Monitoring and assessment of the state of floodplain ecosystems exposed to oil and gas complex wastes

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Abstract. Formation of a huge amount of industrial waste is one of the most urgent problems of the mineral resource complex today. It accumulates on the surface of the Earth, disposed of by burning or stored in anthropogenic arrays, thereby providing a complex and lasting negative impact on all components of the natural environment. This problem is especially acute in regions with a high concentration of enterprises of the mineral resource complex. The results of a scientific study on monitoring the state of the floodplain ecosystems of the Ob River, as one of the most reliable indicators of the intensification of the anthropogenic load in the region, are presented in the article. The progress of the research and the results of computer processing of the data are described in the article in detail. In addition, comparative characteristics of the state of some species of plant communities over a three-year period are given.

1. Introduction

Environmental monitoring today is becoming one of the main tasks of the environmental services, industrial enterprises and the state as a whole [1]. Constantly increasing volumes of extraction and processing of mineral raw materials, the intensification of anthropogenic load and uncontrolled natural disasters of anthropogenic nature cause irreparable damage to the ecosystem of the planet [2]. So, millions of hectares of forest were destroyed, and tens of millions of tons of carbon monoxide and carbon dioxide were released into the atmosphere as a result of forest fires in Siberia in the summer of 2019 [3]. Everything that happens today deserves close attention and needs constant monitoring, the absence of which can lead to irreversible consequences for humanity.

Khanty-Mansiysk Autonomous Okrug - Ugra is one of the leading oil and gas producing regions of Russia. Intensive mining, along with global problems, causes significant damage to the ecosystem of the region, the restoration of which subsequently takes many years [4].

In this regard, the solution to this problem is of high relevance for the region under consideration, since the vast territories of Ugra are subject to pollution by oil and oil products, drilling waste and drilling fluids, mineralized waters. Atmospheric pollution by toxic substances occurs as a result of the operation of internal combustion engines and the burning of a huge amount of associated petroleum gas. Even territories that are not in close proximity to production and processing facilities are affected due to air and water pollution [5].

The Ob River, which is the largest and most important river, both in the region and on the territory of the Russian Federation, is experiencing serious anthropogenic pressure. The concentration of oil products in its waters exceeds the norm by a factor of tens, which may negatively affect, in particular,
the plant communities of the Ob floodplain, the development of which directly depends on the dynamics of floodplain flooding [4,6].

The question of establishing a relationship between environmental factors and elements of the natural environment, in particular plant communities, is poorly studied nowadays [7]. At the same time, green plants are an indirect, but very reliable indicator of the ecological state of the components of the environment in the study area [8,9]. In this regard, the study of the wide-ranging negative consequences of oil and gas production in the region by assessing the disturbance in the ecosystems structure of the central floodplain of the Ob River. Moreover, the degree of ecosystems disturbance was determined on the basis of long-term changes in biodiversity and biomass of green spaces [10].

2. Materials and methods
The following tasks were solved during the study:

1. to identify the patterns of different-year dynamics of flooding of the Ob floodplain for the study period;
2. to study the features of seasonal changes in the regime and area of flooding of the Ob floodplain in the studied area;
3. to evaluate the duration and frequency of flooding of plant communities;
4. to reveal the dependence of the degree of disturbance of the plant communities of the Ob floodplain on the ecological well-being of the study area.

The main methods of research were: system analysis of fundamental scientific works of Russian and foreign scientists on this subject; monitoring, landscape-geochemical, bioindicative, experimental and analytical works in the field and laboratory with a using of modern scientific instrument base; methods of mathematical statistics and forecasting the state of natural complexes affected by the anthropogenic load of the oil and gas complex of the region.

The main methods of chemical analysis of vegetation samples were x-ray fluorescence and atomic absorption methods. It allowed to establish their qualitative and quantitative composition, as well as the degree of contamination of soil and vegetation with heavy metals [11].

Cluster analysis and methods of cartographic modeling were used for the identification of areas, where are observed the maximum inhibition of vegetation and degradation of soil on these territories. The authors have extracted the data, used for cluster analysis and cartographic modeling, during field observations and laboratory experiments [12].

Computer processing of environmental monitoring data was carried out using the MapInfo Professional software product.

3. Results
The studies were conducted on the right bank of the latitudinal section of the Ob River near the village of Barsovo, 8 km west of the city of Surgut. In 2016, a 134-meter profile was laid on this territory with sample plots evenly located on it every two meters. The location of the profile relative to plant communities is shown schematically in figure 1. The laid profile extends to the northeast from the coastal part to the water edge through eight communities: forbs (Anemonidium dichotomum + Sanguisorba officinalis), forbs and reed canary-grass (Phalaroides arundinacea + Veronica longifolia), sedge and reed canary-grass (Phalaroides arundinacea + Carex acuta), reed canary-grass, acute sedge, water sedge (Carex aquatilis), flowered rush (Butomus umbellatus) and pondweed (Potamogeton perfoliatus) [13].

The species composition and distribution of plant communities along the profile in the moisture gradient from the coastal part to the water edge is typical of the central Ob floodplain. The profile shows the spatial predominance of hydrophytes - 59% of the length of the profile.

Every year since 2016, a geobotanical description is performed and grass stands are mowed at each sample plot to determine the productivity of plant communities using the mowing method.
Grass samples were cut in September from accounting sites 0.4 × 0.4 meters in size, dried to an air-dry state in the laboratory, sorted by species, weighed, and the number of vegetative and generative shoots was calculated [14].

Figure 1. The location of the profile relative to plant communities.

The values of the productivity of plant communities for the period 2016 - 2018 are presented in the article.

Figure 2. The distribution of total productivity on the profile in 2016.
For the entire observation period, 2016 was the most productive, and the peak of productivity was in the single-dominant community of forbs and reed canary-grass. The distribution of total productivity on the profile in 2016 is presented in figure 2.

According to the results of the study, the productivity of all communities on the profile, except for forbs, decreased. Forbs meadow, located in a rarely flooded zone on the top of the coastal part, occupies a strip 9 meters wide and has the largest species diversity among the communities on the profile - about 23 species per square meter. Its productivity in 2016 was 132 grams per square meter, in 2017 slightly decreased to 121 grams per square meter, and in 2018 increased to 177 grams per square meter.

The growth of terrestrial phytomass of all other communities gradually decreased over three years. So, for the forbs and reed canary-grass community in 2016 it amounted to 141 grams per square meter, in 2017 - 125 grams per square meter, in 2018 - 101 grams per square meter, and for the sedge and reed canary-grass community 405 grams per square meter, 327 grams per square meter and 266 grams per square meter, respectively.

On the slopes of the top of the coastal part, which are flooded with great frequency, predominantly reed canary-grass and sedge communities develop.

The reed canary-grass community with a length of 16 meters makes the largest contribution to productivity on the profile, however, over three years its productivity has decreased 3.34 times - from 1016 grams per square meter to 304 grams per square meter. The development of the reed canary-grass is not interrupted even at the peak of the high water seasons, since it is a hygromesophyte.

The productivity of the acute sedge community, which occupies only 4 meters, decreased from 695 grams per square meter in 2016 to 230 grams per square meter in 2018.

A rather wide strip at the water edge, about 37 meters, occupied by the water sedge community, is flooded annually for a long period, causing a pause in the development of plants at the time of flooding. Its productivity over the three years has decreased by 4.2 times - from 572 grams per square meter in 2016 to 136 grams per square meter in 2018.

A gap with a sparse vegetation 2 meters wide was formed between the water sedge and flowered rush communities.

The flowered rush and pondweed communities, consisting of hydrophytes, are constantly in the water and are flooded annually to a depth of about 4 m [6].

The productivity of the flowered rush community in 2016 was 320 grams per square meter, in 2017 decreased to 174 grams per square meters, and in 2018 amounted to only 16 grams per square meters.

Until 2016, the space between the flowered rush and pondweed communities was filled with the bur reeds community, but in 2017 it broke up and a six-meter gap with sparse vegetation formed [13]. If in 2016 the stemless bur reed accounted for 73% of the species diversity of the bur reeds community, then in 2017 only a few specimens of this species were found in the community, and in 2018, 93% were found in clasping-leaved pondweed. However, the productivity of the pondweed community decreased from 125 grams per square meters in 2016 to 49 grams per square meters in 2018.

The boundaries of all plant communities are also shifting significantly. In this case, the influence on the displacement of the boundaries of the deposits of alluvium is practically excluded, since studies have shown that its deposits are only fractions of a millimeter throughout the profile [14].

An analysis of the displacement of the boundaries of plant communities was carried out based on data from remote sensing of the Earth and according to the results of field observations during fieldwork [15, 16]. The boundaries of all plant communities in the study area were drawn in the program MapInfo Professional based on Quick Bird satellite imagery. The results showed a gradual shift of all communities towards the water edge an average of 2-3 meters per year. In figure 1, the yellow lines show the boundaries of plant communities in 2016, and the green ones in 2017.

4. Conclusion

Thus, we can observe a pronounced violation of the spatial and species structure of floodplain communities using the example of the central floodplain of the Ob River. This can be explained by the increasing degree of anthropogenic impact on the environment every year, which entails a decrease in
the stability of ecosystems and the gradual extinction of some species. Studies of this kind are very important for assessing the state of ecosystems not only in the region, but also in the whole country as a whole, for preserving natural biodiversity and monitoring the ecological state of all components of the natural environment.

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