



## Negative changes in permafrost due to waste storage

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The problem of waste storage is particularly acute in Arctic. This is due to the vulnerability of northern ecosystems, the existence of permafrost, especially vulnerable to anthropogenic impact, the water-resistant properties of frozen rocks and the effect of destructive cryogenic processes. In addition, the causes of concern are the trends in air and frozen soil temperatures reported for the northern regions: pollutants stored in relatively stable frozen state can be released into the environment as a result of thawing. This is especially true for industrial regions, where billions of cubic meters of waste from the mining and beneficiation of ores and coal, from timber processing, mine water spills and drilling fluids, etc. are stored in a frozen state.

Field investigations were carried out in number of settlements in cryolithozone of Russia (Norilsk, Vorkuta, Igarka, settlements in the lower Ob, national villages of Taimyr, etc.). The observations involved remote sensing methods and included estimation of the area of littering and the types of waste. In many cases sampling for chemical analyzes, thermometry, and mapping of hazardous processes were made.

The impact of stored wastes on permafrost was divided into three main types: a) mechanical (changing the relief and the flow paths of surface and ground waters); b) physical and chemical (pollution by the waste itself and by its decomposition products); c) thermal (heating of frozen soils by high-temperature waste or heat generation during various chemical reactions).

During the research, 6 main types of waste storage were identified, each of which had a destructive effect on permafrost soils and northern ecosystems:

- 1) dumps of municipal solid waste (inherent in all settlements);
- 2) storages of industrial waste, tailing storage facilities in the industrial centers of the north;
- 3) abandoned and cluttered territories;
- 4) landfills of timber processing waste in the centers of the timber industry;
- 5) rock dumps in open-cast mining sites, which in the cold climate can transform into rock glaciers;
- 6) storage areas for polluted snow transferred from built-up areas.

Particular attention was paid to the accumulation of chemical pollutants in industrial centers (with Norilsk industrial region as an example). This problem in conditions of permafrost is exacerbated by the low self-purification of northern biogeocenoses; slowdown of oxidation and some other chemical reactions in cold climates; drainage and unloading of groundwater of seasonally thawed layer, intra-permafrost and under-permafrost taliks into the water bodies.

The use of imperfect technologies for the extraction and processing the raw materials, remains of past years practices with neglected environmental situation, the lack of special standards for the storage of waste and industrial by-products, the lack of development of waste disposal methods for severe climatic conditions led to the pollution of vast territories and to destruction of many ecosystems.

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