Nature management on the Arctic territories of the Russian Far East

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Abstract. The established structure of environmental management, which depends on economic activities, determines the ecological situation of a particular territory. Such studies are particularly important and relevant for areas with low ecological capacity and resistance, which include the territory of the Arctic zone of the Russian Far East (RFE). The discussed territories have a high vulnerability of the natural environment to anthropogenic impacts and a low recovery rate of the disturbed state. Analysis of information on the environmental state of the Chukotka Autonomous Region and the Republic of Sakha (Yakutia) allows us to conclude that the environmental situation is unfavorable in the regions. The established system of environmental management in certain areas of the Russian Arctic has led to the emergence of heavily modified areas as a result of economic activity, where the disturbing dynamic equilibrium of the natural environment has led to changes in the natural geochemical background, depletion of biodiversity, degradation of soil and vegetation, development of erosion processes, and environmental pollution. The paper presents the socio-economic, natural-geographical, ecological characteristics of the Arctic zone of the RFE in the context of ulus, proposed the structure of existing and possible future directions of environmental management.

1. Introduction
The Arctic zone of the Russian Far East (RFE) includes the Chukotka Autonomous Region (CAR) and five uluses of Sakha (Yakutia): Allaikhovsky, Anabarsky, Bulunsky, Nizhnekolymsky, and Ust-Yansky. All of these territories are characterized by the sharp continental climate, widespread distribution of the permafrost, underpopulation, high resource-intensiveness, focal nature of the industrial-economic development, dependence of the life-sustaining activity on the deliveries of goods to the Northern Territories, and low sustainability of ecological systems.

The indicators of the social and economic development of the Arctic and Northern regions lag far behind the all-Russian mean values. The chief problems of the current situation are:

- underdevelopment of the transport and energy infrastructure;
- a high degree of the social infrastructure depreciation;
- a low standard of human well-being;
- reduction in the share of the working-age population (migration outflow).

Absence of the possibility for the construction and maintenance of the modern system of the life support and activity only at the expense of local resources is the fundamental reason for the present situation. On these territories, there is a high level of the accumulated environmental damage, dilution
of traditional lifestyle and decrease in territories of the traditional nature management of the indigenous small-numbered peoples of the North. Natural changes and emergency situations influence significantly: Due to global warming, the permafrost is in critical state; the irreversible processes of thawing the subsurface ice are observed, and, each year, the cryogenic landscapes lose their stability and functional properties, which necessitates the continuous adaptation of population, economy and social sphere to new conditions of economic management and life-sustaining activity.

2. Materials and methods
The appraisal of the current nature management on these territories requires an analysis of the economic activities, structure of nature management, nature protection activities, and its economic provision. In the article, the official statistical information, as well as the analytic, cartographic and statistical analysis methods were used.

3. Results and discussion
The economic development of the Arctic territories of RFE is uneven: On the territories of the Sakha (Yakutia) uluses (except for Anabarsky and Ust-Yansky uluses), the traditional kinds of activities predominate, whereas in districts of the Chukotka AR the kinds of economic activities are more diverse (Table 1). Consequently, the structure of nature management is also more complex. Despite a great decrease in production over the past years, the ecological state has not improved, which the results of the ecological rating confirmed. For many years, the Chukotka AR was one of the leaders in the ecological rating of the RF regions, and Sakha (Yakutia) also held reasonable positions. According to the 2018 rating, these regions essentially worsened their positions: Chukotka AR – down to 12th position and Sakha (Yakutia) – down to 74th position [1]. The major components of the ecological state of the discussed territories are pollution of air and water, generation of production and consumer waste polluting the territories, as well as radioactive contamination. A dynamics of emissions and discharges also suggests the stably polluted state of air and water (figures 1-3).

Table 1. Economic activities in the Arctic zone of RFE [2-6].

| Region, uluses and districts | Natural resources                                                                 | Kinds of economic activities                                                                 | Classes of occupational hazards |
|------------------------------|----------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|---------------------------------|
| **Sakha (Yakutia):**         |                                                                                  |                                              |                                 |
| Allaikhovsky                 | fish, fur game; SPNA: resource reserves “Ktyalyk”, “Ozhogino”, unique protected Lake Mogotoyevo | agriculture (reindeer farming, horse breeding), fur trapping and fishery, food industry    | IV, V                           |
| Anabarsky                    | diamonds, fish resources, fur game                                               | mining and processing of diamonds, fish capture and processing, reindeer breeding, hunting, souvenirs manufacturing | II, IV, V                      |
| Bulunsky                     | fish resources, fur game; SPNA: state natural reserve “Ust-Lensky”               |                                              | III, V                          |
| Ust-Yansky (classified as difficult access and remote areas) | gold, tin, tungsten, mercury, lead, zinc, brown coal; fish, fur game; SPNA: regional state reservation “Jansky mammoths” | reindeer breeding, fur farming, fishery and fur trapping, mining of tin and gold, fish processing | II, IV, V                      |
| Nizhnekolymsky               | raw hydrocarbons, gold, ornamental stone material,                                | Reindeer breeding, fur farming, fishery and fur                                          | III, IV, V                      |
construction materials (loams, sand and gravel mixtures); SPNA: partial reserve
Pleistocene Park

| Chukotka Autonomous Region: |            |                          | I, II, IV, V |
|----------------------------|------------|--------------------------|--------------|
| Anadyrsky                  | coal, gold, silver, natural gas; SPNA: reserve “Lebediny”, “Ust-Tanyurersky”, ‘Avtakuul’ | mining of coal, gold, silver and natural gas, food industry, reindeer breeding, airport |              |
| Bilibinsky                | gold, silver, platinum group metals, tin, zinc, copper, antimony, tungsten, mercury, lead, pyrite, bornite, molybdenite, coal | atomic energetics, gold mining, food industry, reindeer breeding, fishery, hunting and fur trapping, greenhouse facilities, airport | I, II, IV, V |
| Iultinsky                 | gold, silver, tin, tungsten, molybdenum, antimony, lead, mercury, construction materials, coal; SPNA: reserve “Wrangel Island”, regional natural-ethnic park “Beringia” (part) | energetics, gold mining, port facilities, reindeer breeding, fishery, sea hunting industry, airport | III, IV, V |
| Provedensky               | gold, silver, tin, copper, arsenic, mercury, uranium; SPNA: natural-ethnic park “Beringia” (part) | fishery and harvesting of aquatic bioresources, food, leather industry, feed milling, reindeer breeding, pig breeding, poultry breeding, sealing, hunting and fur trapping | III, IV, V |
| Chaunsky                  | gold, silver, tin, mercury, tungsten, coal; SPNA: reserve “Chaunskaya Guba” | heat power industry, mining of gold, copper, tin, port facilities | II, III |
| Chukotsky                 | gold, polymetallic ores, mercury, tin, construction materials, coal; SPNA: regional natural-ethnic park “Beringia” (major territory) | gold mining, fishery, harvesting of aquatic bioresources and sea hunting industry, reindeer breeding, harvesting of wild crops | III, IV, V |

The unfavorable ecological situation is observed in the Anadyrsky and Bilibinsky districts. The Iultinsky and Providensky districts are relatively stable. In the Chukotsky district shows positive dynamics. The most complex situation is in the Chaunsky district. In this district, the energetics is predominant, but radioactive contamination worsens the situation: Directly on shore of the East Siberian Sea, to the east of Pevek, there is the concentration factory of uranium production closed in the early 1950s, and its tailing dump keeps the accumulated radioactive waste. The surface of the settling tank is open; its area is 20 km². According to data on the radiometric surveys, the specific alpha-activity of waste and radon concentration more than 100 times exceed the background concentrations [7].

The main air pollutants are carbon dioxide, carbon monoxide as well as sulfur and nitrogen dioxides. The basic pollutants of waters include the organic substances, compounds of iron, copper, zinc, and manganese, phenols and oil products. Even though the volumes of the discharged polluted wastewaters do not practically increase (figures 1, 3), the state of surface waters worsens. This is due
to the fact that the majority of operating wastewater treatment facilities were built more than 30-40 years ago. The technical state of many of them is unsatisfactory; technology of treatment is outdated; the facilities of only mechanical treatment often function, and, therefore, the operated facilities do not provide the normative treatment of sewage waters. The anthropogenic impact resulted in almost entire pollution of the Lena River, which the category became considered “dirty”.

Figure 1. Environment pollution in the Chukotka AR [8].

Figure 2. Atmospheric air pollution in the Arctic uluses of Sakha (Yakutia) [9].

The rivers Aldan, Indigirka, Jana (Yana), and Amga show the same situation, whereas the Vilyui River became “very dirty” [10]. The previous studies showed that the partial restriction of the functioning of the water-retaining plants was imposed on 2 of 8 districts in the Chukotka AR and 7 of 13 ones in Yakutia (Sakha) due to pollution of water resources [11]. The other districts have no restrictions. High pollution of water and air has resulted in the rapidly rising incidence of diseases among the population, especially infectious, cardiovascular and cancerous ones.

Another significant problem for the territories of the Far-Eastern North is related to the generation and storage of the solid production and consumer waste and organization of unauthorized landfills, which caused pollution of territories, underground and surface waters, deterioration of landscapes, etc.

Figure 3. Pollution of water resources in the Arctic uluses of Sakha (Yakutia) [9].

The extractive industry companies generate the greatest number of waste, and the overburden rocks, refinement tailings and ash-disposal areas form their essential mass. High volume and rate of waste accumulation, as well as poor development of the waste recycling industry, make the waste burial in dumps the basic way of disposal. The sanitary state of the disposal sites remains to be
unsatisfactory: Often, the fencings and containments are absent; the territories and approach roads are not landscaped and are overfilled with waste; the recultivation works are not carried out; the dump holder is not determined, the register of waste generators is not kept; the household waste delivery is not monitored at the level of the municipal settlements, etc. The changes also take place in the categories of lands. The changes in areas took place for four categories: agricultural lands, industrial, transport and other-uses land, forest lands, and reserve lands. At that the same time, an increase in areas took place only for category of industrial lands, whereas the areas of agricultural and forest lands decreased.

According to the accepted structure of the nature management lines [12] in uluses of the Chukotka AR, parallel with the traditional industries, the production line, in which the extraction of commercial minerals dominates, holds a key position. The different kinds of traditional industries predominate in the arctic uluses of Sakha (Yakutia), except for the Ust-Yansky ulus where the mining of tin and gold is carried out. The other structural lines of nature management are underdeveloped (table 2).

| Table 2. Structural lines of nature management |
|-----------------------------------------------|
| Structural lines of nature management         | Chukotka AR | Sakha (Yakutia) (arctic uluses) |
|                                             | existing | prospective | existing | prospective |
| Production                                   | +++     | ++++         | ++      | +++         |
| Spatially-connecting                          | +       | ++           | ++      | ++          |
| Communal                                     | +       | ++           | ++      | ++          |
| Environment-protective                        | ++      | ++           | ++      | +++         |

In addition to the economic activity, nature protection activity also forms nature management efficiency. The nature management efficiency in these regions is very low. In terms of the financial assurance of the activity aimed to reduce the negative impact of production on the natural environment, the current charges, investments in the protection of environment (PE) and sustainable nature management, as well as their structure, do not correspond to necessary ones and remain stably low (figure 4). The actual volumes of the investments in the PE are enormously low in comparison with the economic optimum [13]: 36.8%/18.9% in 2007/2010 and 10.7%/20.4% in 2013/2014 for Sakha (Yakutia) as well as 2.4%/1.16% in 2007/2010 and 5.2%/10.0% in 2013/2014 for the Chukotka AR. The index of economic adequacy (IEA) of the nature protection activity, which is determined as the ratio of actual volumes of the PE and sustainable nature management financing to economic optimum at the optimum value of IEA=1, indicates the same fact (table 3).

Figure 4. Dynamics of investments in: a) Republic of Sakha (Yakutia) and b) the Chukotka AR.
The concept of the sustainable development of the arctic uluses emphasizes that the “The transition to the effective model of development, namely, the balanced solution to the problems of development of the industry and traditional kinds of the economic management of the northern nations with obligatory preservation of the natural environmental systems and biological diversity is the long-term benchmark for developing the arctic uluses and areas of compact settlement of the indigenous small-numbered peoples of the North” [14]. For these territories, the development of industry (mainly, extractive and substantially affecting processing industries) will ensure the growth in GRP, capital investments, etc., but it will unlikely provide the preservation of natural environmental systems and biodiversity (table 3).

| Territorial entities | ∑ of current charges and investments for PE and sustainable nature management, million rubles, 2013/2014 | Economic optimum, million rubles (8% of GRP) 2013/2014 | Index of economic adequacy of nature protection activity (actual/optimun) 2013/2014 | ∑ of current charges and investments for PE and sustainable nature management, million rubles, 2007/2010 | Economic optimum, million rubles (8% of GRP) 2007/2010 | Index of economic adequacy of nature protection activity (actual/optimun) 2007/2010 |
|----------------------|---------------------------------------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| Republic of Sakha (Yakutia) AR | 4889.7/10772.3 | 45530.5/52812.0 | 0.1/0.2 | 7260.8/5811.7 | 19717.5/30778.1 | 0.4/0.1 |
| Chukotka AR | 196.3/452.3 | 3759.2/4524.5 | 0.1/0.1 | 40.8/39.0 | 1697.8/335 | 7.9 | 0.02/0.01 |

4. Conclusion
The conducted analysis allows us to draw the following conclusions.

The territory of the Arctic North of RFE has substantial natural resource potential, including the resources of traditional types of economic management.

The considered territories, in spite of the more favorable ecological state in comparison with the Arctic territories of western Russia, have negative consequences related to the anthropogenic impact.

The financial assurance of the nature protection activity and sustainable nature management remains stably low.

In plans of the social and economic development on the discussed territories, the following measures should be first-priority:
- efforts to remove existing technogenic consequences and restore disturbed landscapes;
- formation of the necessary infrastructure: communication routes, waste disposal plants, electrical power supply using, primarily, non-traditional kinds of energy, house construction, and provision of living environment for the indigenous small-numbered peoples of the North. There is an experience of using the alternative way of the electric supply: Chukotka wind power plant VPP-1 at Cape Observation (Anadyrsky District);
- modernization of the existing branches of industries as well as measures focused on construction of new objects and reconstruction of old (if any) ones for necessary preparation (according to SanPin) of water supply, water discharge as well as utilization or recycling of solid waste.

For these territories, the state support and aid are necessary to develop the traditional kinds of economic management as well as retreatment of products from these fields (perfume, jewelry, leather, soap-making, pharmaceutical, etc.). For the survival of the northern people, it is necessary to keep their identity at the expense of the development of the economic sphere based on traditional industries of these peoples in places of their living. The traditional industries in these places are important not only in cultural terms but also economic ones, although their roles vary in different districts, ethic
groups as well as generations. The development of traditional occupational industries of the indigenous peoples of the North ensures also the own food supply security for the region. The other strategy is the economy of the traditional industry by way of developing food processing, handcrafts, souvenir production, and tourism. Such businesses can be considered the current trend of the traditional economy.

Investment projects aimed to protect the environment and optimize production-natural relationships should be created and promoted.

Currently, the ecological sustainability of the nature management should have a preference within the framework of the support, enhancement and preservation of the Arctic territories of the RFE. Therefore, the top-priority measures, as well as near-future ones, should be focused on the intensified development of the environmental protection in the nature management as well as active and real support from the state in preservation of the uniqueness and further development of the arctic territories of RFE (state investments, tax exemptions, economic encouragement and other preferences) rather than the commercial development.

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