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GEOECOLOGICAL ASSESSMENT OF THE TOBOLSK LANDSCAPE PROVINCE OF WESTERN SIBERIA

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Abstract

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 turn, natural conditions and resources are the determining elements in the formation of agricultural and economic specialization of the territory. Assessment of the state of the natural environment, by studying natural processes in the landscape sphere, as well as determining ecological and geographical characteristics, is carried out to identify the favorability of agricultural production. The geoecological assessment on the territory of the Tobolsk landscape province, the zonal region of the West Siberian taiga, was carried out on the basis of a methodological approach to determine thermal and water-balance characteristics by solving a joint equation of water and heat-energy balances of a land plot. Within the territory under consideration, an assessment of humidification and heat supply resources was carried out, on the basis of which the values and features of the spatial distribution of the maximum permissible anthropogenic load on the surface waters of the landscape province under consideration were determined. The results obtained can be used to form an information base on the ecological and geographical characteristics of the territory, methodological and scientific developments, as well as in the development of environmental standards necessary for agricultural activities within the study area.

Keywords: Heat and moisture turnover resources, landscape province, maximum permissible technogenic load, stability of the natural system

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1. Introduction

The possibilities of 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 standpoint of the unity of physical and geographical processes, the leading elements of which are, of course, the resources of humidification and heat supply. The study of the distribution of heat and moisture availability is an urgent scientific and practical task, the solution of which will enable the management of humidification resources, including taking into account the influence of anthropogenic activities.

2. Problem Statement

In the process of land development into agricultural circulation, the values of the total annual runoff are of particular scientific interest, since the ecological potential of water resources depends on these values, and, consequently, the possibility and level of implementation of the optimal water-air regime of the root layer. In addition, the study of the spatial distribution of ecological and geographical characteristics of the territory is necessary to assess the permissible anthropogenic impact on natural landscapes (Tusupbekov et al., 2024).

The zonal distribution of the values of moisture turnover elements should be carried out on the basis of studies of the regional landscape structure at the level of the selected provinces (Vinokurov & Cimbalej, 2016). The greatest interest from the point of view of studying the elements of moisture turnover is the taiga zone - the zonal region of the West Siberian physical and geographical country.

According to the research results of many experts (Vinokurov et al., 2005), the taiga zone of the West Siberian physico-geographical country is occupied by swamps and wetlands for more than 50% of the total area, on the basis of which it can be concluded about the special conditions of humidification of this territory.

3. Research Questions

In the process of conducting a study on the allocation of a complex 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 of formation and functioning of geosystems. The dynamic combination of interaction of these factors, which has developed in historical development, determines the ecological potential of the province and its resistance to the effects of external natural and anthropogenic components (Tusupbekov et al., 2024).

The integrity of landscape education is its natural and socio-economic features. Currently, the study of only natural factors of 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 ultimately can lead to a significant transformation of landscape formations, loss of stability of the natural system and, as a result, leads to a decrease in the ecological potential of the territory.

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Any human activity related to the use of natural resources has an impact on the components of the landscape environment, the scale of which increases with the development of technical potential. However, the study of the co-measurement of the impact of society on the natural environment is beginning to become relevant in the process of developing problems related to its condition. Issues related to the state of the surrounding geographical environment, which determines the necessary conditions for the life of society and the role of anthropogenic influence on this environment, have been 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. Haskin et al. Currently, it is the geographical approach based on the consideration of environmental factors that should be applied when solving the issues of studying the habitat of any society. At the same time, it must be remembered that it is the natural factors and features of the territory that are undoubtedly a priority and form a certain ecological background that determines the possibility of the development of other processes (Tusupbekov et al., 2024).

4. Purpose of the Study

The purpose of the study is to determine the main characteristics determining the climatic features of the territory of the Tobolsk landscape province of the zonal region of the West Siberian taiga.

5. Research Methods

The Tobolsk landscape province is a natural formation geographically corresponding to the geomorphological area of the latitudinal strike. The slopes of the surface of the territory under consideration are insignificant, which, in turn, causes and contributes to the development of swamp formation processes, since precipitation runoff is significantly hindered with small thermal resources. Swampy massifs are concentrated mainly in open, unforested areas. Ridges and mounds with a height of 0.8-1.2 m in ridge pattern bogs are covered with a continuous soft carpet of sphang mosses. The vegetation of this territory is represented by cedar-spruce-fir forests, birch spikes are common. Most of the territory of the Tobolsk landscape province is represented by sod-podzolic and peat-oligotrophic types of soils (Tusupbekov et al., 2024).

The social and industrial development of the region represents certain features of the territorial system, recognized through various parameters and indicators that are associated with the population of the territory, the quantity and quality of its labor resources and their employment by 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 mainly related to the extraction, transportation and processing of hydrocarbon products (Eder et al., 2017). Based on this, it can be concluded that the main source of pollution of atmospheric air, water sources and soil cover of the territories of this part of the studied region are enterprises of the fuel and energy complex (Zhichkina et al., 2020). In the future, their production capacities will most likely increase. Therefore, the assessment of the ecological and geographical conditions of natural development and the study of the features of the input and expenditure items of natural resource potential remains a

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priority task of the study and will play an important role for the further development of the territory (Tusupbekov et al., 2024). Considering that the enterprises of the fuel and energy complex play a significant role in the impact on the natural environment, the identification and accounting of 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 the territory within the landscape province include the resources of humidification and heat supply, as well as the intensity of physical and geographical processes occurring under the influence of local features (Lutoshkin et al., 2020).

On the recommendation of the FAO of the United Nations (Food and Agriculture Organization of the United Nations), the Penman – Monteith method (Penman – Monteith, PM) is used as a standard method for determining heat and moisture resources (Allen et al., 1998; Chiew et al., 1995). However, the use of this technique presupposes the presence of raw data not included in the list of observables in most meteorological stations, therefore, the absence of which limits the use of this method (Ostapchik, 1989).

The use of the hydrological and climatic theory (Mezentsev & Karnatsevich, 1969) of the formation of moisture and heat resources in the assessment of the incoming and outgoing components of the water balance allows us to determine the ecological and geographical characteristics necessary for the implementation of a geo-ecological assessment of the territory. This method of calculating the thermal energy resources of the climate and total evaporation, as well as the results of calculations of the elements of thermal and water balances on the surface of the catchments of the studied territory determines the actual total evaporation, and therefore the runoff (Tusupbekov et al., 2024).

The transformation of the physical and geographical environment is based primarily on changes in the amount of heat and energy resources as the most important energy factor, changes in humidification resources, and the ratio of heat and moisture. Quantitative assessment of the elements of moisture turnover of the Tobolsk landscape province was carried out on the basis of data from 24 stations and posts located within the province and the adjacent territory. Calculations of hydro-climatic and ecological-geographical characteristics were based on the determination of the annual sums of heat and power characteristics in the average year according to regression equations, which were obtained based on the analysis of materials of regional actinometric characteristics. According to regional dependencies, the amounts of the water equivalent of the thermal energy resources of the climate Zk for the year and the values of the maximum possible total evaporation Zm were determined. The value of evaporation in the south of the study area is largely determined by precipitation (Tusupbekov et al., 2020).

6. Study Results

The main input component of the earth's surface moisture resources are the values of precipitation amounts. Studies of the variability in time of the values of annual precipitation amounts at seven weather stations located within the Tobolsk landscape province have shown that the distribution of the values of the amounts is characterized by latitudinal zonality, which is confirmed by an illustration of the course of precipitation over time in the form of a reduced total curve (RTC) of annual precipitation amounts for Tobolsk (Figure 1) (Tusupbekov et al., 2024).

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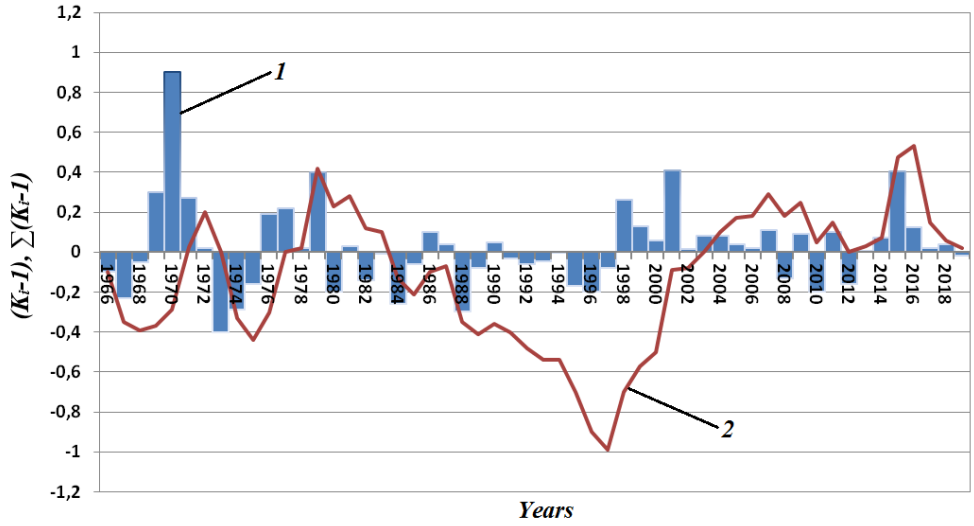

Figure 1. RTC of annual precipitation amounts, Tobolsk. 1 – deviation of annual precipitation amounts from the norm, 2 – reduced total curve of annual precipitation amounts

In addition, the greatest practical interest for assessing the water resource potential is the ratio of moisture and heat resources of the territory (Ding & Ma, 2020). The relative values of this ratio are the value δh, which shows the ratio of the values of precipitation and the water equivalent of heat and energy resources climate Zk, as well as the moisture coefficient Kh, which characterizes the ratio of precipitation falling on the territory to the maximum possible evaporation. Moisture resources, water equivalents of heat and energy resources of climate and total evaporation, the ratio of moisture and heat resources, the coefficient of humidification are presented in Table 1.

Table 1. Moisture resources, water equivalents of heat and energy resources of climate and total evaporation, the ratio of moisture and heat resources, humidification coefficient

No.	Meteo station	Atmospheric precipitation, KX, mm	Water equivalent of thermal energy resources of the climate, Zk, mm	Maximum possible evaporation, Zm, mm	Relative value of water equivalent of heat and energy resources of climate, δh	Moisture coefficient, Kh
1	Demyanskoye	559	1177	668	0.475	0.837
2	Uvat	548	1190	677	0.460	0.809
3	Tobolsk	567	1231	706	0.461	0.803
4	Vagayskoe	515	1227	704	0.420	0.732
5	Ust-Ishim	554	1.208	690	0.459	0.803
6	Tevriz	547	1217	696	0.450	0.786
7	Container	560	1207	689	0.464	0.813

In the works of Mezentsev and Karnatsevich (1969) as optimal conditions under which an optimal water-air regime is created in the root layer of soils, and consequently, the highest productivity of phytomass corresponds to optimal conditions of humidification and heat supply. At the same time, the moisture content of the active layer of soils ranges from the lowest moisture capacity to the moisture

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content of the rupture of capillaries, and the values of the moisture coefficient Kh = H /Hopt = 1.0 ... 0.7 (respectively, H and Hopt are the actual and optimally required moisture resources).

The spatial distribution of the moisture coefficient Kh in the average year is due to the zonal features of the ratio of humidification resources and heat supply. As a result of the calculations performed, it can be concluded that the territory of the Tobolsk landscape province, despite the significant spread of wetlands, belongs to the zone of insufficient natural moisture, since the distribution of the moisture coefficient values is less than one.

The elements of the moisture turnover of the Tobolsk landscape province determine the possibility of using humidification resources for the implementation of nature management in the territory, the relative values of which are presented in Table 2.

Table 2. Relative values of moisture turnover elements in the average year

No.	Meteorological station	ψ evaporation coefficient	η coefficient of total annual runoff	η_1 annual surface runoff coefficient	η_2 annual underground runoff coefficient
1	Demyanskoye	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	Vagayskoe	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	Container	0.788	0.213	0.134	0.079

Having analyzed the values of the relative values of the elements of moisture turnover, it can be concluded 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, the share of surface runoff in the total cumulative value is quite large throughout the Tobolsk landscape province (Tusupbekov et al., 2024).

7. Discussion

The development and placement of material production on the territory should be carried out in accordance with the principle of balanced nature management, as well as the assessment of the natural intensity of production, i.e. the cumulative damage caused to natural resources and the state of the environment by man-made load (Raikhan et al., 2020).

The Scheme of ecological and geographical zoning of the territory of Western Siberia was adopted as the scientific basis for assessing the ecological and geographical parameters of the Tobolsk landscape province (Belonenko G. V., Popova N. B., Tusupbekov Zh. A.), which shows the spatial distribution of physical and geographical natural complexes with their specific zonal features of natural conditions. This methodological basis 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, humidification resources, the ratio of moisture and heat resources in an average year, runoff coefficient,

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moisture coefficient, and other ecological and geographical features, it can be concluded that the territory in question is located in the third (III) ecological and geographical zone with appropriate ecological and geographical conditions and quantitative parameters of this zone (Popova, 2002).

The greatest practical interest in considering the water resource potential of the Tobolsk landscape province is the normalization of ecological and geographical characteristics - the maximum permissible anthropogenic load q (MPAL) on the water resources of the territory in order to ensure the sustainability of natural systems. Earlier studies (Akimova & Haskin, 1994) used an energy approach to assessing the ecological potential of the territory's water resources and, as a result, used a methodology for determining the environmental technology intensity and the 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 single computational and analytical basis (Filippova et al., 2019). The maximum permissible anthropogenic load on water resources determines and characterizes the unified energy exchange in natural landscape formations, and is one of the main factors of 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 anthropogenic load is determined in tons of oil equivalent per year per unit area, while being the lower limit of the technogenic impact on natural formations (Tusupbekov et al., 2024).

8. Conclusions

As a result of the calculations performed, it can be concluded that the main characteristics determining the climatic features of the territory of the Tobolsk landscape province of the zonal region of the West Siberian taiga include the resources of humidification and heat supply, as well as the intensity of physical and geographical processes occurring under the influence of local features (Tusupbekov et al., 2024).

The use of the hydrological and climatic theory of the formation of moisture and heat resources in assessing the incoming and outgoing components of the water balance makes it possible to determine the ecological and geographical characteristics necessary to perform a geoecological assessment of the territory. This method of calculating the thermal energy resources of the climate and total evaporation, as well as the results of calculations of the elements of thermal and water balances on the surface of the catchments of the studied territory determines the actual total evaporation, and therefore the runoff (Tusupbekov et al., 2024).

The performed studies allowed us to obtain the features of the distribution of the values of the maximum permissible anthropogenic loads on the water resources of the landscape province under consideration. Studies show that the distribution of the maximum permissible technogenic load has a pronounced zonal character and increases latitudinal from south to north, varying from 354 toe/km ^{2} to 674 toe/km ^{2}. At the same time, the nature of the distribution 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 waters at the present time and in the future of agro-industrial development of the territory (Tusupbekov et al., 2024).

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