Air pollution of the environment caused by the Kostomuksha Ore-dressing Mill

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Introduction

The basic source of air pollution in Kostomuksha is the emissions from the ore-dressing mill, the most part of which are sulphur dioxide and dust (Table 1).

<table>
<thead>
<tr>
<th>Year</th>
<th>Dust</th>
<th>SO₂</th>
<th>CO</th>
<th>NOₓ</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td>5,30</td>
<td>53,0</td>
<td>0,60</td>
<td>1,60</td>
<td>61,60</td>
</tr>
<tr>
<td>1994</td>
<td>6,40</td>
<td>48,0</td>
<td>0,60</td>
<td>1,50</td>
<td>57,50</td>
</tr>
<tr>
<td>1995</td>
<td>4,96</td>
<td>44,59</td>
<td>0,55</td>
<td>1,26</td>
<td>52,24</td>
</tr>
<tr>
<td>1996</td>
<td>6,36</td>
<td>47,42</td>
<td>0,52</td>
<td>1,19</td>
<td>55,57</td>
</tr>
<tr>
<td>1997</td>
<td>5,99</td>
<td>32,24</td>
<td>0,89</td>
<td>1,51</td>
<td>40,85</td>
</tr>
<tr>
<td>1998</td>
<td>6,42</td>
<td>37,68</td>
<td>0,91</td>
<td>1,56</td>
<td>46,79</td>
</tr>
</tbody>
</table>

It should be mentioned, that the greater part of the emissions of the sulphur dioxide, as well as dust starting from 1997, occur mostly in Kostomuksha in comparison with the other industrial centers of Karelia (Fig. 1, 2).

At the same time, in comparison with such metallurgical plants as “Severonickel” and “Petchenganickel”, located on the Kola peninsula, the emission of SO₂ in Kostomuksha is 20-30% of the emissions at each of the specified mills.

Materials and methods

Precipitation monitoring was conducted during maximum snow accumulation period (late March - early April). Snow samples were taken 3, 10, 24, 40 and 60 km away from the Kostomuksha Ore-dressing Mill north - northwestwards, and also north - northeastwards towards Kalevala (3; 7,5; 10; 15; 25; 45 and 60 km), southestwards (40 km from the ore-dressing mill on Lake Kamenny), south-eastwards towards Lake Nyuk (3, 10, 20, 40 km) and around Kostomuksha.

The results of the research of the chemical composition of precipitation, conducted in the laboratory of hydrochemistry of the Northern Water Problems Institute in 1993 - 1998, are reported in this paper, and those conducted in 1993 with the assistance of the Kainuu Regional Environment Centre.

The snow samples were delivered to the laboratory, where they were thawed at room temperature. The chemical analysis of the snowmelt water was performed by using methods similar to those used for surface water sources samples.
The amount of chemical deposition with snow was calculated according to the formula \( D_m = C_s W_s / D_t \), where

- \( D_m \) - monthly fallout, (mg/l)
- \( C_s \) - concentration of a component in snowmelt water, (mg/l)
- \( W_s \) - water content in snow, (mm)
- \( D_t \) - time of fallout, (day).

In 1994-1998 the water content in snow was not determined during sampling, therefore there are no observations for this period, \( W_s \) was assumed to be equal to the mean value of water content in snow in 1993 (191 mm).

**Results and discussion**

The ionic composition of snowmelt water in the vicinity of the ore-dressing mill is characterized by a high content of Ca (up to 2,75 mg/l) and K (up to 7,0 mg/l) ions. On the average the concentration and the amount of fallout of these elements make 0,94 mg/l (36,9 mg/m² per month) and 2,05 mg/l (80,4 mg/m² per month) accordingly. In the samples collected at a distance from the mill, the content of these substances is lower.
and on the average it makes Ca - 0,37 mg/l (Dm - 17,9 mg/m² per month), K - 0,15 mg/l (Dm - 13,4 mg/m² per month) (Fig. 3), which, however, exceeds the mean values in Finland Ca - 8,0; K - 3,4 mg/m² per month

The high concentration of hydrocarbonates (up to 5,2 mg/l) corresponds to the high concentration of potassium. It is determined by the influence of solid pulp exhausts which occur during the alluviation on the dam. On the average the amount of HCO₃⁻ - fallout is 197 mg/m² per month In the rest of the samples the hydrocarbonates are not to be found, what is also confirmed by the acidic quality of the precipitation (pH < 5,0).

The Mg (up to 0,45 mg/l) and Na (up to 0,8 mg/l) content in snow samples is rather low, irrespective of how far from the mill the samples were collected.

The value of pH in the majority of snow samples is below the equilibrium value for precipitation (5,6), and on the average it makes 4,91, which is close to the mean value in Karelia (4,8). Higher pH values are observed in the samples collected within the 3 km range from the mill (northeastwards 6,93, southeastwards 6,0 and northwestwards 5,77) (Fig. 4).

Strong acids fallout around the mill makes only 0,005-0,07 mmol/m² per month, while beyond the 10 km range it goes up to 0,5 mmol/m² per month The latter values are close to the mean values in Karelia. It appears to be impossible to specify in particular the fallout of strong acids, connected with the emission of oxides of sulphur and nitrogen from the Kostomuksha Ore-dressing Mill and their fallout caused by transboundary transport. In any case, in the vicinity of the mill the environment is affected by

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**Fig. 3. Ca and K contents in atmospheric precipitation.**
acidity to a much smaller extent than at a distance from it. And this fact is contrary to the situation at the plants in “Severonickel” and “Petchenganickel”, where the precipitation acidity is most intensive in the impact zones.

The content of sulphates varies broadly (0,3-8,04 mg/l), and their greatest concentrations are found in the samples collected around the mill, where pH values are increased (Fig. 4). The average content of sulphates in this area makes 2,79 mg/l, the amount of fallout 109,4 mg/m² per month. The fallout of sulphates as salts here reaches 98 %. At a distance from the mill the tendency of decrease of the contents of sulphates as salts and an increase of their contents as acids is observed, and the amounts of fallout make 19-66 mg/m² per month.

The concentration of chlorides in snow is moderate and on the average it makes 0,55 mg/l, the amount of fallout - 21,3 mg/m² per month, what is close to the mean values in Finland (19,6 mg/m² per month).

In the distribution of nitrous matters the dominant form in precipitation is represented by nitrates, the content of which makes 0,24 mgN/l. It is followed by ammonium (on the average 0,094 mgN/l). The nitrite content is rather insignificant (on the average 0,002 mgN/l). The N$_{org}$ content is lower, than the sum of its mineral forms (on the average 0,014 mgN/l). And the concentration of all mineral forms of nitrogen were lower than the average values in Finland (N-NO$_{2}$ = 0,351 mg/l, N-NH$_{4}$ = 0,196 mg/l).

The concentration of P$_{total}$ in most samples did not exceed 50 mg/l. However, it exceeded the mean values in Finland P$_{total}$ = 18,7 mg/l.

No significant variance in the distribution of nutrients in the vicinity of the mill and at a distance was detected.

Of trace elements the tendency of Fe$_{total}$ contents increase is observed. Its highest concentration is detected in the samples collected in the vicinity of the mill, especially north-eastwards 1,14; 1,36 mg/l and south-eastwards 0,75 mg/l, and on the average it

Fig. 4. pH and SO$_{4}$ content in atmospheric precipitation.
makes 0.71 mg/l (the fallout value - 27.8 mg/m² per month). These values exceed by far those determined earlier in 1987-1990. The amount and value of iron fallout at a distance from the mill make 0.09 mg/l and 3.53 mg/m² per month (Fig. 5).

According to the data of 1993 in sample collection points located near the mill increased concentrations of aluminum (160 mg/l, Dm - 6.4 mg/m² per month; as well as in Kamalahti - 240 mg/l, Dm - 10.9 mg/m² per month), nickel (3 mg/l; 123 mg/m² per month), and vanadium were detected. The contents of the latter in snow (0.14-9.1 mg/l) and the amount of its fallout (3.31 - 405 mg/m² per month) increase sharply in the direction of the mill.

Conclusions

In conclusion it can be stated that in snow samples collected in the vicinity of the ore-dressing mill, high concentrations of Ca, K, sulphates as salts (with high pH values), and also Fe total, Al, V, Ni are observed. A higher content of sulphates (with low pH values) at a distance from the mill is due not only to sulphur dioxide exhausts from a local source, but also to the transboundary effect. It is difficult to distinguish between their contributions. As a result, it is possible to state that the influence of the Kostomuksha Ore-dressing Mill shows within the 3 km range, and up to 10 km north-northeastwards, and it is basically due to the fallout of the salt forms of elements, but not acid. The fallout of sulphates is 1.2-4 times higher than the maximum load values (0.3 g/m² per year), adopted for Northern countries, and at a distance of over 60 km away from the mill they do not exceed the critical load value.