

Assessment of ecological and geographical parameters of the Tobolsk landscape province of western Siberia

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Abstract. Agriculture is one of the priority sectors of the national economy of the state. The development of the agro-industrial complex of the country's regions is associated with active economic activity on the territory of landscape complexes through the use of their natural resource potential. In the article, based on the study of natural processes occurring in the landscape sphere, an assessment of the state of the natural environment was carried out. To identify favorable conditions for agricultural production, the elements of heat and moisture circulation in the Tobolsk landscape province have been identified. By jointly considering the equations of water and heat-energy balances of a land plot, a geo-ecological assessment of the study area was carried out. Within the territory under consideration, the values and features of the spatial distribution of the maximum permissible anthropogenic load on surface waters have been determined. The results obtained can be used to form an information base of the ecological and geographical characteristics of the territory, methodological and scientific developments, as well as to develop environmental standards necessary for carrying out agricultural activities within the study area

1 Introduction

The possibilities for environmental management in any territory are determined by natural processes, natural resource potential, as well as ecological and geographical characteristics. The study of such possibilities should be carried out from the position of the unity of physical and geographical processes, the leading elements of which are, of course, the resources of humidification and heat supply. Studying the distribution of heat and moisture supply values is an urgent scientific and practical problem, the solution of which will make it possible to manage moisture resources, including taking into account the influence of anthropogenic activities.

In the process of developing land for agricultural use, the values of the total annual flow are of particular scientific interest, since the ecological potential of water resources, and, consequently, the possibility and level of implementation of the optimal water-air regime of the root layer depends on these values. In addition, a study of the spatial distribution of the

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ecological and geographical characteristics of the territory, necessary to assess the permissible anthropogenic impact on natural landscapes.

It is advisable to carry out the zonal distribution of values of moisture circulation elements on the basis of studies of the regional landscape structure at the level of selected provinces (Vinokurov, Tsimbali & Krasnoyarova, 2016). The greatest interest from the point of view of studying the elements of moisture circulation is the taiga zone - the zonal region of the West Siberian physical-geographical country.

According to the results of studies by many specialists (Vinokurov, Cimbalej & Krasnoyarova, 2005), the taiga zone of the West Siberian physical-geographical country is occupied by swamps and wetlands for more than 50% of the total area, on the basis of which we can conclude about the special moisture conditions of this territory.

In the process of conducting a study to identify a set of factors of landscape differentiation, it was revealed that the largest area of the taiga zone is occupied by the Tobolsk landscape province, which is characterized by a special set of factors in the formation and functioning of geosystems. The dynamic set of interaction of these factors that has developed in historical development determines the ecological potential of the province and its resistance to the influence of external natural and anthropogenic components.

The integrity of landscape formation consists of its natural and socio-economic features. At present, consideration of the natural factors in the formation of landscape provinces is impossible without studying and analyzing the anthropogenic component. Anthropogenic impact on the environment is always associated with the development of natural resource potential and can ultimately lead to a significant transformation of landscape formations, loss of stability of the natural system and, as a consequence, leads to a decrease in the ecological potential of the territory.

Issues related to the state of the surrounding geographic environment, which determines the necessary conditions for the life of society and the role of anthropogenic influence on this environment, were considered in the scientific works of many scientists, such as V. A. Anuchin, A. G. Isachenko, N. F. Reimers, T. S. Khachaturov, N.V. Chepurnykh, T.A. Akimova, V.V. Khaskin, etc. Currently, it is the geographical approach, based on taking into account environmental factors, that should be used when addressing issues of studying the habitat of any society. At the same time, it is necessary to remember that it is the natural factors and characteristics of the territory that are undoubtedly a priority and form a certain environmental background that determines the possibility of the development of other processes.

2 Materials and methods

The Tobolsk landscape province is a natural formation that geographically corresponds to the geomorphological region of latitudinal extent. The slopes of the surface of the territory under consideration are insignificant, which, in turn, causes and promotes the development of swamp formation processes, since the runoff of atmospheric precipitation is significantly hampered with small thermal resources. Swamp areas are concentrated mainly in open, unforested areas.

The social and industrial development of a region represents certain features of the territorial system, recognized through various parameters and indicators that are related to the population of the territory, the quantity and quality of its labor resources and their employment in production sectors; with the functioning of the economic complex as a whole and the distribution of its elements; with the development of infrastructure, etc. The specialization of the economy of the territory under consideration is associated to a greater extent with the production, transportation and processing of hydrocarbon products (Eder,

Filimonova, Provornaya & Nemov, 2017). Based on this, we can conclude that the main source of pollution of atmospheric air, water sources and soil cover in this part of the region under study are enterprises of the fuel and energy complex (Zhichkina, Nosov, Zhichkin, Mirgorodskaya, & Avdotin, 2020). In the future, their production capacity will most likely increase. Therefore, assessment of the ecological and geographical conditions of environmental development and the study of the characteristics of income and expenditure items of natural resource potential remains a priority task of research and will play an important role for the further development of the territory. Considering that enterprises of the fuel and energy complex play a very important role in influencing the natural environment, identifying and accounting for the magnitude of damage and economic losses are an important indicator in assessing the rational use of natural resources.

The main characteristics that determine the climatic features of a territory within a landscape province include moisture and heat resources, as well as the intensity of physical-geographical processes occurring under the influence of local features (Lutoshkin, Morkovkin, & Sadridinov, 2020).

According to the recommendation of the UN FAO (FAO, Food and Agriculture Organization of the United Nations), the Penman-Monteith method (RM) is used as a standard method for determining heat and moisture supply resources (Chiew, Kamadalasa, Malano & McMahon, 1995; Allen, Pereira, Raes & Smith, 1998). However, the use of this technique presupposes the availability of initial data not included in the list of those observed at most meteorological stations, therefore, the absence of which limits the use of this method (Ostapchik, 1989).

The use of hydrological-climatic theory (Mezentsev & Karnatsevich, 1969) of the formation of moisture and heat resources when assessing the incoming and outgoing components of the water balance makes it possible to determine the ecological and geographical characteristics necessary to perform a geo-ecological assessment of the territory. This methodology for calculating the heat and energy resources of the climate and evapotranspiration, as well as the results of calculations of the elements of heat and water balances on the surface of the catchment areas of the study area, determines the actual evapotranspiration, and, consequently, the runoff.

The transformation of the physical-geographical environment is based, first of all, on changes in the amount of heat and energy resources, as the most important energy factor, changes in moisture resources, and the ratio of the amount of heat and moisture. A quantitative assessment of the elements of moisture circulation in the Tobolsk landscape province was carried out based on data from 24 stations and posts located within the province and adjacent territory. Calculations of hydrological-climatic and ecological-geographical characteristics were based on determining the annual sums of heat and power characteristics in an average year using regression equations, which were obtained based on the analysis of materials of regional actinometric characteristics. Based on regional dependencies, the amount of water equivalent of climate heat and energy resources per year Z_k and the value of the maximum possible total evaporation Z_m were determined. The value of evaporation in the south of the study area is largely determined by precipitation (Tusupbekov, Ryapolova & Nadochiy, 2020). Snow cover in the study basins sets at approximately the same time, on average at the end of November.

3 Results

The main input component of the earth's surface moisture resources is the amount of atmospheric precipitation. Studies of the temporal variability of the values of annual amounts of atmospheric precipitation at seven weather stations located within the Tobolsk landscape province showed that the distribution of the values of the amounts is

characterized by latitudinal zonality, this is confirmed by illustration of the course of atmospheric precipitation over time in the form of an abbreviated total curve (SCC) of annual amounts of atmospheric precipitation for the city of Tobolsk (Figure 1).

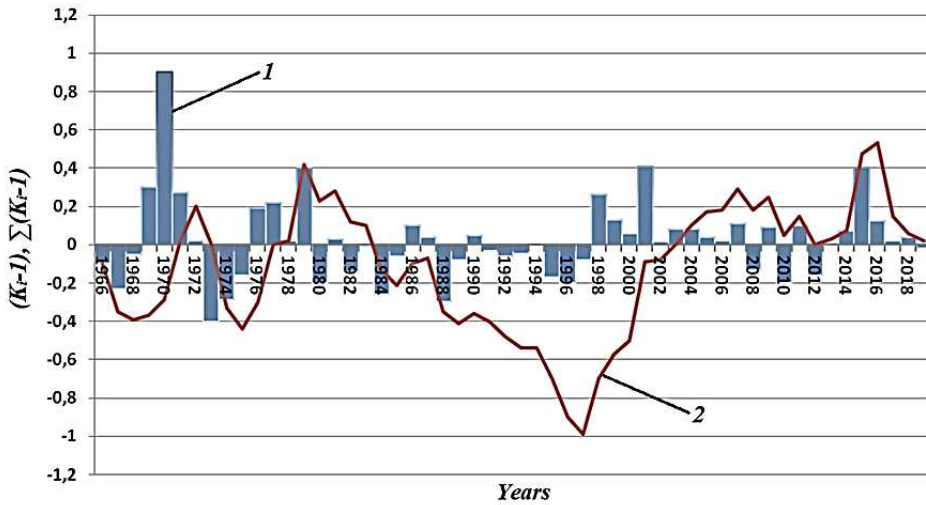


Fig. 1. Abbreviated summary curve of annual amounts of atmospheric precipitation, Tobolsk. 1 deviation of annual precipitation amounts from the norm; 2 reduced total curve of annual precipitation amounts.

In addition, the ratio of moisture and heat resources of an area is of greatest practical interest for assessing water resource potential (Ding & Ma, 2020). The relative values of this ratio are the value δ_H , which shows the ratio of the amount of precipitation and the water equivalent of heat and energy resources climate Z_k , as well as the humidification coefficient K_n , which characterizes the ratio of precipitation falling on the territory to the value of the maximum possible evaporation.

In the works of V.S. Mezentsev (Mezentsev & Karnatsevich, 1969), the optimal conditions under which an optimal water-air regime is created in the root layer of soils, and, consequently, the highest productivity of phytomass, correspond to optimal conditions of moisture and heat supply. At the same time, the moisture content of the active soil layer is in the range from the lowest moisture capacity to the moisture content of capillary rupture, and the values of the moisture coefficient $K_n = H/H_{opt} = 1.0 \dots 0.7$ (H and H_{opt} , respectively, are the actual and optimally required moisture resources).

The spatial distribution of the humidification coefficient K_n in an average year is determined by the zonal features of the ratios of humidification resources and heat supply. As a result of the calculations, we can conclude that the territory of the Tobolsk landscape province, despite the significant distribution of wetlands, belongs to the zone of insufficient natural moisture, since the distribution of moisture coefficient values is less than one.

Elements of moisture circulation in the Tobolsk landscape province determine the possibility of using moisture resources for environmental management in the territory, the relative values of which are presented in Table

Having analyzed the values of the relative values of the elements of moisture circulation, we can conclude that within the territory under consideration, the distribution of the total annual runoff has a latitudinal zonal character, increasing from south to north. At the same time, throughout the entire territory of the Tobolsk landscape province, the share of surface runoff in the total total value is quite large.

Table 1. Relative values of moisture cycle elements in an average year.

No. p/p	Weather station	ψ evaporation coefficient	η coefficient of total annual runoff	η_1 coefficient of annual surface runoff	η_2 coefficient of underground annual flow
1	Demyanskoe	0.767	0.233	0.147	0.086
2	Uvat	0.790	0.210	0.133	0.077
3	Tobolsk	0.795	0.205	0.129	0.076
4	Vagaiskoe	0.849	0.151	0.097	0.054
5	Ust-Ishim	0.794	0.206	0.130	0.076
6	Tevriz	0.808	0.192	0.122	0.071
7	Tara	0.788	0.213	0.134	0.079

4 Discussion

The development and placement of material production on the territory must be carried out in accordance with the principle of balanced environmental management, as well as assessment of the environmental intensity of production, i.e. total damage caused to natural resources and the state of the environment by anthropogenic pressure (Raikhan, Gulnur & Aizhan, 2020).

The scientific basis for assessing the ecological-geographical parameters of the Tobolsk landscape province was taken as the Scheme of ecological-geographical zoning of the territory of Western Siberia (Belonenko, Popova & Tusupbekov, 1912), which shows the spatial distribution of physical-geographical natural complexes with their specific zonal features of natural conditions. This methodological framework allows us to evaluate and analyze the ecological and geographical parameters of the formation and functioning of landscape formations.

As a result of the analysis of such characteristics as the water equivalent of heat resources, moisture resources, the ratio of moisture and heat resources in an average year, runoff coefficient, moisture coefficient and other ecological and geographical features, we can conclude that the territory under consideration is located in the third (III) ecological-geographical zone with corresponding ecological-geographical conditions and quantitative parameters of this zone (Popova, 2000).

The greatest practical interest when considering the water resource potential of the Tobolsk landscape province is the standardization of ecological and geographical characteristics - the maximum permissible anthropogenic load q (MPTL) on the water resources of the territory in order to ensure the sustainability of natural systems. Previous studies (Akimova & Haskin, 1994) used an energy approach to assessing the environmental potential of a territory's water resources and, as a result, used a methodology for determining environmental technology intensity and maximum permissible load on water resources.

This methodological approach is based on the fact that the energy values of natural and man-made characteristics are determined on a unified calculation and analytical basis (Filippova et al., 2019). The maximum permissible technogenic load on water resources determines and characterizes the unified energy exchange in natural landscape formations, and is one of the main factors in the stability of geosystems and their ability to reproduce and restore. The works (Akimova & Haskin, 1994) present a methodology for assessing the maximum permissible anthropogenic load, as well as a modern interpretation of the concept, which is the specific value of the energy equivalent of surface water resources. The maximum permissible technogenic load is determined in tons of equivalent fuel per year per unit area, while being the lower limit of technogenic impact on natural formations.

5 Conclusion

As a result of the calculations, we can conclude that the main characteristics that determine the climatic features of the territory of the Tobolsk landscape province of the zonal region of the West Siberian taiga include moisture and heat resources, as well as the intensity of physical and geographical processes occurring under the influence of local features.

The use of the hydrological-climatic theory of the formation of moisture and heat resources when assessing the incoming and outgoing components of the water balance makes it possible to determine the ecological and geographical characteristics necessary to perform a geo-ecological assessment of the territory. This methodology for calculating the heat and energy resources of the climate and evapotranspiration, as well as the results of calculations of the elements of heat and water balances on the surface of the catchment areas of the study area, determines the actual evapotranspiration, and, consequently, the runoff.

The studies carried out made it possible to obtain the specific distribution of values of maximum permissible anthropogenic loads on the water resources of the landscape province under consideration. Research shows that the distribution of the maximum permissible technogenic load has a pronounced zonal character and increases in latitude from south to north, varying from 354 tye/km² to 674 tye/km². At the same time, the nature of the distribution of the values of the maximum permissible technogenic load depends on the natural ecological water resource potential of the territory, which makes it possible to determine possible directions for the use of surface water at the present time and in the future for the agro-industrial development of the territory.

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