	24	0.035	0.035
	Yearly	15	15
CO	1	40	–
	8	10	–
O_3	1	0.235	0.235
	8	0.235	0.235
NO_x	Yearly	0.10	0.10
	Quarterly	1.5	1.5

The next problem having impact on the state of the environment, especially in large cities, is noise pollution. This is due to existence of a variety of sources of noise: the source of noise is any process that causes local pressure changes or mechanical vibrations in solid, liquid and gaseous media. Machines and mechanisms are technogenic sources of sounds of different frequency and intensity, varying in time. The main sources of external noise are traffic flows on the streets and roads, railway, water and air transport, industrial and energy enterprises and their equipment and installations, local open space noise sources (transformer substations, central heating points, facilities and storeyards of different shops, sports and playgrounds, etc).

Noise pollution negatively affects people's health, leads to specific and nonspecific changes in the human body. According to the European Environment Agency, noise pollution created by traffic flows is one of the major environmental health problems; ambient noise causes at least 10,000 premature deaths in Europe every year [22].

The normative act of the Russian Federation, which establishes the criteria for the safety and (or) harmlessness to the human of the factors of his habitat and the requirements for ensuring favorable conditions for his life, are sanitary rules, norms and hygienic standards [18], which establish the classification of noise; normalized parameters and maximum permissible noise levels at workplaces, permissible noise levels in residential premises, public buildings and on the territory of residential buildings in the Russian Federation (Table 3).

Table 3

Acceptable sound pressure levels, sound levels, equivalent and maximum sound levels of noise penetrating the residential and public buildings and noise in the residential construction area

Types of work activity, work place	Time of day, h	Levels of sound pressure, dB, in octave bands with center frequencies, Hz									Levels of sound and equivalent levels of sound, dBA	Maximum levels of sound, L_{Amax}, dBA
		31.5	63	125	250	500	1000	2000	4000	8000		
Territories directly adjacent to residential buildings, policlinic buildings, outpatient clinics, dispensaries, rest homes, boarding houses, boarding homes for the elderly and disabled, children's pre-school institutions, schools and other educational institutions, libraries	7-23	90	75	66	59	54	50	47	45	44	55	70
	23-7	83	67	57	49	44	40	37	35	33	45	60
Residential rooms of apartments, living quarters of holiday homes, boarding houses, boarding houses for the elderly and disabled, sleeping rooms in preschool institutions and boarding schools	7-23	79	63	52	45	39	35	32	30	28	40	55
	23-7	72	55	44	35	29	25	22	20	18	30	45

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The state of noise pollution of atmospheric air in the cities of the Russian Federation is determined periodically: when justifying the boundaries and sizes of sanitary protection zones (SPZ) of enterprises, and also on the basis of studies conducted on complaints of residents about the increased noise level. This information (in printed from) is stored in the territorial bodies of the Rospotrebnadzor. These studies were mainly conducted in Moscow. Periodic monitoring of noise levels is also carried out in other cities (for example, in Stain-Petersburg, Murmansk) [3, 5].

Despite the relevance of this topic and the approved standards, permanent comprehensive monitoring of the impact of noise of different origin, performed to exclude, prevent or reduce the harmful effects of noise on human beings and the environment in the cities of the Russian Federation is not being conducted.

One possible way to solve the problem of high noise pollution is to monitor the acoustic situation in order to determine the main sources of noise for the development of noise protection measures. Regular assessment of noise levels is necessary for a comprehensive assessment of the physical impact on the state of atmospheric air.

To measure all possible noise characteristics, special noise meters are used, which make it possible to measure sound intensity levels in decibels within a wide range.

The sound meter is composed of a high-quality microphone, wideband amplifier, sensitivity switch, that changes the gain in steps of 10 dB, the switch of frequency characteristics and dial gauge, which scale is directly calibrated in decibels. The front panel of sound level meters in addition to the main controls generally have available slots, allowing you to connect to a different scheme options: the frequency and amplitude analyzers, filters, recorders and other devices. From Russian sound level meters of industrial production, we can name devices like MIU, SHA-63, SH-3M, SH-71, ISHV-1.

The main technical requirements for noise meters, which are recommended to be installed at monitoring posts, are the following:

• measurement of sound levels with an accuracy of 1 dBA;

• possibility of use with all-weather protective devices;

• automated transfer of measured parameters to the computer and further to the control and analysis center.

Equipping existing and new monitoring stations with noise level meters is necessary to ensure input of reliable information on the basis of a permanent monitoring system for the development of appropriate environmental measures, which is the basis for environmental safety for many residents, especially large cities of the country.

This information can be used both to improve the existing system of instrumental monitoring, and to serve as a basis for calculating monitoring – the construction of noise maps of cities. The results of such calculations contribute to timely and correct management decisions in terms of territorial planning and development of cities, protection of the population from increased noise impact.

The figure shows the proposed scheme for the organization of environmental monitoring of atmospheric air quality.

The technical support for the monitoring and interaction of the components of the environmental monitoring system lies in the modular organization of information processing, which involves the integration of external sources of primary data, long-term information stored in internal databases, models for transforming information according to accepted methods and means of displaying the results of calculations.

The components of the environmental monitoring system consist of the following main elements:

• measuring equipment:

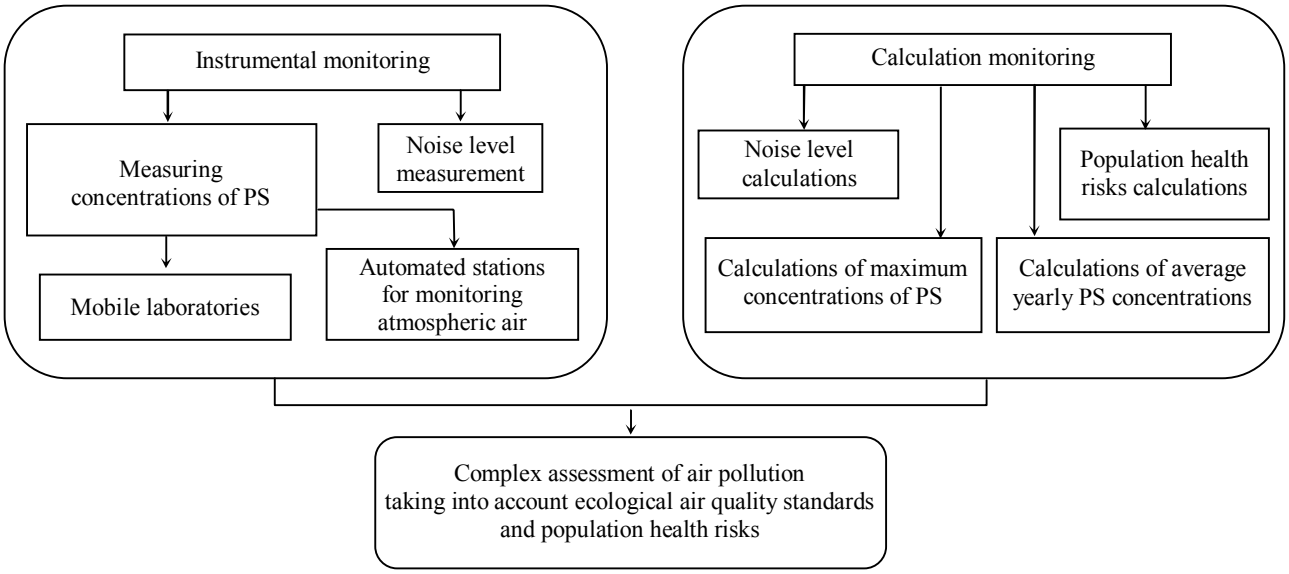
– gas analyzers at monitoring stations that measure a certain list of polluting substances (PS);

– sound level meters at monitoring posts that measure the main standardized parameters from non-permanent sources of noise;

• devices for primary data processing, providing accumulation and initial monitoring of measurement data directly at monitoring posts;

• data transmission devices using a telecommunication system;

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The suggested system for organization of ecological monitoring of atmospheric air quality

• software for collection and secondary monitoring of measurement data on the server of the data collection and analysis center;

• software for calculating the ground field concentrations of pollutants in the air, assessing the health risks of the population, and noise levels.

To measure concentrations in the ambient air of polluting substances in automatic mode, monitoring devices require the use of concentration measurement instruments and devices that control the operation of the atmospheric monitoring station, as well as the collection, processing, storage and transfer of information via communication lines to a computer and then to the analysis management center.

The conclusion. Modern air monitoring network in Russia performs measurements of concentrations of various pollutants. Nevertheless, there are a number of problems associated with the technical equipment of monitoring stations, insufficient provision of analytical laboratories with modern measuring instruments. Moreover, Roshydromet monitoring system and its methods with manual sampling do not meet modern requirements for the transfer of latest and immediate information on air pollution.

Taking into account the urgency of the problem of air pollution, these shortcomings indicate the need for the development and modernization of the monitoring network in Russia, the introduction of automated systems for the continuous measurement of the content of the main pollutants, the development of new and revision of existing measurement methods, and the improvement of processing, storage and transmission of information.

The most promising air monitoring systems are those that are based on the conscientious use of calculation and instrumental methods for assessing its pollution, and as assessment criteria not only hygienic standards are used, but also the methodology of risk assessment, environmental standards.

Since noise pollution is a growing problem of the state of the environment, equipping existing and new monitoring stations in large cities of the Russian Federation with noise level meters will help provide reliable information for the development of relevant environmental measures.

Improvement of the existing system of environmental monitoring by regular measurements of noise levels, construction of noise maps of the city, development of AMS for checking air quality, the results of which will be used to assess the impact on human health and the state of green areas, will reduce uncertainties and increase information in the process of making management decisions.

Improving the quality of the environment is a complex, multifaceted problem that requires global and local efforts to solve it. The development and use of modern Russian instruments for control and monitoring of the environment makes it possible to obtain objective knowledge about the quality of the environment.

REFERENCES

1. Volkodaeva M.V. Levkin A.V. Use of results of summary calculations for improvement of quality monitoring systems of atmospheric air in cities. *Uchenye zapiski Rossiiskogo gosudarstvennogo gidrometeorologicheskogo universiteta.* St. Petersburg, 2012. N 26, p. 27-31 (in Russian).

2. Volkodaeva M.V. The use of geoinformation technologies for optimization of the location of air quality monitoring stations. *Zapiski Gornogo instituta.* 2015. Vol. 215, p.107-114 (in Russian).

3. Volkodaeva M.V. Il'ina Ya.A. On measuring the noise impact of road traffic (the example of St. Petersburg). Tekhnicheskie nauki: sovremennyi vzglyad na izuchenie aktual'nykh problem: Sb. nauchn. trudov po itogam Mezhdunar. nauchn.-praktich. konf., 25 iyulya 2016. Astrakhan', 2016, p. 110-115 (in Russian).

4. Volkodaeva M.V., Shpakova E.N. Use of the results of calculations of the dispersion of pollutants in the atmospheric air of the city to assess the quality of atmospheric air. Okhrana okruzhayushchei sredy i ekologicheskoi bezopasnosti v Sankt-Peterburge v 2007 g. Komitet po prirodopol'zovaniyu i okhrane okruzhayushchei sredy i obespecheniyu ekologicheskoi bezopasnosti Sankt-Peterburga. St. Petersburg 2008, p. 214-220 (in Russian).

5. Volkodaeva M.V., Levkin A.V., Demina K.V. Use of noise maps of the city to select management decisions to regulate traffic flows. *Teoriya i praktika shuma*. Voenmekh im.Ustinova. St. Petersburg, 2015. Vol. 1. N 1, p. 22-31 (in Russian).

6. Temporary standards for the maximum allowable concentrations of pollutants in the air, which have a harmful effect on forest plantations in the area of the museum estate «Yasnaya Polyana». VNIILM. Moscow, 1984, p. 12 (in Russian).

7. Yearbook of atmospheric pollution in cities in Russia in 2012 Pod red. E.Yu.Bezugloi. Rosgidromet. Moscow, 2013, p. 247 (in Russian).

8. Kiselev A.V., Fridman K.B. Health risk assessment. Approaches to use in medico-ecological research and practice of environmental quality management. St. Petersburg: Deita, 1997, p. 100 (in Russian).

9. Method for determining the maximum permissible concentration of harmful gases for vegetation. Moskovskii lesotekhnicheskii institut. Moscow, 1988, p. 15 (in Russian).

10. MGSN 1.02-02. Norms and rules for the design of complex landscaping in the territory of Moscow. Moscow, 2002, p. 70. Available at: http://www.kodeks.ru (data of access 15.09.2016) (in Russian).

11. Nikolaevskii V.S., Miroshnikova A.T. Permissible standards of air pollution for plants. *Gigiena i sanitariya*. 1974. N 4, p. 16-18 (in Russian).

12. Nikolaevskii B.C. Ecological assessment of environmental pollution and state of terrestrial ecosystems using phytoindication methods. Moskovskii gosudarstvennyi universitet lesa. Moscow, 2002, p. 220 (in Russian).

13. Review of the status of work on monitoring atmospheric air pollution in 2013. Glavnaya geofizicheskaya observatoriya im. A.I.Voeikova. SPb, 2014, p. 136 (in Russian).

14. Rakitin I.A., Mel'tser A.V., Kiselev A.V., Erastova N.V., Vladimirova E.I. The practice of applying an aerogenic risk assessment for public health to substantiate priority measures for air quality management in St. Petersburg. Ed. A.P.Shcherbo. Khlopinskie chteniya: Materialy XXXXIV nauchnoi konferentsii. St. Petersburg: Izd-vo SPbMAPO, 2011, p. 134 (in Russian).

15. The maximum permissible concentrations of pollutants in the ambient air of forest tree growth zones. Moskovskii gosudarstvennyi universitet lesa. Moscow, 1995, p. 5 (in Russian).

16. Kiselev A.V., Pan'kin A.V., Sorokin N.D., Laikhtman V.I., Chigaleichik S.A. Calculation methods in the system of assessing the health risk of the population associated with air pollution. Gigienicheskie i mediko-profilakticheskie tekhnologii upravleniya riskami zdorov'yu naseleniya: Materialy 2-i Vserossiiskoi nauchno-prakticheskoi konferentsii. Perm', 2011, p. 147-151 (in Russian).

17. Decree of the Government of the Russian Federation of September 3, 2010 N 1458-r «Strategy of activities in the field of hydrometeorology and related areas for the period up to 2030 (taking into account aspects of climate change)". Moscow, 2010. Available at: http://www.kodeks.ru (data of access 15.09.2016) (in Russian).

18. SN 2.2.4/2.1.8.562-96. Noise in workplaces, in residential, public buildings and residential buildings. Informatsionno-izdatel'skii tsentr Minzdrava Rossii. Moscow, 1997, p. 12 (in Russian).

19. Federal Law N 96-FZ of 04.05.99 «On the Protection of Atmospheric Air». Available at: http://www.kodeks.ru (data of access 15.09.2016) (in Russian).

20. Federal Law of 10.01.2002 N 7-FZ «On Environmental Protection». Available at: http://www.kodeks.ru (data of access 15.09.2016) (in Russian).

21. Air Quality Guidelines for Europe. WHO Regional Publications no 91, World Health Organization, Copenhagen. Available at: http://www.euro.who.int/en/home (date of access 15.09.2016).

22. The European Environment Agency (EEA) is an agency of the European Union. Available at: http://www.eea.europa.eu/ru/publications (date of access 15.09.2016).

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