Computer analysis of atmospheric air pollution by stationary and mobile sources

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Аннотация. *The article studies linear and nonlinear mathematical models of emissions from stationary and mobile sources that pollute the earth's atmosphere. These models make it possible to trace the dynamics of emissions for subsequent periods and make it possible to develop the necessary recommendations to reduce the level of atmospheric pollution.*

Ключевые слова: *Emissions, sources, mathematical models, forecasting, activities.*

Introduction

The negative impact that emissions of pollutants have on the quality of atmospheric air and the environment is a global problem that requires prompt solutions. Increased air pollution by emissions from mobile and stationary sources has a very negative impact on human health and the sustainability of ecological systems. The factors that weaken national security and hinder the development of the country are the following: social tension; decrease in labor activity; environmental disasters and catastrophes; environmental degradation and various diseases caused by it. Air pollution is the main risk factor for human health and makes it unsuitable for the respiratory process, technical needs and leads to long-term carcinogenic and mutagenic effects, somatic and infectious diseases, various poisoning. About 50% of all environmentally caused diseases are caused by chemical pollution of atmospheric air. In 2020, in 34 cities of the Russian Federation, which is 15% of the country's cities, the level of air pollution is high and very high . In 66% of cities, the level of pollution remains low. 9.6 million people live in cities with high and very high levels of atmospheric air pollution, which is 9% of the urban population. Total emissions of pollutants in 2020 decreased by 2.2% compared to 2019 and amounted (according to Rosprirodnadzor) to 22227.6 thousand tons, which is the minimum value for the period 2010-2020.

Emissions from stationary sources decreased compared to 2019 (17295 thousand tons) and amounted to 16951.5 thousand tons Also in 2020 there was a slight reduction in emissions from mobile sources – 5276.1 thousand

tons against 5440.1 thousand tons in 2019. The use of mineral resources and the activity of geological processes have a significant impact on the environment.

Extraction of solid minerals is accompanied by pollution of reservoirs, emissions of pollutants into the atmosphere, accumulation of mining waste. During the extraction and transportation of oil and gas, oil spills, soil and atmospheric air pollution with petroleum products are noted. The dynamics of the behavior of emissions from mobile and stationary sources serves as the basis for the formation and implementation of state policy in the field of environmental development of the Russian Federation, the identification of priority areas of activity of public authorities in this area, as well as for the development of measures aimed at preventing and reducing the negative impact on the environment.

Mathematical models make it possible to develop strategic recommendations and implement predictive actions to improve the efficiency of management of stationary and mobile sources of pollution.

Model development

The article studied and analyzed data on emissions of pollutants into the atmosphere from mobile and stationary sources in the period from 2010 to 2019, taken from [1]. The dynamics of emissions of gaseous and liquid substances, solid substances, as well as the dynamics of the behavior of emissions by types of economic activity were studied.

Data on atmospheric air pollution should be periodically entered into computer databases and processed by an automated system that includes various mathematical models that allow predicting the dynamics of atmospheric air pollution by mobile and stationary sources. The results of one-time measurements are used to prepare emergency and operational information about sudden changes in the level of pollution, as well as for forecasting during periods with adverse weather conditions. Within the framework of regime processing, the database management programs used provide analysis of long-term series of observations; allow comparison of initial and statistical data for a long-term period; calculate the index of atmospheric pollution and pollution trends. Atmospheric quality data processing programs allow us to calculate characteristics that can be used to control emissions of both operating and projected enterprises. The presentation of information is carried out mainly at the level of the statement of factual material. The depth of the analysis of the material, due, in particular, to the capabilities of the applied mathematical apparatus, is not always sufficient, which to a certain extent limits the circle of information consumers. The main deterrent until recently was the lack of mechanisms for

tracking the use of monitoring information and, as a result, the lack of feedback from consumers [2-5].

It is necessary to develop new databases and software tools for analyzing and processing information about environmental pollution stored in them.

Regression models describing the dynamics of pollution from emissions from stationary and mobile sources were constructed using tools [6-7]. Interpretation of the results obtained will make it possible to draw conclusions on forecasting changes in the amount of atmospheric air pollution.

Table presents the developed time series models with the best statistical characteristics. All emissions were measured in thousands of tons.

Таблица

Statistical parameters

Model equations	*RMSE*	*MAPE*	Accu-racy
The total volume of pollutants into the atmospheric air from mobile sources and stationary sources			
$Y = -72,724 \cdot t^3 + 1027,9 \cdot t^2 - 4193,6 \cdot t + 36550$	1482	4,18	95,82
The volume of emissions from stationary sources			
$Y = 28,178 \cdot t^2 - 584,27 \cdot t + 20158$	409,3	1,7	98,3
Volume of emissions from mobile sources			
$Y = -85,174 \cdot t^3 + 1205 \cdot t^2 - 4556,6 \cdot t + 17460$	1364	9,4	90,6
Total emissions of solid, gaseous and liquid substances from stationary sources			
$Y = 28,18 \cdot t^2 - 584,25 \cdot t + 20158$	409,5	1,7	98,3
Volume of emissions of gaseous and liquid substances from stationary sources			
$Y = 22,9 \cdot t^2 - 429,79 \cdot t + 17588$	375,1	1,68	98,31
Volume of solid emissions from stationary sources			
$Y = 5,3534 \cdot t^2 - 154,86 \cdot t + 2570,4$	51,57	2,25	97,75
The volume of emissions from stationary sources by type of economic activity: manufacturing			

Окончание таблицы

Model equations	*RMSE*	*MAPE*	Accuracy
$Y = 1,8948 \cdot t^2 + 81,029 \cdot t + 5615,9$	102,9	1,42	98,58
The volume of emissions from stationary sources by type of economic activity: mining			
$Y = -10,885 \cdot t^3 + 185,29 \cdot t^2 - 800,89 \cdot t + 5718,9$	239,7	3,8	96,2
The volume of emissions from stationary sources by type of economic activity: provision of electric energy, gas and steam, air conditioning			
$Y = -9,2144 \cdot t^2 + 254,72 \cdot t + 2630,5$	167,9	3,98	96,02
The volume of emissions from stationary sources by type of economic activity: hunting, fishing and fish farming, agriculture and forestry			
$Y = 1,542 \cdot t^2 - 34,259 \cdot t + 328,98$	18,25	5	95
Volume of emissions from stationary sources by type of economic activity: other			
$Y = 28,334 \cdot t^2 - 310,65 \cdot t + 3542,5$	96,3	2,59	97,41

These models allow us to estimate the amount of emissions from mobile and stationary sources.

Time series and nonlinear regression-type dependencies make it possible to effectively estimate the volume of atmospheric air pollution.

Conclusion

Time and regression models have been created and analyzed to predict the dynamics of the behavior of pollutant emissions. Based on the analysis, it is necessary to formulate proposals for the development of ecology in the Russian Federation, as well as to develop specific measures for the development of public administration in this area, including the development and implementation of national, federal and regional programs. It is required to carry out systematic development of research activities aimed at conducting scientific research in the field of environmental protection.

The results of the research can serve as a basis for the formation and implementation of state policy in the field of environmental development of the Russian Federation to determine the priority areas of activity of state authorities in this area, as well as to develop measures aimed at preventing the negative impact of economic and other activities on the environment and eliminating its consequences.

Forecast data on emissions are used in the preparation of draft state programs for the rational use of natural resources and environmental protection, as well as in the preparation of plans and programs for socio-economic development and land management schemes of administrative-territorial units.

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