Anthropogenic aerosols of urbanized areas and their effects on human health

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A methodological basis for mapping the pollution levels of an urban air basin averaged over extended periods has been worked out. The urban area of Belovo, Kemerovo region, was taken as an example for analyzing the relationship between pollution parameters of the atmosphere of remote sectors of the city and the occurrence of different forms of disease among the population of those sectors. A clear correlation with the pollution parameters of the air basin is observed. The developed approach is of practical importance for establishing regional policy of ecological safety.

For many regions of Siberia anthropogenic aerosol is the dominant factor of pollution of the environment. Kuzbass territory is a typical example, where the dust content of the atmosphere creates a direct threat to human health. The action of the aerosol factor is of a prolonged, chronic nature. With the exception of cases of large-scale technogenic catastrophes, the chronic nature of the action of pollutants in the atmosphere of an industrialized city is the main factor determining the state of human health.

In order to establish the nature of the effect of aerosol pollution on occurrences of illness in the general population, data are needed on mean concentration levels of toxic substances in the near-ground layer of the atmosphere in various sectors of the city. It is necessary to average the pollutant concentration levels over sufficiently long time periods, such as a season or a year.

The problem arises of determining the weighted-mean chronic doses of toxic substances contained in anthropogenic aerosol, and of determining correlations between the parameters of atmospheric pollution and individual forms of illness observed among the inhabitants of the investigated regions. The qualitative and quantitative characteristics of the pollution of the air basin of the city are distinguished by significant inhomogeneity. This circumstance makes it possible to perform a correlation analysis with the aim of establishing the causes of the appearance of various forms of pathology.

Studies were conducted in the urban area of Belovo in Kemerovo Region. The main source of atmospheric pollution of the city is a battery of boiler houses spread out over the entire territory. Our methodological scheme for solving the stated problem is the following. Taking into account the inhomogeneity of the distribution of sources of pollution of the air basin and the significant remoteness of the regions, one from the other, the built-up area was divided up into six ecological sectors, distinguished from one another by the nature and number of pollution sources located in them. Next, with the help of climatological models we constructed a map of the pollution of the air basin of each ecological sector. Concentration levels were averaged over season and year. The corresponding medical information was obtained from the medical records of children in the Belovo urban area. As a result, we determined the various correlations between the concentration levels of various aerosol toxic substances and various epidemiological indicators in the investigated sectors.

The development of climatological models makes it possible to determine the concentrations of pollutants over long time scales such as an year, a month, a season. Average concentrations were found using the formula

$$\bar{C}(x, y) = Q \, \Sigma \, \psi_i \, C_i(x, y) \ ,$$

where Q is the intensity of the emission source, ψ_i is the distribution function of the repeatability of the meteorological conditions, $C_i(\mathrm{x}, y)$ is the specific concentration of the ith state.

Average values of the concentrations $\bar{C}$ over a prescribed time period were calculated using the formula

$$\bar{C}(R, n) = P_n \, C(R, n) \ ,$$

where R is the distance from the source and n is the number of the wind direction; $C(R, n)$ is the limiting axial concentration; P_n is the repeatability of the wind directions for the nth direction. The limiting axial concentrations were calculated in accordance with the OND–86 branch standard.

Figure 1*a* shows a map depicting how the city of Belovo is divided up into individual ecological sectors, while Fig. 1*b*, by way of an example, shows a map depicting the pollution of the air basin of the Central sector of the city. The period of averaging was one year. So that the map constructed on the basis of the model calculation reflect real pollution levels, we tuned the model to the experimental data of Ref. 1. As the experimental data for tuning the model, we used the

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results of an analysis of snow samples for content of the dangerous toxic substance benz(a)pyrene.

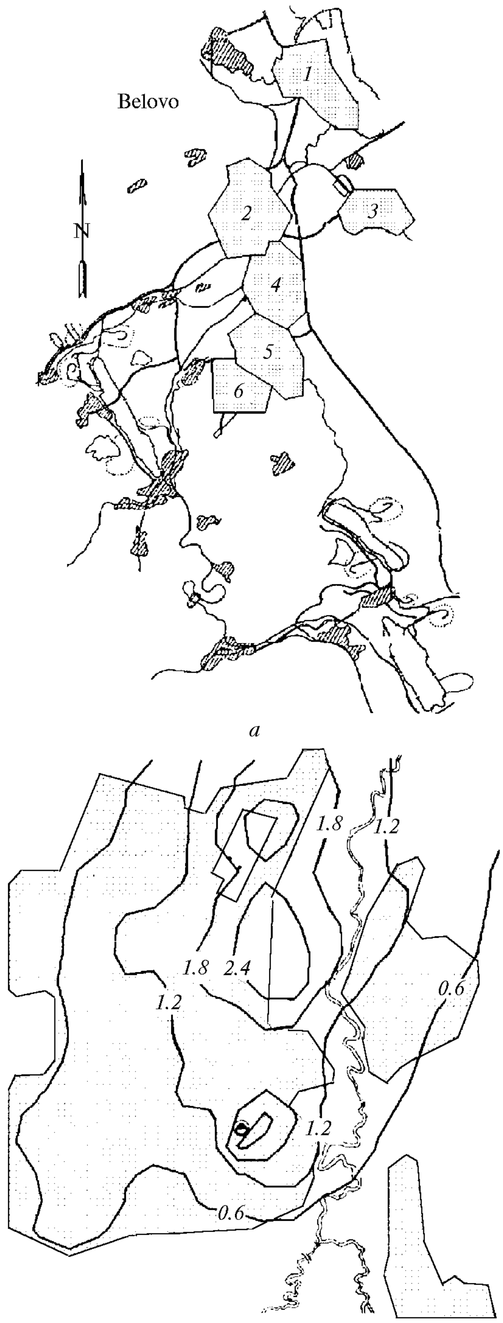

Fig. 1. Sectorization of the air basin of the Belovo urban area: (a) schematic map of relative locations of the ecological sectors: Gramoteino (*1*), Central (*2*), Inskii (*3*), Babanakovo (*4*), Chertinskii (*5*), and Novyi Gorodok (*6*); (b) sample map of pollution of the air basin of the Central sector (averaged over one year, the figures labeling the isocontours indicate the concentration of suspended particles in mg/m^3).

In its own way, snow cover plays the role of a "photographic plate," reflecting an averaged picture of aerosol contamination of the air basin. Snow samples carry a large amount of valuable information about the nature of the aerosol pollution and the toxic substances contained in the aerosol particles. In order to make use of this information, various inverse-problem solution methods were employed, as described in Ref. 2.

Thus, employing a map of the distribution of average concentration levels of aerosol toxic substances in the air basin of the city and information provided by medical facilities about the incidence of various forms of illness among the general population, it is possible to perform a correlation analysis with the aim of establishing correlations between the manifestation of various forms of illness and environmental factors.

Figures 2*a* and 2*b* present histograms for two forms of the pathologies we investigated in the urban area of Belovo. The histogram shown in Fig. 2*a* compares the distribution of cancer of the lungs and bronchi over the indicated urban sectors with the total level of pollution of the air basin of these regions. The total was defined to include the concentrations of the five main pollutants of the atmosphere: benz(a)pyrene, sulfur dioxide, nitrogen dioxide, carbon monoxide, and suspended particulates. The concentration levels of these toxic agents are expressed as fractions of their maximum acceptable levels (MAL's). Figure 2*b* presents a histogram of the incidence of bronchitis and laryngitis in children. As can be seen from an analysis of Figs. 2*a* and 2*b*, a clear correlation is observed between the parameters of morbidity and atmospheric pollution.

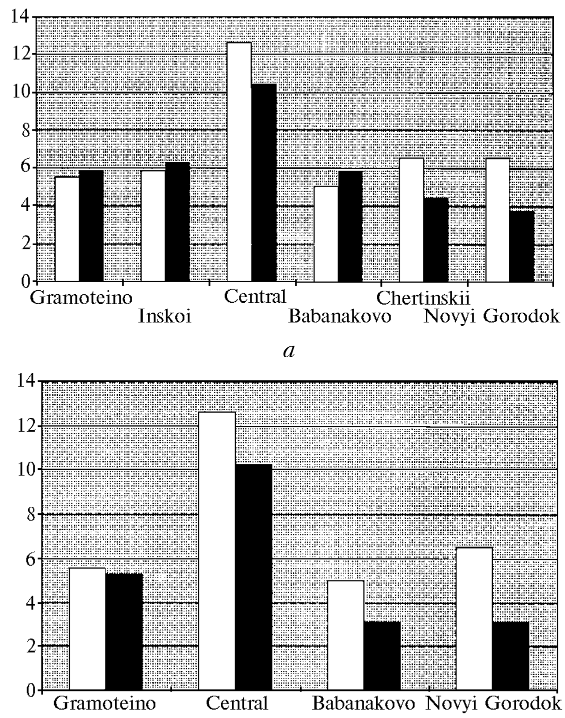

Fig. 2. Histogram of atmospheric pollution levels and incidence of illness in the population by sectors: malignant tumors of bronchi and lungs (*a*), laryngitis and tracheitis among children (*b*). Scale of the ordinate axis in arbitrary units: pollution level (light columns), incidence of illness (dark columns).

The methodological approach developed here has a number of important potential applications in the formation of the ecological policy of urbanized areas with human safety in mind. The potential opens up of solving such problems as protection and medical rehabilitation of populations living in ecologically unfavorable regions, the prevention of outbreaks of illness due to seasonal ecological factors; optimization of emissions with the aim of reducing the threat to the health of nearby populations; and, finally, determining the specific harm to the level of health of inhabitants caused by a specific industrial installation.

References

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