Comprehensive studies of chemical composition of atmospheric aerosol above Lake Baikal surface area, Russia

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Long-term studies of the chemical composition of aerosols above the surface area of Lake Baikal (53º30' N, 108º0' E) were performed. This lake is one of the world's deepest lakes (1,637 m) which contain 20% of the world's surface fresh water.

Natural aerosol was sampled from the forebody of the research vessel at a height of 6 m above the water surface. Two types of sampling equipment were used – a standard high-volume pump and a six-phase high-volume slit cascade impactor TE-236 (Tisch Environmental Inc.) for particle sampling of the following size fractions – <10.2 μm and 10.2-4.2; 4,2-2.1; 2.1-1.3; 1.3-0.69; 0.69-0.39. "Whatman 41" served as a substrate for mineral particles. Persistent organic pollutants (POPs) were collected onto a fibrous glass filter.

Mean annual total concentration of ions amounted to 1.0-1.3 $\mu m/m^3$ in aerosol particles above the central areas of the lake water surface, which made up 25-30% of the total aerosol.

The majority of aerosols above Lake Baikal were represented by fractions of less than 1 μm, 60% of them being within the range less than 0.7 μm. Bicarbonates, sulphates, calcium and ammonium dominated in their composition. Differences in chemical composition of aerosol particles were mainly attributed to local sources of their origin which were located on the lake shore. Elevated concentrations of components were recorded in aerosol above the southern basin of Lake Baikal in the vicinity of settlements where total ions increased up to 2.0-4.0 $\mu m/m^3$. In the coastal area near the town of Baikalsk, the contribution of sodium and chloride ions was higher due to Baikalsk Pulp and Paper Plant located on the lake shore.

Distribution of microelements was also studied in aerosol particles of different sizes. Coarse-dispersion fraction (over 2 μm) was dominated by typical terrigenous elements (Ca, Mg K, Ti, Fe, Al, and Si). Such elements as Br, Zn and Pb prevailed in the fractions less than 0.7 μm. Some elements (V, Ni and Cu) had two peaks of maximal distribution in coarse (2.1-1.3 μm) and fine (0.69-039 μm) particles. To study remote and regional transfer of components to Lake Baikal (at tens and hundreds of kilometres), element composition of aerosol particles of 0.39-0.69 μm was analysed. Among 20 elements analysed by XRFA-SR, Mn, Ni, Cu, Zn, Ga, Sr, Br, and Pb were the most informative elements.

The concentration of the majority of microelements in aerosol particles above the Baikal surface area corresponded to the clarkes of the Earth's crust. The enrichment factor for such elements as Mn, Ni, Cu, Zn, Ga, Sr, Br, and Pb was by 1-2 orders higher compared to that of the soil. Therefore, there were some other sources for these elements besides terrigenous ones.

Electron microscopic analysis (X-ray spectral microanalysis) showed a high diversity of aerosol particles above the lake. Faceted particles were the most common in Northern Baikal. Particles >1 μm of oval or spherical shapes were registered above all three basins of the lake. The composition of rounded particles together with organic material (~ 80 %) consisted of inclusions of Al, Si, K, Ca, and Mg of terrigenous origin. Faceted particles and aggregations of particles like conglomerates contained C, O, Al, Ca, Si, and Mg. A more diverse range of elements (O, C, Si, K, Fe, Al, S, Ca, Na, and Mg) was recorded in particles of other shapes.

Twelve polycyclic aromatic hydrocarbons (PAH) and n-alkanes were analysed in Baikal aerosol. Maximal PAH concentration was detected in the size fraction less than 0.7 μm. The atmosphere above Southern Baikal contained benz(a)pyrene and chrysene – dominant components of forest fires, and benz(g,h,i)perylene and indeno(1,2,3-c,d)pyrene, indicators of atmospheric pollution by automobile transport. The ratio between PAH concentrations showed that the submicron fraction was represented by "aged" particles existing in the atmosphere for a long time and by aerosol of local origin in the coarse-dispersion fraction. The highest content of n-alkanes was registered in aerosol of Central Baikal where there are natural oil seepages. The dominance of odd homologues from n-C_{23} to n-C_{33} was observed in the fraction of higher homologues which is evident of their natural origin.

The results obtained allow us to conclude that the atmosphere above Lake Baikal remains relatively pure, and the components in it are mainly of natural origin. The southern part of the lake experiences some anthropogenic impact. However, the concentration of contaminants here is rather low.