CODEN [USA]: IAJPBB ISSN: 2349-7750

INDO AMERICAN JOURNAL OF
PHARMACEUTICAL SCIENCES

http://doi.org/10.5281/zenodo.1439316

Available online at: http://www.iajps.com Research Article

EVALUATION OF THE CITY AIR POLLUTION DURING UNFAVORABLE WEATHER CONDITIONS

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Abstract:

Calculated-instrumental methodology of ecological monitoring of the city air pollution by emissions from industrial enterprises and automobile transportation during unfavorable weather condition (UWC) is offered. The core of the methodology is to track the critical states of atmospheric pollution, a sign of which are high and very high degree of air pollution danger, expressed through the calculated complex index of atmosphere pollution (RKIZA).

Distinguished feature of the developed calculated-instrumental methodology of ecological monitoring of the city air pollution by emissions from industrial enterprises and automobile transportation during UWC is the refinement and addition of information collected using calculation methods, results of instrumental control, which are analyzed with regard to the necessity of reducing emissions of pollutants from industrial enterprises during UWC.

The developed methodology ensures the continuity of the environmental monitoring process due to time-dependent changes in the characteristics of motor transport flows that is recorded in field investigation and is taken into account in calculation assessment when compiling digital maps of the distribution of ground level concentrations of pollutants and when selecting control points.

The condition of continuity is also satisfied in the course of the instrumental assessment, which is necessary to refine the calculations results of maximum level-ground concentrations, zoning of digital maps according to the level of the calculated complex index of atmosphere pollution.

Keywords: *motor transport flows, unfavorable weather conditions, emissions of harmful substances, industrial enterprises.*

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Please cite this article in press Ilnar F. Suleimanov et al., ***Evaluation of the City Air Pollution during Unfavorable Weather Conditions.,*** *Indo Am. J. P. Sci, 2018; 05(09).*

1. INTRODUCTION:

Now, the problem of studying the ecological state of cities is becoming increasingly important. The relevance of this kind of study is dictated by the need to protect environment, to preserve a favorable ecological situation, and by the need for environmental management. Industrial production, having concentrated an enormous amount of various types of energy, harmful substances and materials, has become a constant source of technogenic hazards. In addition to stationary sources, emissions from automobile transportation cause serious damage to the environment condition [1-4].

Analysis of the atmospheric air condition in cities with developed manufacturing industries and motor transport infrastructure shows a tendency to deterioration of the environment quality. Dispersion of air pollution, created by the emissions from enterprises and vehicles, largely depends on meteorological conditions. In certain periods, when meteorological conditions contribute to the accumulation of harmful substances in the surface layer of the atmosphere, namely during periods of unfavorable meteorological conditions, emission concentration in the air can increase sharply. In this connection, the highest content of pollutants is observed during the period of UWC. The presence of zones with a large amount of pollutants during the UWC is due to lack of a comprehensive approach that requires registration and control of emissions from both industrial enterprises and vehicles [5-9].

The presented calculated-instrumental methodology of ecological monitoring of the city air pollution by emissions from industrial enterprises and automobile transportation during UWC implies the use of private methods of experimental research, due to the fact of high requirements to reliability and accuracy of the results. The following procedures were regulated: on-site investigation of motor transport flows, inventory of stationary emission sources, methods and number of air sampling, methods of laboratory-instrumental analysis, metrological characteristics of instruments and equipment, conditions of experimental study and processing of experimental data [10-13].

2. METHODS:

Provided by the city Mendeleevsk enterprises information on the actual sources of atmospheric pollution, their physical parameters and emission volumes, qualitative and quantitative composition of the emitted pollutants was collected, processed and systematized in order to assess the quality of air pollution in the city.

A survey of the moving traffic flow characteristics on 36 highways was conducted, 74 protocols of inspection of the composition and intensity of the moving motor road traffic flow for each section of the main transport artery were compiled.

The instrumental evaluation procedure includes measurements at control points near highways and at the boundaries of sanitary protection zones of stationary sources during UWC period.

Measurement of the pollutants content in the atmospheric air was carried out in accordance with the requirements described in the measurement techniques of the selected indicators (Table 1).

Table 1 - General characteristics of applied techniques

Name of substance	Regulatory document	Method of measurement
Nitrogen dioxide	The instruction manual for the gas analyzer "Elan" (EKIT 5.940.000 IM)	Electrochemical
Carbon monoxide		

Measurement of carbon oxide and nitrogen dioxide concentrations was carried out by a direct method using gas analyzers "Elan".
Monitoring of temperature, pressure, wind speed is carried out using the meteorometer "MES-2".

5 priority pollutants are identified based on the analysis of dispersion results. According to these substances, a calculated complex index of atmospheric pollution is defined. The calculated complex index of atmospheric pollution is calculated, using the following formula:

$$CCIAP_5 = \sum_{i=1}^{5} \left({Cc}/{MAC} \right)^{\beta_i}$$

$$CCIAP_5 = \sum_{i=1}^{5} \left({Cc}/{MAC} \right)^{\beta_i}$$

where i – impurity;

β_i – a constant for various classes of danger on reduction to the degree of dioxide sulfur harm;

C_c – calculated concentration of i-impurity.

Table 2. The level of air pollution that depends on levels of the air quality indicators.

level of air pollution	$CCIAP_5$
low	0–4
rather high	5–6
high	7–13
very high	≥14

RESULTS AND DISCUSSION:

Provided by the city enterprises information on the actual sources of atmospheric pollution, their physical parameters and emission volumes, qualitative and quantitative composition of the emitted pollutants was collected, processed and systematized to assess the quality of evaluation of the city air pollution. When collecting information, the following data were used:

- results of the emission inventory;
- data on emissions from enterprises based on the results of departmental and state ecoanalytical control;
- statistical reporting on the form of "2TP - air";
- draft standards of maximum permitted emissions (MPE).

The data on emissions from urban vehicles are obtained as a result of motor transport flows inventory.

Ranking of pollutants from industrial emissions in Mendeleevsk showed that the gross emission of substances of the hazard class 1 amounts to 3.3 tons from the total mass of emissions, substances of the hazard class 2 amounts to 33.1 tons, substances of the hazard class 3 - to 180.6 tons, substances of the hazard class 4 - to 1678.9 t, with determined approximately safe level of impact (ASLI) - 4343.2 t.

Dispersion calculation for 79 pollutants and for 14 summation groups was performed; digital distribution maps of ground-level concentrations of pollutants in the territory of Mendeleevsk were compiled.

The following concentration of pollutants on the territory of Mendeleyevsk is predicted: sodium sulfite 0.71 MPC, hydrogen sulfide 0.7 MPC, nitrogen dioxide 0.55 MPC, hexavalent chromium (expressed as chromium 3-oxide) 0.54 MPC, soluble salt of barium (acetate, nitrate, nitrite, chloride) 0.53 MPC, barium sulfate (expressed as barium) 0.50 MPC, hydrogen chloride (hydrochloric acid) according to the HCl molecule 0,44 MPC, calcium chloride 0,44 MPC, sulfurous anhydride 0,39 MPC, amorphous silicon dioxide 0.36 MPC, sodium sulfate 0.31 MPC, phenol 0.19 MPC, iron oxide (expressed as iron) 0.19 MPC, carbon oxide 0.18 MPC.

The main contribution to gross emissions from sources of the enterprise is made by: sulfurous anhydride - 324.9 tons, carbon oxide - 208.3 tons, nitrogen dioxide - 182.9 tons, sodium sulfate - 121.8 tons, ethyl alcohol - 66.2 tons.

The content in the atmospheric air was monitored at Gassar Street from the south-west side of the chemical factory in Mendeleevsk. Carbon oxide and nitrogen dioxide measurements were carried out during UWC and under normal meteorological conditions.

Results of instrumental measurements found no excess of the maximum single MPC for the analyzed pollutants. After statistical processing, results of the measurements are summarized and presented in the form of Table 3.

Table 3 – Results of instrumental measurements

№	Date of sampling	Index/measure	Nitrogen dioxide	Carbon oxide
1	2	3	4	5
1	11.07.2017	C	0,06	0,85
		C/ maximum single MPC	0,30	0,17
2	12.07.2017	C	0,08	1,05
		C/ maximum single MPC	0,40	0,21
3	13.07.2017	C	0,07	1,11
		C/ maximum single MPC	0,35	0,22
4	14.07.2017	C	0,14	2,41
		C/ maximum single MPC.	0,70	0,48
5	17.07.2017	C	0,12	2,75
		C/ maximum single MPC.	0,60	0,55
6	18.07.2017	C	0,08	1,06
		C/ maximum single MPC	0,40	0,21
7	19.07.2017	C	0,07	0,81
		C/ maximum single MPC	0,35	0,16
Average		C	0,09	1,43
		C/ maximum single MPC	0,44	0,29
Maximum		C	0,14	2,75
		C/ maximum single MPC	0,70	0,55
Minimum		C	0,06	0,81
		C/ maximum single MPC	0,30	0,16

The average value for nitrogen dioxide concentration coefficient according to maximum single MPC totaled 0.44, maximum value - 0.70, minimum value - 0.30. During UWC the average coefficient for nitrogen dioxide concentration according to maximum single MPC was 0.65, maximum value was 0.70, minimum value - 0.60. Under normal meteorological conditions, for nitrogen dioxide the average concentration coefficient according to maximum single MPC was 0.36, maximum value was 0.40, and minimum value was 0.30.

For carbon oxide, the average value of the concentration coefficient according to maximum single MPC totaled 0.29, maximum value was 0.55, and minimum value was 0.16. During UWC the average value for carbon oxide concentration coefficient according to maximum single MPC was 0.52, maximum value - 0.55, minimum value - 0.48. Under normal meteorological conditions for carbon oxide, the average concentration coefficient according to maximum single MPC was 0.20, maximum value was 0.22, and minimum value was 0.16.

Chart of changes in the concentration of carbon oxide and nitrogen dioxide is shown in Fig. 1.

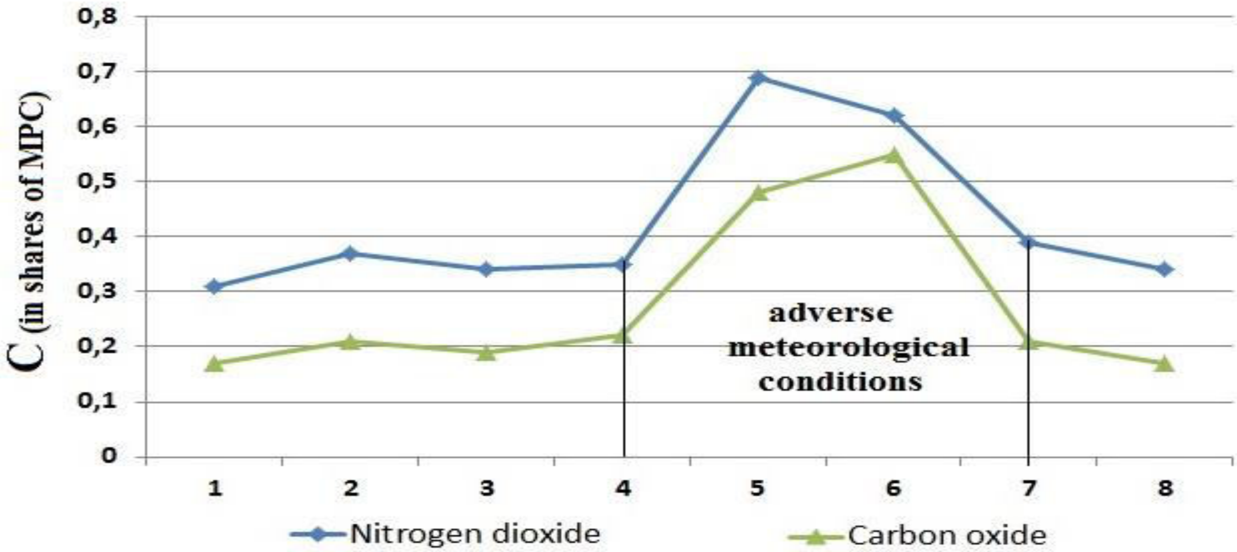

Figure 1 – Chart of changes in the concentration of carbon oxide and nitrogen dioxide

The increase in the concentration of carbon oxide and nitrogen dioxide is related to unfavorable meteorological conditions.

Based on the results of instrumental and calculated evaluation, Mendeleyevsk digital map is divided into zones according to the level of atmospheric air pollution based on the calculated complex index of atmosphere pollution (RKIZA) (Figure 2). Territories of the city with the levels "very high", "high" and "elevated" during UWC amount to 17%, 21% and 26% respectively. Pollution of the air basin within this area is mainly formed by enterprises of the chemical complex (more than
(90%)

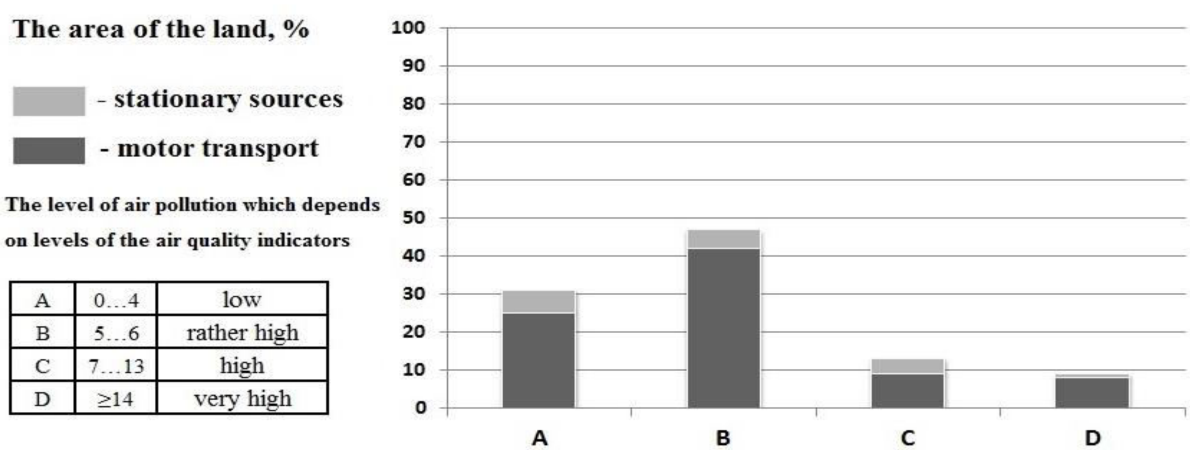

Figure 2 – Results of calculation and instrumental environmental monitoring of Mendeleevsk territory.

SUMMARY:

The work outlines new scientifically grounded solutions that are of significant importance for the development of rationing system of pollutant emissions in industrial cities during unfavorable weather condition in order to ensure compliance of quality of atmospheric air with sanitary standards and requirements.

Database of physical parameters, qualitative and quantitative composition of pollutants, actual amount of emissions from existing air pollution sources of Mendeleevsk enterprises was established.

In order to ensure compliance of atmospheric air quality with regulatory requirements, it is necessary to reduce the actual amount of pollutants emissions by 20...67 % that will allow reaching "low" level of atmospheric air pollution according to the calculated complex index of atmosphere pollution (RKIZA).

CONCLUSION:

The purpose of the developed calculated-instrumental methodology of ecological monitoring during UWC is to continuously monitor the behavior of the system "and to monitor critical conditions, the sign of which is a high and very high hazard degree of the air pollution level, expressed by the calculated complex index of atmospheric pollution.

Distinguished feature of the developed methodology is the refinement and addition of information obtained by calculation methods, results of instrumental control that are analyzed for the purpose of establishing a limit on pollutant emissions from industrial enterprises as a result of emission limitation.

ACKNOWLEDGEMENTS:

The work is performed according to the Russian Government Program of Competitive Growth of Kazan Federal University.

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