Assessment of natural and technogenic conditions of the area of the water-supply system upgrade in Dudinka (Krasnoyarsk Region, Russia)

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Abstract. Territories of the subarctic forest-tundra of Taymyr are characterized by an insufficient state of exploration of their natural conditions. Another feature is vulnerability of natural landscapes to man-made impacts. Along with this, the increased public attention to preservation of the ecological status of these territories necessitates detailed studies of environment components during construction activities. This work is devoted to the geoecological substantiation of the water-supply system upgrade in Dudinka (Taimyr Dolgan-Nenets Autonomous District of the Krasnoyarsk Region, Russia), considering specific natural conditions of the sub-arctic forest-tundra and technogenic impacts of the upgrade project. This work describes primary results of engineering and environmental surveys, which provided necessary and sufficient basic data. It was established that due to a localized nature of technogenic impacts during environmental activities, the combined impact of technogenic factors is insignificant and will not cause environment degradation. A set of recommendations and proposals for environment protection and ecological monitoring organization was developed.

1 Introduction

Territories of the subarctic forest-tundra of Taymyr are characterized by an insufficient state of exploration of their natural conditions and vulnerability of natural landscapes to man-made impacts. Particularly, due to technogenic impacts on landscape components geochemical changes occur in soils, bottom sediments, surface waters and vegetation cover in these territories [1]. It should be noted that at large industrial facilities in most cases environmental impacts are observed at all stages of technogenic activity, especially during their construction and operation. Therefore, construction activities in these territories should comply with the "green" construction concept [2, 3] and consider quality improvements in geoecological substantiation of such projects [4].

Taking into account the above considerations, acquisition of adequate baseline data for ecological design during construction development of the subarctic forest-tundra territories shall include appropriate composition and scope of engineering and environmental surveys.

The purpose of the study is a comprehensive geoecological assessment of the territory of the reconstructed water supply system in Dudinka (Taimyr Dolgan-Nenets Autonomous District of the Krasnoyarsk Region, Russia), which is necessary for the development of measures to protect the environment.

2 General characteristics of the project and surveyed territory

Figure 1 shows an outline map of the surveyed territory. The main water-supply source of Dudinka is the Lake Samsonkino. The first stage pumping station (point A in Figure 1) is located on its south bank. The project includes:

- upgradation of the first stage pumping station;
- construction of treatment facilities with the second stage pumping station (point B in Figure 1);
- upgradation of the existing main water pipelines and construction of new ones;
- construction of a 6 kV power transmission line from the main step-down substation (point C in Figure 1) for power supply to the designed facilities.

The surveyed territory is situated outside the residential zone of the city and includes (refer to Figure 1):

• an area within the sanitary protection zone (SPZ) of the Lake Samsonkino (shaded);

• sites of the first stage pumping station, treatment facilities and the main step-down substation;

• a 20 m wide strip on the both sides of infrastructure facilities.

The city lies on the right bank of the Yenisey, near the confluence point of the Dudinka river, its right-bank tributary. The distance between the city and the Yenisey estuary is about 430 km.

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The water-supply source – Lake Samsonkino – is located 3 km north-east from the city. The catchment area is 8.4 km^2, the lake length – 1,960 m, average width – 450 m, average depth – 5.2 m, volume – 4.6×10^6 m^3, water-surface area – 0.89 km^2. The lake is supplied by snow melting and rainfalls. According to the data of long-term hydrological observations at the Lake Samsonkino, the highest flood occurs in mid-May – early June. The minimum water level is observed in March-April.

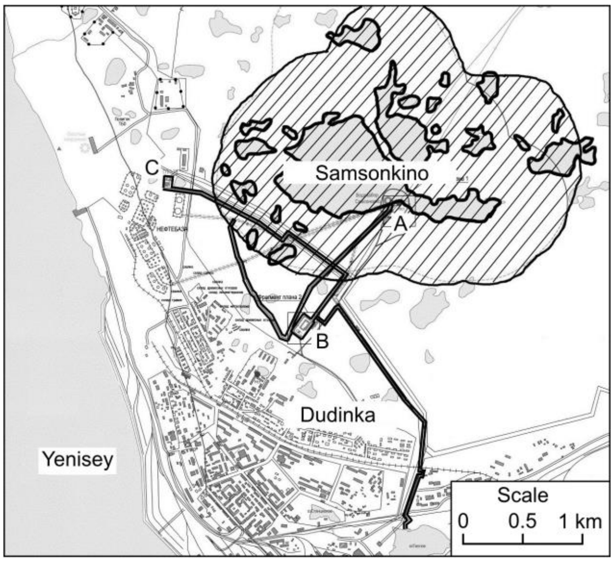

Fig. 1. Outline map of the surveyed territory.

The territory is a vast low gently rugged plain with diverse and composite topography and pervasive cryogenic structures [5]. Specific landscape forms are shown in Figure 2. The surveyed territory is characterized by numerous small lakes and boggy areas. The territory is dissected by shallow valleys of small creeks running dry in summer.

The territory belongs to the transitional zone between Arctic tundra and taiga. The dominant form of the vegetation cover is shrubby (including alder, rowan, briar) [6, 7]. Suppressed trees with crooked trunks and irregular crowns occur. Many berry plants grow near the Lake Samsonkino – blueberry, cloudberry and, cowberry. There are high blooming sally and hogweed thickets. Large areas of the territory are covered with lichen. Water birds, mainly ducks, nest in thick grasses (sedge and cotton grass) near the lake.

A reconnaissance survey of the territory showed that it is characterized by a complex combination of peaty-gley tundra soils and gley-podzolic soils, specific for the northern taiga. Based on the results of the reconnaissance it was established that the humus thickness is insignificant, only several centimeters.

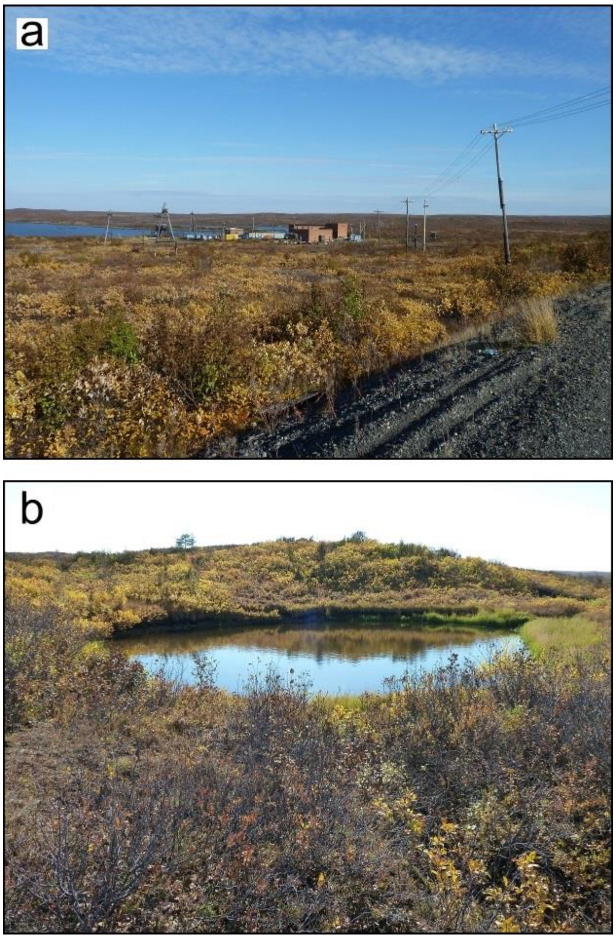

Fig. 2. Specific landscape forms. Near the Lake Samsonkino (a), one of numerous small lakes (b).

3 Basic geoecological works

Survey works were carried out by specialists of Scientific & Industrial Association Gidrotekhproekt and the National Research University – Moscow State Construction University in September of 2016 according to requirements and recommendations [8, 9].

Preparatory works included collection, processing and analysis of data on environment conditions within the target area, including materials of similar surveys previously performed in this territory.

The composition and scope of field works and laboratory studies are shown in Tables 1 and 2. During radio ecological studies – measurement of the gamma Equivalent Dose Rate (EDR), radionuclide analysis of soil samples, measurement of radon flux density – special attention was paid to areas of prolonged exposure for the personnel.

Cameral works included geoecological generalization of field and laboratory research results, predictive assessment of the environment condition, development of proposals for protection measures and ecological monitoring organization.

Table 1. Composition and scope of field works.

Types of works	Work scope
Field reconnaissance	Route length – 10 km
Engineering and environmental survey of the territory (detection of visual signs of pollution and conditions of landscape components of the environment)	Route length – 10 km, description of 48 typical local points
Gamma survey	Survey area – 460 ha
Radon hazard survey	35 measurement points
Noise level measurement	10 measurement points
Electromagnetic radiation measurement	10 measurement points
Soil sampling for chemical analysis	6 samples
Soil sampling for radionuclide analysis	6 samples
Soil sampling for microbiological and parasitological analyses	6 samples
Water sampling for chemical analysis	4 samples
Water sampling for microbiological analysis	4 samples

Table 2. Composition and scope of laboratory studies.

Test subject	Number of samples	Types of laboratory analyses
Soil	6	Multi-element chemical analysis
Soil	6	Gamma-spectrometric analysis of radionuclide activity
Soil	6	Microbiological and parasitological analyses
Water	4	Quality chemical analysis
Water	4	Microbiological analysis

4 Results

During the field reconnaissance and engineering and environmental survey, the territory was walked over with execution of ecological descriptions of typical points. A part of the territory, surveyed during reconnaissance and located mostly beyond the SPZ limits, has insignificant signs of technogenic disturbance. The reconnaissance survey did not reveal any signs of pollution within the Lake Samsonkino's SPZ. Generally, the landscape condition can be assessed as satisfactory, with separate areas of technogenic disturbance.

Information on disturbance and pollution levels of environmental components in the surveyed territory, obtained during engineering and environmental surveys, is summarized in Table 3.

Table 3. Information on disturbance and pollution of environmental components in the surveyed territory.

Environmental components	Disturbance and pollution levels
Landscape conditions	Generally satisfactory, with separate small disturbed areas
Radiation conditions	Radiation characteristics: - gamma EDR at the territory is not more than 0.22 μSv/h; - soil radioactivity level does not exceed 22.5 Bq/kg; - radon flux density is less than 47 mBq/(m^2×c). The characteristics meet sanitary standards
Noise	Noise level is less than 50 dBA and does not exceed the maximum permissible value
Electromagnetic fields	Electric and magnetic field strength are respectively 0.19 kV/m and 3.8 A/m and does not exceed the maximum permissible value
Atmospheric air conditions	Concentrations of main pollutants do not exceed relevant maximum permissible values
Surface water quality	Water of the Lake Samsonkino meets sanitary standards
Soil conditions	Chemical contamination category – permissible; no bacteriological or parasitological contamination

Laboratory analyses of water samples from Lake Samsonkino and other water bodies (Lake Mishkino, the Three Lakes System and the Dudinka river) show that for organoleptic, generalized indicators, the content of harmful ingredients, microbiological and radiation criteria, the water is suitable for drinking supply. After the cleanup envisaged by the project of reconstruction of the water-supply system the water entering into the plumbing from the treatment facilities will improve its quality.

The results of analyses of soil samples and the criteria of the existing Russian sanitary standards allowed to establish that:

• the category of chemical contamination in soils is permissible;

• the category of epidemic danger is pure;

• the level of radioactivity meets the established standards of radiation safety for building materials.

The performed calculations of concentrations fields for the most significant polluting agents showed that the impact of the water-supply system facilities will not lead to noticeable effects on the quality of atmospheric air at the border of the living area of Dudinka.

A comprehensive analysis of landscape components shows that the cumulative state of the natural environment in the areas of reconstruction of the facilities and the surrounding territories as a whole is assessed as safe.

Based on the field and laboratory studies, forecasting was made regarding changes in the ecological conditions of the territory during construction works for the facility upgrade and operation, as well as emergency situations. Potential changes in the ecological conditions in case of technogenic impacts on the atmospheric air, surface and ground waters, environmental impacts of waste, impacts on the soil cover, the geological environment, flora and fauna, influence of the facility on conditions of especially protected natural territories, natural monuments, historical and cultural monuments. It was established that due to a localized nature of technogenic impacts during construction activities, their limited period (about one year) and during environmental activities, the combined impact of technogenic factors is insignificant and will not cause environment degradation. Analysis of technogenic impacts established that during operation of the water-supply system their combined influence will be insignificant too. Protection measures for emergency situations (fires, emergency power cut-offs, water pipeline ruptures, pumping equipment failures, etc.) will also ensure ecologically safe operation of the facility.

Based on predictive assessments of the changes in landscape components a set of recommendations and proposals for prevention and mitigation of the upgrade project impacts was developed. For identification of tendencies in quantitative and qualitative changes of the environment condition proposals for an ecological monitoring organization were developed.

5 Conclusions

• The comprehensive environmental assessment of the territory adjacent to Dudinka provided the design process for the water-supply system upgrade with necessary and sufficient baseline data on the environmental conditions.

• Analysis of landscape component conditions established that the general environment conditions at facility upgrade sites and adjacent territories are considered satisfactory.

• Radiation characteristics (gamma EDR, soil radioactivity level, radon flux density), the noise level and electromagnetic pollution of the territory, the state of the atmosphere, surface waters and soils meet the current sanitary standards.

• It was established that due to the localized nature of technogenic impacts during environmental activities, the combined impact of technogenic factors is insignificant and will not cause environment degradation.

• A set of recommendations and proposals for environment protection and ecological monitoring organization was developed.

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