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Ecological Monitoring of Specially Protected Natural Areas of the Russian Arctic

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Abstract. active industrial development of the Russian Arctic leads to the increase of anthropogenic pressure on natural ecosystems. One of the main ways to preserve unique territories is the establishment of special regimes for natural resources use and environmental protection, including monitoring of environmental pollution. The creation of network of integrated environmental monitoring in specially protected natural areas will allow studying the environmental response to anthropogenic impact, as well as monitoring the biosphere in places distant from production activity. The conducted analysis of environmental threats, and ongoing environmental monitoring activities, has shown the need to establish programs for environmental monitoring in specially protected natural areas. In the long term, monitoring components will be integrated into a single network that will provide information for assessing the effectiveness of environmental measures; data on the dynamics of natural processes. This network is supposed to help identify the most vulnerable components of the biosphere as well.

1. Introduction

The great resource potential of the Arctic regions within Russia makes these territories a platform for active industrial and economic activity. Modern rates of industrial development lead to exceeding the threshold level of the load on natural ecosystems. There is a gradual merger of industrial centers as well as an increase in the number of components of the technosphere, which lead to the degradation of territories and the reduction of species composition. At the same time, there is a growing need to monitor the state of the environment and to conduct environmental monitoring [1].

Compared to other regions the rate of warming is accelerating in the Arctic [2]. Factors such as shipping, oil and gas production, fish poaching, intensify the negative effect. The Arctic marine benthos, which provides key ecosystem functions such as nutrient cycling, organic transport, sediment mixing and the metabolism of pollutants [3], is likely to depend on many direct and indirect effects of climate change [4].

In the last decade, the commercial use of Arctic bioresources has become spontaneous and chronic [5]. Uncontrolled capture and poaching of rare species of animals and biological raw materials exceeds the permissible standards. This causes serious damage to the status of populations of mammals, fish and birds. The Russian sector occupies not less than a third of the entire territory of the Arctic and plays an important role in conserving Arctic ecosystems, since it is in the Russian sector that the most typical arctic landscapes are represented, that up to 80% of all species of living organisms and 90% of typical Arctic species are inherent in Arctic ecosystems [6].



Considering the high degree of the pollution threat and the undoubted value of the territories, environmental safety becomes one of the priorities in the development of Russian Federation policy towards Arctic Region. One of the main environmental measures is "the establishment of special environmental management and environmental protection regimes, including monitoring of environmental pollution" [7].

The aim of the work is to define the main principles for creating the environmental monitoring program in the specially protected areas of the Arctic (SPNA). To fulfill the set goal, the following was accomplished:

- consideration of the main threats of anthropogenic pollution;
- assessment of the current status of the specially protected natural Arctic zone of the Russian Federation;
- consideration of the Arctic region particular nature, which influences taking measures for environmental monitoring;
- identification of the main structural components of monitoring, which include methods and means of monitoring;
- development of the general scheme for the environmental monitoring system in a specially protected natural area.

2. Consideration of the main pollution threats and assessment of the current status of the specially protected natural areas of the Arctic zone of the Russian Federation

Currently, the Russian Arctic sector comprises more than 300 industrial facilities, which are classified as particularly responsible. Also, over 400 surface oil and gas fields were discovered over the Arctic Circle. Production is actively conducted at 60 of them. More than two thirds of the producing fields are located in Russia.

The development of Arctic offshore deposits is going to constitute a serious environmental threat in the future. Gazprom, Gazprom Neft and Rosneft control up to 90% of promising offshore areas [8]. Gazprom holds licenses for development of 40 offshore sites, Rosneft - for 51 sites. Subsequently, oil and gas production components such as platforms, surface subsurface and underwater modules, process and transport pipelines, temporary storage facilities, receiving and transshipment coastal terminals, processing plants, main oil and gas pipelines, etc., will be largely concentrated in the region.

Drilling activities have a chronic impact on the Arctic ecosystems, leading to long-term changes, while the consequences of an emergency oil spill are spontaneous and can cause serious damage to the environment in a short period of time [9].

Nowadays there are more than 450 specially protected natural areas in the Russian Arctic with a total area (excluding marine areas) slightly more than 94.6 million hectares, which is about 16.2% of Arctic's total area [10].

However, the establishment of a special regime for nature management means not only the cessation of any industrial activity in a given territory and the maintenance of natural ecosystems in a natural state. Such categories as SPNA, national parks and biosphere reserves perform following tasks: the study of environmental reaction towards anthropogenic impact, as well as control of the state of the biosphere in places distant from production activity.

Currently there is no network of comprehensive environmental monitoring in the Arctic zone of the Russian Federation.

According to the regulation "On the organization and implementation of state environmental monitoring," state environmental monitoring (hereinafter referred to as monitoring) means a comprehensive system for monitoring the state of the environment, assessing and forecasting changes in the state of the environment under the influence of natural and anthropogenic factors [11].

The major tasks of monitoring in the specially protected natural areas of the Arctic are:

- research of natural processes (climatic, geological, etc.);
- assessment of the influence, caused by anthropogenic impact in high Arctic latitudes in order to predict regional consequences of global change;

- monitoring the populations of endemic species of animals and plants.

a. *Specific conditions of the Arctic region*

Specific conditions of the Arctic territories impose certain requirements for the activities conducted there. When implementing monitoring programs in the Arctic, it is necessary to take into account the specifics of the region and natural and climatic features such as:

1. Remoteness from the main cities and infrastructure.
2. The Arctic does not have adequate coverage by satellite systems, which allows to accurately determine the coordinates of any point. Compared with the lower latitudes, location and navigation in the Arctic are difficult.
3. The conditions of the polar day and the polar night affect the diurnal and seasonal biological cycles. When planning studies with sampling, organizations should assess the risks associated with the polar cycle of day and night alternation.
4. The methods used for environmental monitoring should take into account that in the Arctic there are low temperatures.
5. The presence/absence of ice, permanent/temporary, should be taken into account when developing an environmental monitoring program [12].

3. Monitoring system

The monitoring system of the environment state and its pollution is formed using modern ground-, air- and space-based surveillance devices and by means of integration with existing and established international systems of environmental monitoring and providing detection and prediction of the degree of anthropogenic impact on natural ecosystems in the Arctic zone, including tracking of climate change of the Earth, as well as timely detection and prediction of natural and technical emergencies genetic nature [13].

In this paper, the main components of the monitoring system in specially protected natural areas were identified and a basic program with a description of the monitoring stages was developed.

Figure 1 shows the structural diagram of the monitoring. Depending on the characteristics of the territory, an optimal program is developed. It includes a rightful combination of various observation block components, which allows obtaining the most complete information about the monitoring object [14].

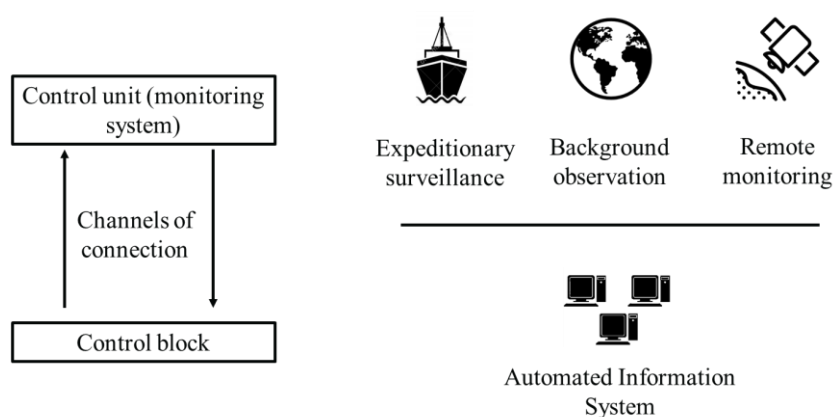


Figure 1. Structural scheme of monitoring.

Each element of the monitoring unit includes a set of tools and methods of environmental monitoring, which are selected based on the tasks assigned and regulated by state standards [15].

There can be a stationary monitoring post on the territory of SPNA, which includes: a laboratory in which a chemical analysis of all types of samples from the controlled area is carried out; an analytical pavilion that performs continuous automated monitoring (Figure 2):

- Atmospheric air conditions
- Radiation background
- Meteorological parameters

The information received during the monitoring is transferred to the data receiving and processing center. Figure 3 shows the functional scheme of environmental monitoring.

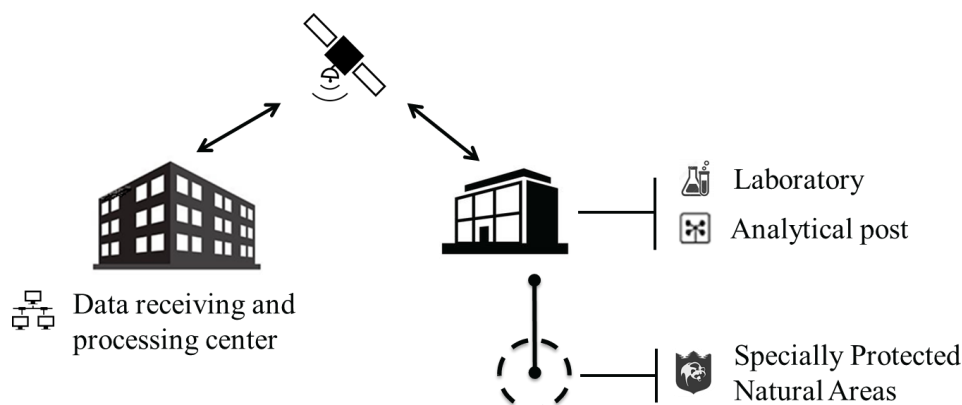


Figure 2. Scheme of the environmental monitoring system in a specially protected natural area.

The objectives of the field survey include the identification of environmental problems associated with contamination of territories due to human economic activity and requiring immediate operational intervention; issuing practical recommendations on reducing the negative impact on the environment [16]. There is also a background monitoring, which allows you monitoring the state of natural systems that are beyond the immediate impact of anthropogenic factors. When conducting studies by remote methods, the main efforts are aimed at studying atmospheric and meteorological processes [17].

At the subsequent stages of the environmental monitoring program, the elimination of previously identified violations is monitored, as well as a survey of the territory to identify new violations that have not occurred here before.

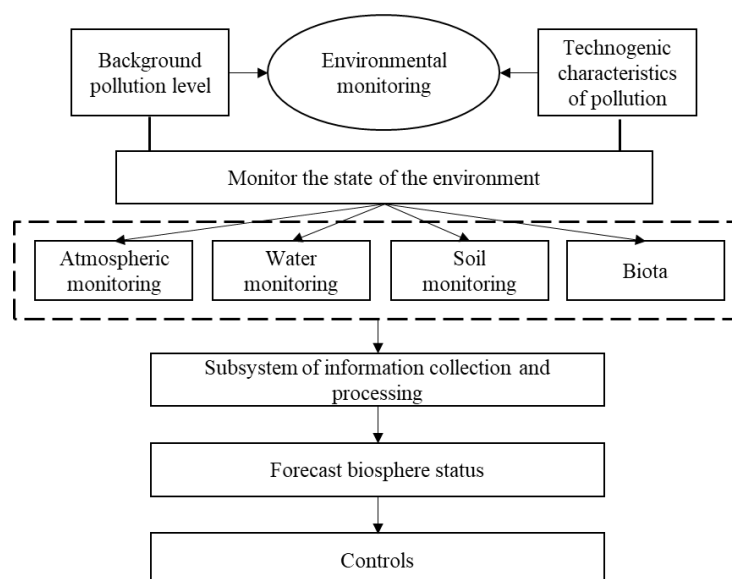


Figure 3. Functional scheme of ecological monitoring.

4. Conclusion

After analyzing the environmental threats, as well as ongoing environmental monitoring activities, a decision on the establishment of environmental monitoring programs in specially protected natural areas was justified. The environmental monitoring activities should take into account the territorial location and special climatic conditions of the region. This can be done by combining remote observation methods and field geoecological studies. Locations choice for the construction of modern stationary stations is based on the representativeness of the data, the most rational geographic location, as well as the possibility of finding employees in the station. In the long term, monitoring components will be integrated into a single network that will provide information for assessing the effectiveness of environmental measures; data on the dynamics of natural processes. This network is supposed to help identify the most vulnerable components of the biosphere as well.

The current reality and pace of industrial power development require serious environmental protection measures aimed at protecting and monitoring the state of the environment. Environmental monitoring is one of the main means of environment's protecting. Extending of the monitoring network, properly planned measures and providing modern equipment meeting world standards will allow obtaining information for assessing the effectiveness of environmental protection measures; data on the dynamics of natural processes, as well as help identify the most vulnerable components of the biosphere.

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