COMPARATIVE STUDY OF THE AEROSOL SPECTRA IN THE GROUND ATMOSPHERIC LAYER OVER ALTAI REGION

V.G. Monoshkina and I.A. Sutorikhin

Scientific–Research Institute of Ecological Monitoring at Altai State University
Institute for Water and Ecology Problems,
Siberian Branch of the Russian Academy of Sciences, Barnaul
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Some results of a field study of the microphysical parameters of aerosol in the ground atmospheric layer over Altai region are presented. Particle size distributions and diurnal behavior of the aerosol particle number density in an industrial center and rural area are discussed. The influence of natural and anthropogenic factors on the near–ground atmospheric aerosol is discussed.

The atmospheric pollution in Altai region exposed to radioactive precipitations due to the nuclear tests in Semipalatinsk nuclear test fields made the ecological studies in Altai region to be an urgent task, especially as concerning the accumulation of toxic materials there.

As known, aerosol most easily penetrates into a human body because of breathing. Toxic agents adsorbed by the surface of aerosol are captured along the respiratory tract. The following dependence has been established between the aerosol size and its penetration depth into the body. From 70 to 90% of particles with 7 to 10 μm diameter are captured in the nasopharynx and windpipe.[1] As was noted in Ref. 1, the small particles of 0.1 μm diameter are normally exhaled. Thus, neither large nor small particles penetrate deep into the lungs. As was found in such studies, the particles with 0.3 to 5 μm diameter are most dangerous among the respirable aerosols since they penetrate into the alveolar part of lungs; about 30 to 35% of these particles are captured there and then being dissolved they get into the blood.

During the field study of near–ground aerosol microphysics undertaken from 10th till 30th of July, 1992, at 15 localities of Altai region we have got information on the aerosol number density and size spectra. A particle counter PKZV–906 used in our study provides measurements of aerosol particles number density in seven subranges of particle size. Brief characterization of the localities where the measurements were conducted is given in Table I.

The absence of large industrial enterprises except the mining plant in Gornyak is the main feature of the areas under study. For a comparison similar measurements have been carried out in the city of Barnaul during the period from September 11 till September 22, 1992. The population of Barnaul is about 800 000 people and there are more than 120 plants in the city. More than 50 pollutants, including those of the first and the second class of risk, are found in the atmospheric emissions in Barnaul.[4]

The experimental data on the aerosol size spectra were analytically approximated with a lognormal function of particles volume distribution over particle size, dV/dr. The values of the distribution function parameters, r_V and σ, and the mean number density, $\bar{N}$, of particles with radii from 3 to 100 μm are presented in Table II. For a comparison the same parameters r_V, σ, and $\bar{N}$ for a near–ground aerosol in the city of Alma–Ata[5] are also given in Table II.

TABLE I.

Locality	Population	Main production activity
Gornyak	15 871	mining
Altaiskii	12 808	food, textile
Belokurikha	11 445	food
Troitskoe	11 020	food
Smolenskoe	9326	food
Krasnogorskoe	6469	food
Veseloyarsk	5437	building materials
Togul	5423	timber, food, textile
Staroaleiskoe	4621	food, textile
Uglovskoe	4063	food
Solton	3361	food, timber
El'tsovka	3590	food
Zonal'noe	3322	food
Topol'noe	< 3000	food, timber
Zolotukha	< 3000	food

TABLE II.

Locality	Accumulative fraction		Coarse fraction		$\bar{N}$,
	r_V, μm	σ	r_V, μm	σ	cm^{-3}
Barnaul	0.32	1.33	2.2	1.3	103
Altai rural areas	0.32	1.4	2	1.33	32
Alma–Ata	0.35	1.38	2.04	1.28	100

To study diurnal behavior of aerosol particle number density we have conducted a daily cycles of measurements in Barnaul (April 1991) and in Uglovskoe (April 1992). Our experimental results are shown in Fig. 1. There are two distinct maxima (morning and evening) and two minima (day and night) in the curve presenting the diurnal behavior of aerosol in Barnaul, that agrees well with the data from Refs. 5 and 6.

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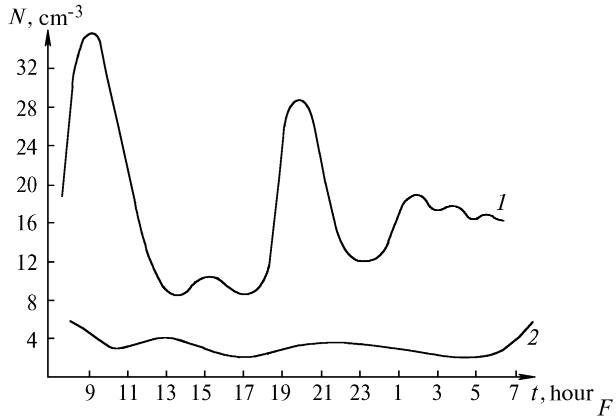

FIG. 1. Diurnal behavior of the aerosol number density: Barnaul (1) and Uglovskoe (2).

The results of particle number density measurements in Uglovskoe may be considered as presenting the aerosol background because there are no large industrial enterprises and local pollution sources nearby this locality.

For a comparative analysis of the experimental data, one should clearly realize that not only the pollution of anthropogenic origin influences the aerosol particle number density in a particular locality but the weather conditions also contribute into the formation of a local ecological situation. Thus, temperature stratification, wind regime, precipitations, air pressure and moisture can strongly affect the level of concentration of air pollutions in the ground atmospheric layer at a constant power of anthropogenic emissions.

As a rule, the cyclonic weather seasons characterized by plentiful precipitation and strong wind favor rapid cleaning of air. On the contrary, an increase in the concentration of pollutants in the ground atmospheric layer is often observed under stable, clear, and windless weather.

Thus, it can be stated based on the results of our investigations that in summer time the aerosol particle number density is not high in rural areas. The local weather conditions (the temperature inversions are only occasional in summer) and termination of heating (the stoves are the main source of anthropogenic pollution in villages) favor this circumstance.

This is not the case with aerosol in Barnaul where numerous aerosol sources emit the year round. The comparative analysis of our data for rural regions and Barnaul shows high level of pollution in the atmosphere over the city.

The mean number density of particles, $\overline{N}$, in Barnaul is three times higher than that in suburbs (see Table II).

The distribution function analysis (Fig. 2) confirms correct aerosol microstructure description in rural and urban areas as a superposition of two size spectra, that is, of the submicron aerosol size spectrum and the size spectrum of the coarse aerosol fraction.

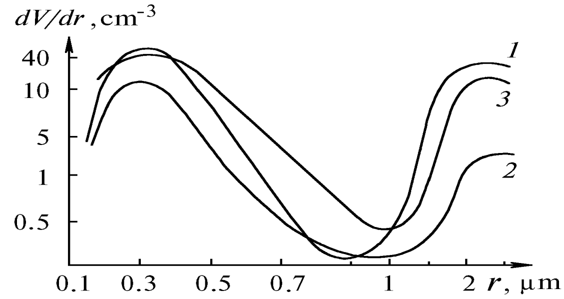

FIG. 2. Particle size distribution functions: Barnaul (1), Altai rural areas (2), and Alma–Ata (3).

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