



LONG-RANGE ATMOSPHERIC TRANSPORT OF HEAVY METALS FROM THE INDUSTRIES OF URAL AND NORILSK TO SIBERIAN ENVIRONMENT

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Abstract

The main idea of the work is to analyze atmospheric transport of heavy metals (Ni, Cu, Pb) from the industries of the region of Norilsk, and the Ural over the territory of Siberia (Fig. 1). The basic data were 5-day air mass trajectories from the sources calculated for every day of January, April, July, and October during 28 years from 1981 to 2008. NCEP/NCAR Reanalysis Data Files and HYSPLIT 4 model were used. Spatial, seasonal and long-term variations in heavy metal (HM) concentrations in surface air and precipitations, as well as in fluxes of these elements onto the surface were studied (Fig. 2). The obtained results may be used as assessment of anthropogenic influence from the sources under investigation on the environment of remote and hard-to-reach areas.

The HM air concentrations and fluxes onto the surface depend on surface properties and precipitation regime, and experience great seasonal and spatial variations. The maximal air concentrations are in cold seasons, whereas the maximal fluxes onto the surface occur in warm period. In comparison anthropogenic loadings at different places the cleanest air does not guarantees the minimal vertical fluxes (Fig. 3).

The pollution trends (modulo) caused only by the transformation of air circulation processes are quite comparable with the contributions of source-emissions' changes (Table 1). The Siberian environment pollution from studied sources through the atmosphere have been decreasing during the last years. But spatial and temporal variations are high (Fig. 3).

At a distance about 2000 km from a large source under investigation its atmospheric emission forms only the background levels of HM in the surface environment, and the real pollution levels are determined by local anthropogenic sources (with less emissions) if they exist (Fig. 4). So, for the Lake Baikal, the HM inputs from our distant sources through atmosphere to the water surface are insignificant in comparison with the flowing rivers' ones, and lake water pollution occurs mainly due to rivers' pollution.

However, annual HM fluxes from Ural and Norilsk regions through atmosphere on the Arctic Seas and on the territories of basins of large Siberian Rivers – Ob, Yenisei or Lena – are quite comparable with HM's fluxes carrying away by river's water to the Arctic Ocean (Fig. 5). Atmospheric circulation varied from the 2000s to the 1990s in such way that the lead fluxes to Lena's and Yenisei's basins slightly increased (Fig. 6) in spite of decreasing sources' emissions (Table 1).

Source	Decade	Annual emissions		
		Pb	Ni	Cu
Norilsk	The 1980-s	100	3000	3500
	The 1990-s	40	1400	2000
	The 2000-s	26	600	700
Ural	The 1980-s	2000	90	4500
	The 1990-s	1200	30	2000
	The 2000-s	500	150	1000

HM emissions from the sources

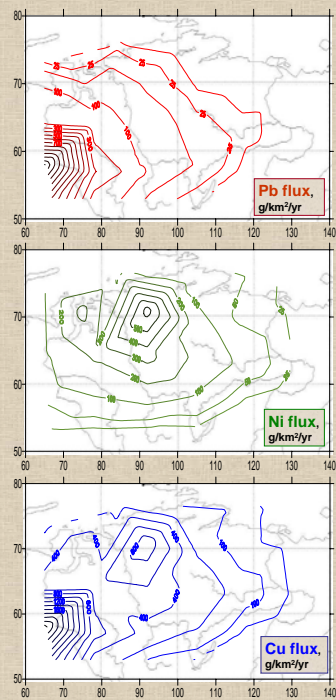


Fig. 2. Fluxes onto the surface in Siberia

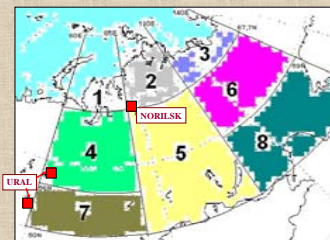


Fig. 1. Source positions and zones for calculations

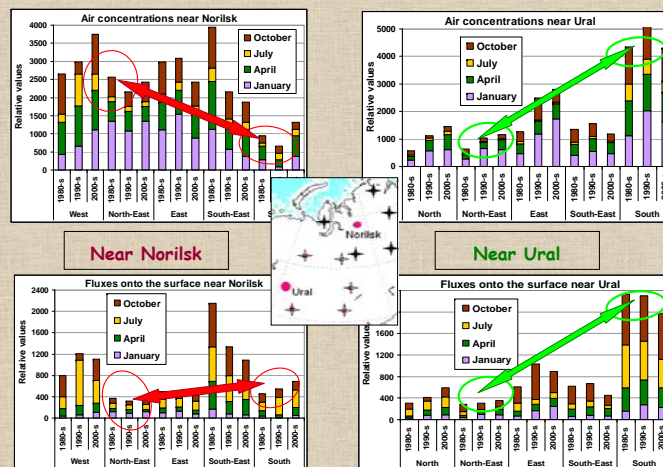


Fig. 3. The cleanest air not always guarantees the minimal loading to the surface environment

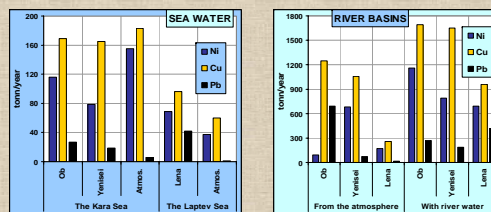
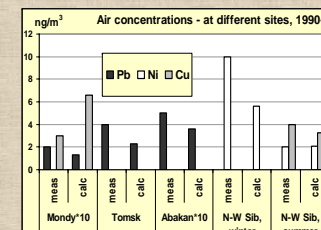


Fig. 5. HM fluxes to sea water and River basins



Comparison between measured and calculated data

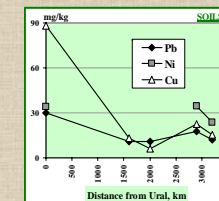
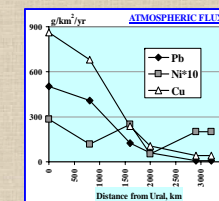


Fig. 4. HM from air and in soils – the 1990-s

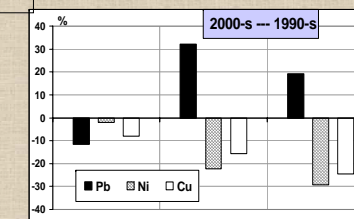


Fig. 6. Differences in HM fluxes

The long-range atmospheric transport of heavy metals from Ural and Norilsk regions must be taken into account as one of the processes forming compositions of surface water objects and soils, as well as of food chains in different ecosystems of Siberia.