

Increasing the efficiency of atmospheric air control in urban areas with developed engineering and chemical clusters

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Abstract. The article gives an example of organizing independent monitoring of atmospheric air using a mobile environmental laboratory. An approach to the formation of the technical characteristics of a mobile laboratory, as well as a methodology for determining the conditions for the departure of the laboratory, is described. The main results of the mobile laboratory are shown, the exceedances of maximum permissible concentrations found and recommendations developed to ensure a radical reduction in the level of atmospheric air pollution on the example of the urban district of Tolyatti are shown.

1 Introduction

According to the RBC news portal, in 2020 Russia set a record for air pollution [1]. Already in November, the number of cases of atmospheric pollution was three times higher than the previous year. The most polluted regions were Samara, Orenburg regions and Buryatia.

Due to the rapid development of enterprises in the automotive, metallurgical, chemical, energy and processing industries, the increase in vehicles has led to an increase in the level of atmospheric air pollution, which is in contact with residents of single-industry towns on the territory of which the above enterprises are located. The negative consequences for the population when inhaling such air, in addition to unpleasant sensations (soreness in the nose, the presence of an unpleasant odor), contribute to the development of respiratory diseases, allergies, chronic respiratory diseases, and in the long term, cause reproductive dysfunction in women and the development of developmental pathologies in women. children.

Thus, the quality of atmospheric air is one of the most important components of a healthy life for people. Consider the environmental situation and ways to improve it using the example of the city of Togliatti as one of the largest single-industry towns in the Russian Federation.

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2 Materials and methods

The city of Tolyatti, located in the Samara region of Russia, is a large industrial center, largely represented by the automotive and chemical industries. The largest enterprises of the machine-building and chemical cluster are located on the territory of Togliatti: OJSC AvtoVAZ, which is a city-forming enterprise, and no less significant LLC Togliattikauchuk, PJSC KuibyshevAzot and PJSC Togliattiazot. The concentration of large industrial enterprises leads to a high anthropogenic load on the ecological environment of the city.

In order to determine the main toxicants characteristic of the city of Togliatti, based on the existing production facilities, a research work was carried out "Comprehensive determination of the composition of atmospheric air in the urban district of Togliatti" [2]. The table shows data on toxic properties and maximum allowable concentrations of a number of toxicants typical of the atmospheric air of large cities, including the city of Togliatti.

Table 1. Data on toxic properties and maximum allowable concentrations of a number of toxicants typical of the atmospheric air of large cities, including the city of Togliatti.

Substance	Effect on the body	MPC (OBUV) m.r/d.s, mg/m ³
1.	2.	3.
Nitrogen oxide	They are blood poisons, affect the central nervous system	0.4/0.06
Nitrogen dioxide		0.2/0.04
Sulfur dioxide	Causes spasms of the bronchi, irritates the respiratory tract.	0.5/0.05
Carbon oxide	Displaces oxygen from hemoglobin, reduces the supply of oxygen to body tissues.	5.0/3.0
Ammonia	Eye and nasal irritation, sneezing, facial flushing, sweating	0.2/0.04
Hydrogen sulfide	Very low threshold of sensation 0.0012mg/m ³ . Dangerous addictive to the smell. Affects the central nervous system	0.008/-
Soot	Prolonged inhalation of coal dust leads to lung damage	0.15/0.05
Suspended solids	Human exposure depends on dust particle size and composition. Fine dust with a high content of silicon oxide causes the greatest damage to health. enters the deep respiratory tract	0.5/0.15
Limit and unsaturated hydrocarbons	The most inert among organic compounds	200/50 (C ₁ -C ₅) 50/5 (C ₆ -C ₁₀)
Benzene	They affect the central nervous system, gastrointestinal tract, hematopoietic organs, and have narcotic properties. Benzene is the most dangerous.	0.3/0.1
Toluene		0.6/-
<i>m</i> -, <i>p</i> -, <i>o</i> -Xylenes		0.2/-
Ethylbenzene		0.02/-
Styrene		0.04/0.002
α -Methylstyrene		0.04/-
Phenol	When inhaled, 60 to 80% is retained in the lungs. Causes irritation of the respiratory tract, indigestion, itching, insomnia.	0.01/0.006
Acetophenone	It has the smell of bird cherry, at high concentrations causes a decrease in pressure, irritation of mucous membranes.	0.01/-
Formaldehyde	Irritate the upper respiratory tract	0.05/0.01
Acetaldehyde		0.01/-
Benzaldehyde		0.04/-
Cyclohexanol	Causes irritation of mucous membranes, easily penetrates the skin, causes swelling of mucous membranes and dermatitis.	0.06/0.06
Cyclohexanone	Has a narcotic and irritant effect	0.04/-
Methanol	Substance of moderate toxicity	1.0/0.5
Benz(a)pyrene	They are carcinogenic substances that cause liver dysfunction, leukocytosis, a decrease in hemoglobin in the blood.	-/0.001 $\mu\text{g}/\text{m}^3$
Isopropyl alcohol	Prolonged exposure to high concentrations of isopropanol vapor in the air causes headache, irritates the eyes and respiratory tract. It has a depressant effect on the central nervous system. Prolonged inhalation of air with a concentration significantly exceeding the MPC can cause loss of consciousness.	0.6

In order to ensure the operational control of atmospheric air in the territory of Togliatti, a mobile environmental laboratory (PEL) operates. It is important to note the approaches to the formation of the PEL configuration - controlled substances were coordinated at the

working group on the development of measures aimed at improving the environmental situation in the Togliatti urban district, created by a decree of the head of the Togliatti urban district. This process was carried out through a combination of three main aspects (Figure 1):

- Accounting for identified toxicants identified during the implementation of the research work "Comprehensive determination of the composition of atmospheric air in the urban district of Tolyatti" (Table 1).
- Analysis of draft standards for maximum permissible emissions of pollutants into the atmospheric air, developed by the main industrial enterprises of the machine-building and chemical cluster.
- Accounting for available measuring instruments capable of promptly monitoring atmospheric air and those entered in the state register of measuring instruments.

The mobile environmental laboratory of Togliatti State University is the main mobile tool for monitoring atmospheric air pollution. PEL is capable of measuring a large number of substances such as: suspended solids (PM1; PM2.5; PM4; PM10), ammonia (NH₃), nitric oxide (NO), nitrogen dioxide (NO₂), hydrogen sulfide (H₂S), sulfur dioxide (SO₂), carbon monoxide (CO), as well as organic substances: formaldehyde, a mixture of saturated hydrocarbons CH₄-C₅H₁₂ and C₆H₁₄-C₁₀H₂₂, phenol, benzene, toluene, xylenes, α -methylstyrene, styrene, ethylbenzene, acetone, methanol, propanol-2, butanol.

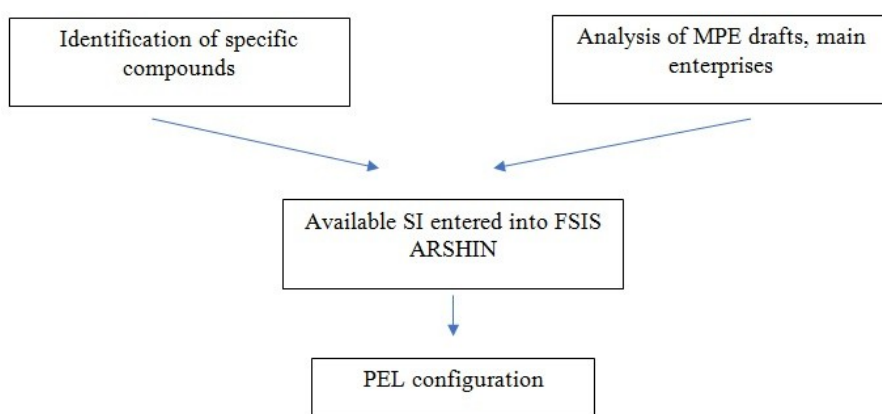


Fig. 1. Algorithm for forming the configuration of a mobile ecological laboratory for air pollution control.

In addition to the listed substances, laboratory specialists can use portable devices GANK-4 to analyze a wide range of substances: gasoline, butan-1-ol, butyl acetate, methanol, acetone, solvent - naphtha, white spirit, saturated hydrocarbons C₁₂-C₁₉, ethanol, ethyl acetate, hydrogen fluoride, methyl mercaptan, lead and its inorganic compounds, chlorine, trichlorethylene, acetic acid. Also, using the foreign device Nasal Ranger, laboratory staff can measure the intensity of odor in the atmospheric air.

The mobile laboratory cooperates with government agencies, scientific institutions and industrial enterprises to provide reliable control and monitoring of air quality in the city. As part of its work, the laboratory conducts regular measurements of harmful emissions in the atmospheric air, potential sources of which may be the above enterprises and vehicles. The decision to conduct measurements is made by the administration of the city of Togliatti based on the receipt of at least 5 complaints from the population, while these complaints must come from one territorial area (for example, residents who sent complaints live on the same street). In addition, when adverse weather conditions are announced, the

administration can send PELs for predictive sampling. Measurements carried out by the Mobile Ecological Laboratory make it possible to accurately determine the content of harmful substances in the air and timely identify and control sources of pollution. This helps to take the necessary measures to reduce industrial emissions and protect public health.

One of the main advantages of the Mobile Laboratory is its mobility. Thanks to this, it can quickly and effectively respond to changes in the environmental situation and carry out the necessary measurements anywhere in the city. In addition, the laboratory has qualified specialists who are ready to help industrial enterprises in solving air pollution problems.

To inform the public about the state of the atmospheric air, an interactive system operates (Figure 2), which displays the results of measurements of a mobile environmental laboratory [3].

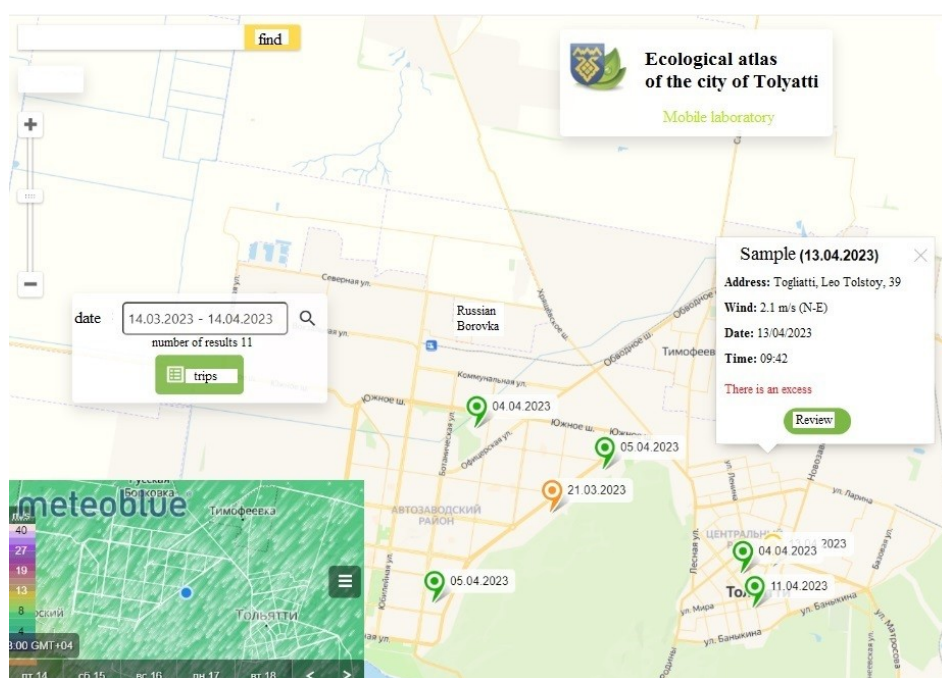


Fig. 2. Ecological atlas of Togliatti, showing the results of measurements of a mobile environmental laboratory.

3 Results and Discussion

The results of the work of the Mobile Ecological Laboratory for 2022.

In 2022, the Mobile Ecological Laboratory made 142 trips with 3692 analyzes in total for all of the above substances, of which 21 exceeded maximum permissible concentrations were detected [4]. Some of the most frequently detected substances were ethylbenzene, carbon monoxide and isopropyl alcohol.

Ethylbenzene is used in the production of rubber products, plastics, paints, varnishes, resins, as well as in the oil refining and petrochemical industries. Ethylbenzene is also used to increase the octane number of gasoline. Its emissions can occur as a result of production activities, as well as in the process of fuel combustion [5].

Isopropyl alcohol is used as a solvent, surface cleaner, as well as in the production of paints and varnishes and pharmaceuticals, fragrances. Just like ethylbenzene, isopropyl

alcohol can be used as a fuel additive to increase the octane number. Its emissions can occur both as a result of production and during the use of vehicles [6].

Carbon monoxide is a product of the incomplete combustion of carbonaceous substances such as natural gas, gasoline, fuel oil and coal. It is a dangerous gas that can lead to poisoning at high concentrations. Emissions can occur both as a result of industrial activities and when using vehicles, as well as during the combustion of firewood and other solid fuels [7].

Recommendations aimed at improving the environmental situation in large industrial cities.

The proposals were based on the results obtained during field measurements of atmospheric air, as well as an analysis of the practices of other cities that have similar problems and complaints from the population related to atmospheric air quality. At the same time, the list of measures was discussed at the working group on the development of measures aimed at improving the environmental situation in the Togliatti urban district, created by a decree of the head of the Togliatti urban district with the involvement of representatives of public organizations. The involvement of public figures in such issues is an important point, since environmental problems in large cities often contribute to an increase in social tension among the population of cities. All proposed measures are systematized in the context of the following main 5 blocks: a block of measures aimed at reducing emissions of pollutants from vehicles, a block of measures aimed at reducing emissions from industrial enterprises, a block of measures aimed at greening and beautification of the city, a block of measures related to the improvement existing legislative acts, a block of activities aimed at popularizing environmental issues [10].

4 Conclusion

The issue of air quality in large industrial cities is a socially important task for ensuring the health and well-being of the population. For example, when developing the “Strategy for the socio-economic development of Togliatti for the period until 2030”, the issue of ecology became a key development priority, since more than 81% of respondents, when conducting a survey organized as part of the development of the city development strategy, said that they were not satisfied with air quality in the city.

Although industry and transport are important elements of the economy, they are also major sources of air pollution. To normalize the environmental situation, it is necessary to improve production technologies, strengthen control and monitoring, support environmentally friendly production, and promote the use of alternative energy sources. Air quality control is an integral part of the sustainable development of the city. The mobile environmental laboratory plays an important role in this process, providing accurate and timely data on air quality and helping industrial enterprises reduce harmful emissions, as well as helping to raise public awareness of environmental issues and environmental protection.

The proposed approaches to solving environmental problems and the developed recommendations described in this article have been tested in the city of Togliatti and can be applied in other areas that have problems with air quality. At the same time, the number of complaints from the population related to atmospheric air quality has decreased by more than 40% since 2020 in the city of Togliatti.

However, this requires not only the efforts of state and municipal authorities, but also the active participation of industrial enterprises and the population. Only by joint efforts can we create an ecologically favorable environment and ensure the health and well-being of all city residents.

Acknowledgement

This article was supported by the Russian Science Foundation grant No. 23-29-10135.

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