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Assessment of the Impact of Mining Enterprises on the State of Atmospheric Air on the Results of Geochemical Snow Surveys

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Abstract. A snow mantle characterized for a high sorption ability seems to be the most informative object in the context of revealing a man-caused pollution of the atmosphere. The winter and spring periods of 2018 saw a selection of snow samples by the authors aimed at revealing the atmosphere air pollution of the environment with regard to the Slyudyanka region territory of Irkutsk province. The survey covering the sample selection was carried out in view of a system of a key areas (mining enterprises) taking into consideration the sources of the atmosphere pollution and the wind diagrams. The results of snow surveys in the region of mining works location are presented in the paper (Angasolka Crushed Stone Plant, the quarry of "Pereval"). The ecological situation resulting from the production activities on the territory under consideration is assessed.

1. Introduction

The atmosphere pollution of Baikal elemental territory (BET) has been a problem exposed to a common discussion. Carrying over and scattering admixtures generated by industrial enterprises and road transportation to and from Irkutsk-Cheremkhovski industrial center is registered along the Angara river-valley, the center being located in the ecological zone of the BET atmosphere influence. Along with the above, steady and unsteady sources of emitters functioning in the central and protective ecological zones contribute significantly to the atmosphere pollution over the lake of Baikal. Mining enterprises in the town of Slyudyanka and settlement of Angasolka where marble and granite are extracted and processed are among the sources of this kind. While the above mentioned enterprises are functioning, some dusty discharges are emitted into the atmosphere where they can get scattered for considerable distances and affect both the personnel and the population of nearby communities along with the lake of Baikal.

A snow survey is a method that allows to assess the degree of a man-caused dusty load directed at the environmental complex. In view of its high sorption ability, the mantle of snow accumulates and stores in its composition practically all the components polluting the atmosphere. Due to this characteristic it is a convenient and reliable indicator of air pollution as well as a consequent soil and water pollution [1].

A snow survey is an approach to studying the state of a snow mantle with regard to a definite net of points [1-2] that is used in selecting snow samples. On the average, a stable snow mantle remains unchanged for a sufficiently long time, for 4-5 months, on the BET being at the same time depositing surroundings which makes it an extremely favourable object when the atmosphere pollutions with



substances of a man-caused generation are exposed to investigation [3-5]. The composition of snow is formed under the influence of a number of factors, such as the occurrence of different chemical admixtures following atmosphere precipitations, the absorption of gases from air by the snow and solid matter sedimentation from the atmosphere, the interaction of the snow mantle and the vegetative ground cover. Geochemical information is stored in the snow mantle during the whole period of hibernal snow level. The survey under consideration makes an attempt to assess the share of mining works in the pollution of the South Baikal atmosphere with solid dusty discharge.

2. Materials and methodology in investigarion

After the Baikal pulp and paper mill closure in Slyudyanski region the main permanent source of atmosphere pollution in the southern part of Baikal lake has become an industrial zone formed by two mining enterprises, namely, Angasolka crushed stone plant where granites and migmatites are extracted from Angasolka deposits to produce chip stone for ballasting rail roads and "Pereval" the quarry where marbled limestone is extracted to produce cement at "Angarsktsement" JSC. Technological processes of extracting and processing of raw materials (screening, crushing, grinding) are the sources of emitting dust into the atmosphere, the dust being characterized for its various gradation and chemical composition.

The general atmosphere circulation conditions the predominance of southern, south-western and western wind directions on the industrial enterprise areas that are given consideration to in the present paper. The major part of the apartment block is situated on the windward side of the industrial zone [6].

Snow samples were selected in early March 2018. In correspondence with the wind diagram and the disposition of the main pollution sources, a sample selection net was constructed. It contains 15 points all in all (Fig.1-2): 8 samples from the quarry of Angasolski and 7 ones from the quarry of "Pereval". The selection of the points for the investigation aiming at carrying out a snow survey is determined by a number of factors such as: geomorphological characteristic of an area position, its meteorological features, man-caused load on a given territory.



Figure 1. Chart-scheme of the territory being investigated (Angasolka crushed stone plant), the points of the snow survey being indicated.



Figure 2. Chart-scheme of the territory being investigated (the quarry of “Pereval” being a marble quarry), the points of the snow survey being indicated.

The snow survey was performed in correspondence with ND 52.04.186-89 [7-8]. The places for snow surveying are chosen mainly in open spaces that are horizontally and visually even and alienated with regard to obstacles capable of creating windless regions on the areas that visually are not exposed to human-induced disturbances and are far from the motor roads. Sample selection is performed in the period of a maximum moisture-retention in the snow.

The method of “envelope” was used for a sample selection, when an open test pit was excavated (Figure 3). The samples were selected in view of the total capacity of the snow cover from the open test pits, the rubbish (leaves, branches, etc.) being removed from the surface in order to prevent soil particles from getting into a sample [9-10]. At the same time the square of the test pit was being measured and the time was calculated by 24 hour periods from the stable snow cover to the date of sampling.



Figure 3. The process of snow sample selection from the open test pit.

[1]The sizes of open test pits were varying within 40x40x25 to 50x50x30 cm. The weight of a sample made up 4 to 6 kg and it was put into a container made of a chemical stable polymerous material (a plastic bag) and labeled.

After that, the samples were poured in a receptacle and exposed to melting at the room temperature of 18-19 °C for 24 hours. Following that, big inclusions were removed with pincers and the water was to settle for 2 days to be filtered (Figure 4).



Figure 4. The process of filtering snow water.

The solid fraction settled on the filter was dried and weighed. The weight of the mechanical dust was the basis for the dust load evaluation, i.e. the calculation of the solid precipitation amount per a test pit area unit.

3. Discussion and results

The results of dust load assessment are represented in the table:

Table 1.

Place of sampling	Dust load, mg / m ² / diurn								bgr
Angasolski crushed stone plant	1A	2A	3A	4A	5A	6A	7A	8A	0,08
	0,16	0,23	1,08	1,31	0,98	0,72	0,77	0,66	
Quarry of "Pereval" (Marble quarry)	1P	2P	3P	4P	5P	6P	7P	–	0,08
	0,18	1,27	0,15	0,18	0,86	0,11	0,10		

Further processing of the snow survey results was performed in accordance with the strategy used to assess the air quality, in particular, by means of comparing the calculation results and background concentrations [1–5, 15]. At the points under investigation the dust load was changing between 0.10 and 1.27 mg/m²/diurn. A concentration exceeding the background one is registered in all the points of sample selection. With regard to Angasolski crushed stone plant, the dust concentration registered to the west of the enterprise exceeds the background load by the factor of 16.3 on the average, whereas the one to the south-east shows the exceeding by the factor of 13.5. The greatest concentration is registered in the point of .4A located to the west of the enterprise.

As for the quarry of "Pereval", the most significant dust load is registered at the point of 2P and reaches 1.27 mg/m²/diurn. The dust concentration registered to the north-east of the enterprise exceeds the background one on the average by the factor of 13.2, whereas the least concentration is found with distance from the enterprise, it exceeding the background one on the average by a factor of 5.

4. Conclusion

Basing on the survey performed the following conclusions were made:

- the revealed radius of a marble quarry effecting the components of the natural environment makes up 1324 m, that of a granite quarry and Angasolski crushed stone plant is 1564 m.

- the greatest dust content of the southern territory is observed in connection with the operation of Angasolski crushed stone plant.

- the circles of the basic territory dustiness are conditioned by the wind diagram direction;

- the degree of Angasolski crushed stone plant effect is more brightly expressed than that of the quarry of "Pereval" which can result from the volumes of extractions;

- the territory pollution within several kilometers is formed due to functioning surface boundary sources, namely, crushing and sorting plants, drilling and blasting operations, crushing materials.

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