The impact of industrial cities in front of the Western Urals, Russia, on natural reserves

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Abstract: Intensive development of industry in the eastern part of the Perm region of Russia has caused air pollution. As a result of regional atmospheric effects, pollutants of many trace metals are found in excess of their maximum concentration limit. These can be observed not only in the immediate proximity of the industrial enterprises but also in undeveloped areas, specifically created for the preservation of the natural environment.

The impact of the industrial cities on such areas was researched on the natural reserve of 'Basegi'. This reserve comprises a mountain ridge and an adjoining large forest that is largely unfelled. Basegi Reserve is a good representative of the natural mountain-taiga landscapes of the western macroslope of the Ural Mountains.

The research into trace metal concentrations in snow, soil and plants in the natural reserve indicated the high impact of the industrial cities of the area in front of the Eastern Urals.

Résumé: Le développement intensif de l'industrie dans la partie orientale de la région de Perm de la Russie a causé la pollution atmosphérique. En raison des effets atmosphériques régionaux, des polluants de beaucoup d'oligo-métaux sont trouvés au-dessus de leur limite maximum de concentration. Ceux-ci peuvent être observés non seulement dans la proximité immédiate des entreprises industrielles mais également dans des secteurs peu développés, spécifiquement créée pour la conservation de l'environnement normal.

L'impact des villes industrielles sur de tels secteurs a été recherché sur la réservation normale de 'Basegi'. Cette réservation comporte une arête de montagne et une grande forêt contiguë qui est unfelled en grande partie. La réservation de Basegi est un bon représentant des paysages normaux de montagne-taiga du macroslope occidental des montagnes d'Ural.

La recherche sur des concentrations en oligo-métal à la neige, au sol et aux plantes dans la réservation normale a indiqué l'impact élevé des villes industrielles du secteur devant les Monts Oural orientaux.

Keywords: geochemistry, pollution, trace metals, contaminated land

Mountain-taiga landscapes occupy 20 percent of the Perm region territory and are ecosystems with a unique biodiversity. The “Basegi” Reserve was designed for the protection of the natural mountain-taiga landscapes of the western macroslope of the Ural Mountains. Basegi, which includes three mountain peaks (highest point, 997 m.), comprises a mountain ridge and an adjoining large forest that is largely unfelled. The mountain ridge stretches meridionally and forms a natural barrier for western air masses. The location of the reserve provides geochemical isolation and the risk of the entry of pollutants into the reserved landscapes, via atmospheric precipitation, are large. The “Basegi” Reserve is therefore an important background landscape for research into air pollution and its impact on pristine landscapes

To determine air pollution, the chemistry of atmospheric precipitation was analyzed and possible technogenic sources identified. Study of the wind conditions of the research area during the period 1994 - 2003 showed that westward and southward winds are dominant. Industrial cities are situated less than 50 km away to the west and south of the reserve of “Basegi” and within these cities there are enterprises of cement making, coal firing, ferrous and non-ferrous metallurgy and mechanical engineering. Emissions from all these types of industry contain trace metals. Figure 1 shows the total volume of industrial emissions near to the reserve of “Basegi”. According to preliminary estimates, about 18 thousand ton/year of trace metals and their compounds containing trace metals are emitted and the main sources are Chusovojj, Berezniki, Gornozavodsk and Kachkanar.

The industrial emissions form a different spectrum of air pollution. To the north-west of the reserve vanadium, manganese, chromium and barium are dominant. To the south-east, the city of Kachkanar is an intensive source of chromium, nickel, vanadium, manganese and abiotic dust (Semjachkov 2001). To the south of the reserve, both the spectrum of trace emissions is more varied and the volumes of pollutants greater. The emissions contain vanadium, manganese, magnesium, zinc, lead, copper and nickel with coal ash, non-organic dust, suspended matter and cement dust also detected.

The industrial specialization of these cities and their vicinity to the reserve of “Basegi”, provides an opportunity to research the effects of atmospheric precipitation on the territory of the reserve. The chemistry of thirty-one samples of snow, taken on biogeochemical monitoring sites at the end of the snow period (the end of March), were compared with samples taken from the reserve of “Visherskjj”, the most distant reserve from the industrial cities (Figure 1).

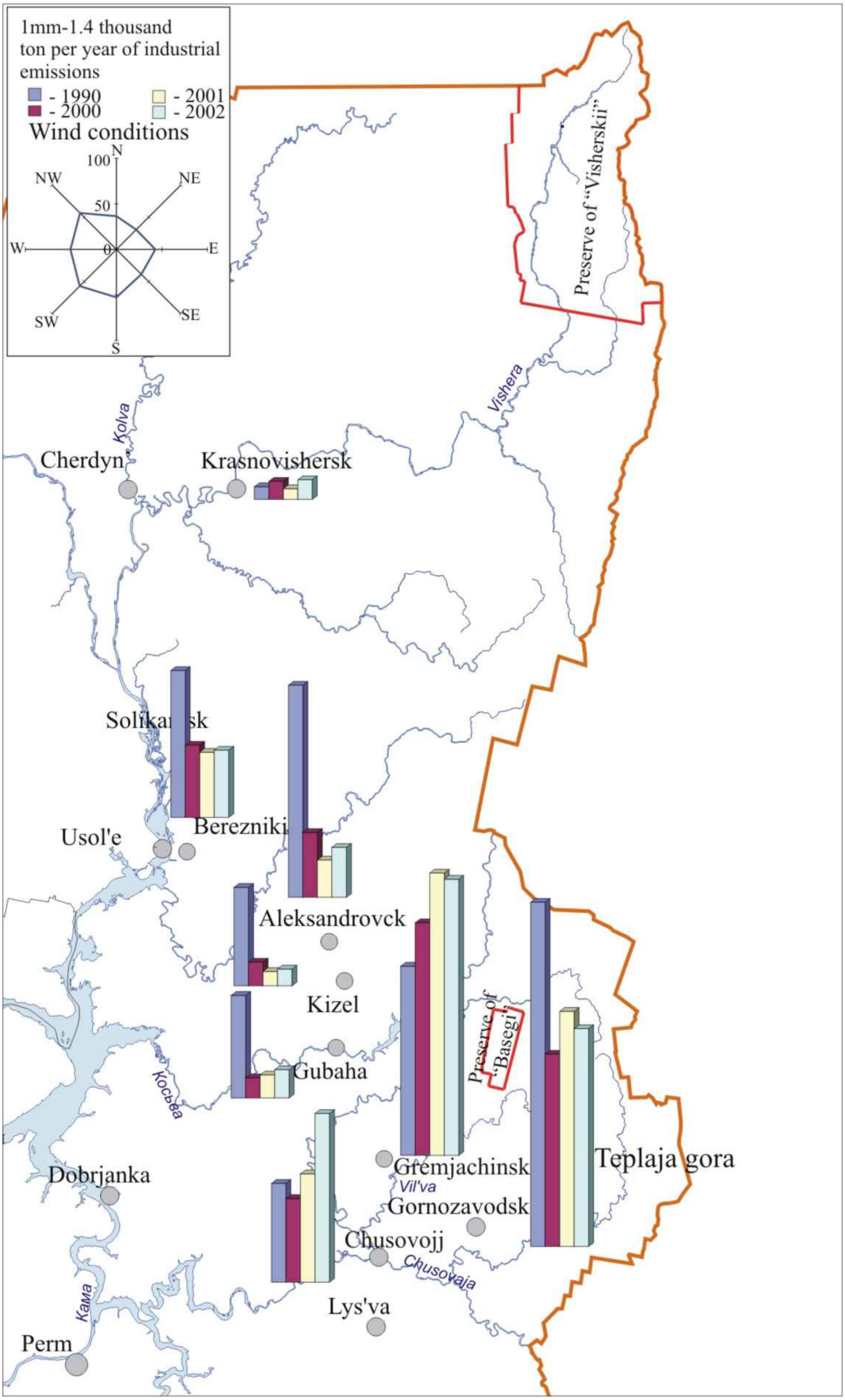

Figure 1. Total pollutant volume of industrial emissions

As a whole, melting snow is an HCO_3-Na hydrochemical facies at pH 5,8. Under the domination of southerly winds, the highest content of macrocomponents was detected in southern part of the reserve of "Basegi", with mineralization of about 18,08 mg/l (the eastern slope of South Basegi) and pH of 6,6 due to the high concentration of hydrocarbons. The increase in pH and hydrocarbon concentration corresponds with the huge cement enterprise that is situated 40 km away from the south boundary of the reserve. The prevalence of winds from the west appeared to cause macrocomponent concentration growth in snow for all studied sites. Mineralization of snow reached up to 21,06 mg/l on western slope of North Basegi and pH did not exceed 6.

Chemical analysis by emission spectrophotometry of trace metals found in the snow showed that higher concentrations of these elements were detected in the preserve "Basegi" compared to the preserve "Visherskii" (Figure 2) and that average concentrations of almost all trace metals exceed the norms according to Ju.A. Saet *et al.* (1990).

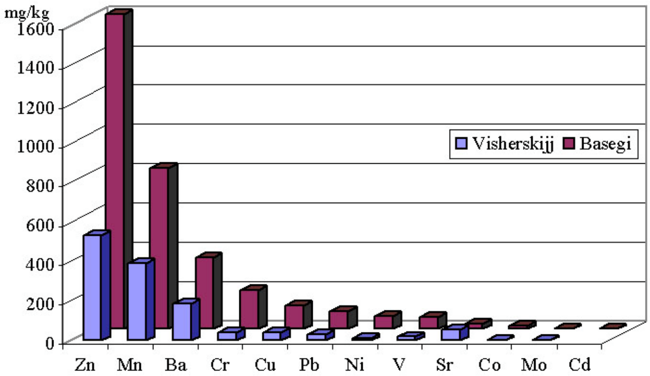

Figure 2. Average data for the melting snow of the preserves of "Basegi" and "Visherskijj" (between 1994-2001)

The total content of microelements in the melting snow of the preserve "Visherskijj" is 1581,6 mg/kg. The geochemical line of trace metals (mg/kg) is:

$$\frac{Zn}{537,5} > \frac{Mn}{404,5} > \frac{Ba}{188,2} > \frac{Sr}{57,5} > \frac{Cr}{43,2} > \frac{Cu}{40,7} > \frac{Pb}{31,9} > \frac{V}{22,8} > \frac{Ni}{13,2} > \frac{Co, Mo}{2,3}$$

In the preserve "Basegi" concentration of trace metals is higher. The geochemical line of trace metals for the western slope of North Basegi (mg/kg) is:

$$\frac{Zn}{2531,1} > \frac{Mn}{1291,2} > \frac{Ba}{435,2} > \frac{Cr}{243,0} > \frac{Cu}{156,1} > \frac{Ni}{121,8} > \frac{Pb}{59,7} > \frac{V}{55,5} > \frac{Co}{19,9} > \frac{Sr}{3,1} > \frac{Mo}{2,9}$$

For the eastern slope of North Basegi the geochemical line of trace metals (mg/kg) is:

$$\frac{Zn}{2470,7} > \frac{Mn}{683,1} > \frac{Ba}{565,3} > \frac{Cr}{231,3} > \frac{Cu}{72,9} > \frac{Ni}{50,7} > \frac{Sr}{38,9} > \frac{Pb}{34,2} > \frac{V}{31,3} > \frac{Co}{16,7} > \frac{Mo}{3,6}$$

For the eastern slope of South Basegi the geochemical line of trace metals (mg/kg) is:

$$\frac{Mn}{441,7} > \frac{Ba}{349,2} > \frac{Zn}{217,5} > \frac{Cr}{150,9} > \frac{Cu}{141,5} > \frac{Pb}{117,7} > \frac{V}{90,1} > \frac{Sr}{59,1} > \frac{Ni}{52,8} > \frac{Co}{6,5} > \frac{Mo}{1,7} > \frac{Cd}{0,2}$$

For the western slope of South Basegi the geochemical line of trace metals (mg/kg) is:

$$\frac{Mn}{393,8} > \frac{Ba}{187,0} > \frac{Cr}{171,2} > \frac{Zn}{154,7} > \frac{Cu}{102,4} > \frac{Pb}{87,9} > \frac{V}{60,9} > \frac{Ni}{47,8} > \frac{Sr, Co}{3,4} > \frac{Mo}{3,2} > \frac{Cd}{1,3}$$

In the snow of the reserves of "Basegi" and "Visherskijj" zinc, manganese and barium dominate in different orders. For North Basegi's ecosystems the maximum content of microelements is revealed. The average total content is 5876,2 mg/kg on western slope and 4755,3 mg/kg on eastern slope. This is higher than the given value by 3,7 and 3 times (respectively). Trace metals in the snow of South Basegi are present in lower concentrations nevertheless, concentrations of the most ecotoxic metals (lead, vanadium and cadmium) are highest.

In these ecosystems different associations of pollutants were detected. For the first site (North Basegi) there are zinc, manganese, chromium, barium, copper, nickel and cobalt, whilst for the second one - lead, vanadium, cadmium, chromium and copper. These elements are main pollutants, which are emitted by enterprises. Different spectrum of pollution is connected with features of industrial emissions.

The wide range of data (coefficient of variation - up to 3432.8%) in the reserve of "Basegi" confirms that technogenic factors determine chemistry of atmospheric precipitations. In the reserve of "Visherskijj" natural factors are predominant and are not much changed geochemically (coefficient of variation – up to 78.4%).

The study of snow chemistry has showed that the industrial cities of the Western Urals significantly impact on ecosystems of “Basegi” compared with “Visherskijj”. The same differences in trace element contents were investigated for soils and plants. High concentration of nickel, cobalt, chromium, zinc, lead, vanadium, copper and cadmium in ecosystems of “Basegi” results in destructive processes, which are currently being researched.

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