Identification of a potential danger zone for industrial enterprises in the Far North

Yuliya Lukyanova and Andrey Lavrusevich

Moscow State University of Civil Engineering, Yaroslavskoe shosse, 26, Moscow, 129337, Russia

E-mail: YNLukyanova@gmail.com

Abstract. The accident on may 29, 2020 in Norilsk showed that the problem of permafrost melting is currently relevant for all industrial enterprises in the Arctic region. Soil thawing leads to deformation of objects located on territories with similar engineering and geological conditions. You can often see houses and roads riddled with small and large cracks, buildings with deformed foundations. All these are the results of the processes that control the life of permafrost. It is necessary to study and observe the processes of degradation of permafrost so that this phenomenon does not come as a surprise, in order to have time to take measures to prevent an accident. It is shown that the boundaries established by regulatory documents do not prevent the release of pollutants into the environment in the event of an accident at the facility. As a result, it is useless to establish a sanitary protection zone. Continuous monitoring of the state of permafrost in the area where industrial facilities are located can be a preventive measure.

1. Introduction
On may 29, 2020, a diesel fuel tank was damaged on the territory of CHPP-3 of the Norilsk-Taimyr energy company (NTEK, part of the Norilsk Nickel group), due to a sudden subsidence of supports, as a result, 21 thousand tons of petroleum products leaked to 180 thousand square meters of soil and into reservoirs [1]. As a result of the accident, oil products got into the Daldykan river, Ambarnaya river, their tributaries, and the lake, and the soil on the territory of the Strait in the area of TPP-3 was polluted [2]. When studying the circumstances of the accident, experts suggested that the reason for the subsidence of the supports was the thawing of the soil at the location of the reservoir [3].

Underground ice and permafrost are dynamic formations. High ice content of rocks exists along with unstable thermodynamics of soils. The system is complex, very fragile and balanced. It is only necessary to slightly change the climatic conditions, vegetation cover and surface topography — and permafrost conditions begin to rebuild [4].

At the location of an industrial enterprise, soil thawing is accelerated due to its thermal impact, as well as due to contamination of soil and water with industrial waste.
2. Monitoring the state of permafrost in the area where industrial facilities are located

After the fuel leak at CHPP-3, it was suggested that the cause of the accident could be the melting of permafrost, the destruction of the concrete base, a burst container or soil vibrations that swayed the liquid in the storage.

To study the cause and consequences of the accident, a Large Norilsk expedition was sent to Taimyr by the Siberian branch of the Russian Academy of Sciences (RAS) at the invitation of the management of MMC Norilsk Nickel. It consists of scientists from 14 institutes of the Siberian branch of the Russian Academy of Sciences. Based on its results, scientists will prepare proposals and recommendations for the best environmental solutions for industrial companies in the Arctic region. The expedition is designed for five months - from July to November 2020.

Experts examined the level of soil freezing under the fuel storage facility of NORILSK CHPP-3, and measured the temperature of the soil on the territory of the fuel storage facility. Scientists have worked to determine the temperature in three dozen previously drilled wells. In addition, three new wells were drilled for the team. The first well was laid on a site where relatively undisturbed conditions, it is necessary as a background for comparison. The second well is in the valley of the stream, where it was supposed to record the consequences after the spill. And the third well directly on the site, 50 meters from the tank where the spill occurred. The researchers conducted a week-long monitoring of the temperature in the wells, studied the results of drilling-by ice content, material composition, and other parameters. Temperature measurements were carried out at different depths - from 5 to 15 meters, route studies were conducted to identify cryogenic processes on the surface and possible technogenic influence on them.

On August 20, 2020, field work to study the state of permafrost at the site of the fuel spill that occurred in May at the CHPP-3 in Norilsk was completed. Now scientists will have about two months in the laboratory in Yakutsk to create a picture of the permafrost situation in the area of CHPP-3 using the results of measurements, landscape observations, and information obtained using satellite images. The final conclusions about the impact of permafrost melting on the accident will be made together with scientists from the Institute of oil and gas Geology and Geophysics of the Siberian branch of the Russian Academy of Sciences, who previously conducted a geophysical survey of the CHP [5].

3. Purpose of the sanitary protection zone (SPZ), its role during an emergency situation at the facility

The problem of establishing the boundaries of the SPZ of an industrial enterprise is one of the most widely discussed among environmentalists, specialists in the field of industrial safety and lawyers who protect the interests of companies. The main problems faced by the copyright holders of the objects in establishing the SPZ are:

- the need to protect the population from the impact of harmful emissions of the enterprise;
- the need to protect the company from claims of citizens who accidentally or intentionally found themselves under this influence;
- prevent the construction of residential buildings in an area where the maximum permissible emission standards are exceeded;
- not violate the rights of land owners;
- the need to comply with the requirements for landscaping, and maintain an environmentally friendly state of the territory of the SPZ, which is not the property of the enterprise by legal status;
- costly procedure of the establishment of the SPZ;
- the obligation of the enterprise to conduct research (measurements) behind the contour of the object to confirm the absence of chemical, physical and/or biological effects exceeding sanitary and epidemiological standards;
- re-justification of the SPZ boundaries during the reconstruction or technical re-equipment of the object.

The establishment of the SPZ does not exclude the fact of emissions and discharges of pollutants, but only indicates the zone within which the enterprise, in its normal mode of operation, pollutes the
environment. How the size of the SPZ can reduce the impact of pollution on the atmospheric air to the values set by hygiene standards? [6]. Is it worth carrying out labor-intensive and expensive measures to determine the zone that provides protection only in the normal operation of the object?

In accordance with clause 7.1.10. SanPiN 2.2.1/2.1.1.1200-03, thermal power plants (TPP) with an equivalent electrical capacity of 600 mW and higher, running on gas and oil-gas fuel are classified as hazard class II, the size of the SPZ must be at least 500 meters. Figure 1 shows an example of the border of a sanitary protection zone equal to 500 meters.

On the example of the accident on May 29, 2020 on the territory of the CHPP-3 of the Norilsk-Taimyr power company, we see that pollutants spread over 180 thousand square meters.

![Figure 1. An example of the border of a sanitary protection zone equal to 500 meters.](image)

Based on this, the following conclusions are formed:

1. Geological processes in the Arctic zone inevitably lead to the destruction of the soil, which, in turn, provokes the deformation of objects;
2. Deformation of objects leads to an accident, and the consequence of the accident is the release of pollutants at a distance much greater than the boundaries of the established SPZ (Figure 2);
3. The Zone, which, in accordance with the SanPiN[5], is a protective barrier, is not such, since the boundaries of the SPZ, established on the basis of current legislation, do not ensure safety in the event of an accident at the facility.
Figure 2. Distribution of pollutants through the hydrographic network

4. Conclusion
Taking into account the inconsistency of the term "protective" in relation to the zone of danger, the author suggests:

1. Use the term "area of potential danger". Danger is the threat of occurrence of a phenomenon or process with certain parameters over a given period of time that pose a threat to the life or well-being of people, economic objects, or the environment[7].
2. Determine the zone of potential danger based on possible scenarios of beyond-design accidents.
3. When determining the zone of potential danger, it is necessary to take into account the geographical and geological conditions of the location of industrial facilities, including the possibility of environmental pollution by spreading pollutants through the hydrographic network.
4. To build "zones of potential danger", it is advisable to use the topography or General plans of the territories where it is necessary to draw the boundaries of the selected zones of potential danger.

The most reliable way to prevent similar Norilsk technogenic accidents is to conduct object monitoring of the state of industrial structures located in the zone of permafrost development.

The most reliable way to prevent similar to the Norilsk technogenic accident is to conduct object monitoring of the state of industrial structures located in the permafrost development zone. The main measure aimed at assessing and preventing technological accidents is environmental monitoring in the area where the industrial facility is located. Monitoring is a system of regular observations of a dangerous object, assessment and forecast of its impact on the environment, as well as the impact of natural and climatic conditions on the object, which may result in deformation and destruction of the object.

So, there was a need for urgent monitoring in the Arctic zone of our country. The process of melting permafrost is an immediate threat to industrial facilities located in the Far North.
This region produces products that provide about 11% of Russia's national income and up to 26% of Russia's total exports. The Arctic zone of Russia is the largest resource base in the world. Moreover, there are more objects in the Russian Arctic that are attractive for long-term investment than in any other state. Therefore, it should be borne in mind that in the Arctic zone of Russia, there are very high risks of natural, man-made and environmental emergencies that must be considered.

References
[1] https://tass.ru/obschestvo/8643555
[2] The website of JSC "MMC "Norilsk Nickel» https://www.nornickel.ru/news-and-media/press-releases-and-news/ao-n-tek-likvidiruet-posledstviya-identsenta-na-rezervuare-khraneniya-dizelnogo-topliva-tets-3/?dateStart=46800&dateEnd=1597093199&type=releases
[3] The website of JSC "MMC "Norilsk Nickel» https://www.nornickel.ru/news-and-media/press-releases-and-news/khod-rabot-po-likvidatsii-avarii-obnovlyaetsya/?type=rele
[4] Kotlyakov V. M. "The World of snow and ice" // «science» 1994//c. 125
[5] Website of the Siberian department of the Russian Academy of Sciences https://www.sbras.ru/ru/bne2020
[6] p. 2.1. Sanitary and epidemiological rules and regulations of the SanPiN 2.2.1/2.1.1.1200-03 " «Sanitary protection zones and sanitary classification of enterprises, structures and other objects»
[7] Natural hazards of Russia vol. 6. Assessment and management of natural risks // ed. by Ragozin A. L. // M. 2003// 320 c.