Humidification resources of the Tomsk region

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Abstract. To determine the standards of anthropogenic load on the water resources of the territory, as well as to carry out their geo-ecological assessment, the question arises of quantitative determination of the characteristics that influence the conditions for the formation and functioning of water resources of geographical systems. The ability of an ecosystem to withstand external stress depends on its resident resilience and ability to recover after a reduction in stress. Among the many factors in assessing the geoecological state of a territory, an important place is occupied by the availability of water resources and their quantitative characteristics, as well as the distribution of moisture resources throughout the territory at different periods of time. Analysis of the water supply of the territory is necessary, both from the point of view of determining the natural capabilities (potential) of aquatic ecosystems, and determining the qualitative state of water bodies. In the presented article, based on observational data over a long-term period, the average durations of wet and dry periods, as well as the percentage of precipitation at weather stations in the study area, are determined. Based on the data on humidity and heat resources, the heat and energy resources of the climate, evaporation and their water equivalents were calculated. The calculations made it possible to determine characteristics important for water availability, such as the ratio of heat and moisture resources and the humidification coefficient. Based on a study of the main directions of economic development of the territory, industries that place a significant burden on water resources were identified and recommendations were given for restoring impaired functions.

1 Introduction

The correct determination of these characteristics is directly related to the hydrometeorological study of the territory. The main component of the climate of any territory is precipitation, which forms the surface moisture resources of the territory (Ronalton, Tais & Matheus, 2021).

The variety of relief forms, moisture content of air masses, as well as their direction and intensity of circulation determine the magnitude, territorial and temporal distribution of atmospheric precipitation in the territory.

The combined influence of zonal and azonal factors on the formation of quantitative characteristics of atmospheric precipitation amounts determines the dependence of the

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distribution of precipitation over the territory depending on the latitude of the area (Jonathan, Jens-Christian & Monica, 2023).

2 Materials and methods

Geographically, the Tomsk region is located in the southeastern part of the West Siberian Plain, covering most of the Vasyugan Plain, represented by marshlands (Vinokurov, Cimbalej & Krasnoyarova, 2005). Administratively, the study area is located within the Siberian Federal District and has common borders with six constituent entities of the Russian Federation: the eastern part of the Krasnoyarsk Territory, the Kemerovo region in the south, the Novosibirsk region in the southwest, the Omsk and Tyumen regions in the west, and the Khanty-Mansiysk region in the north. JSC.

Almost the entire territory with a total area of 314.3 km² is located in the taiga landscape zone, with the exception of its southern part, represented by mixed forests.

The climate of the study area belongs to the continental type, temperate zone. The continental climate is characterized by cold, long winters, with inherent snowstorms, strong winds, stable snow cover, and rather hot and short summers (Weather and climate, n.d.). Short transition seasons are characterized by sharp temperature fluctuations. Spring and early summer are dry. There is sufficient moisture, most of the precipitation falls in the warm half of the year.

The climatic conditions here are favorable for the development of surface runoff processes. The abundance of atmospheric precipitation with low losses due to evaporation and infiltration provides increased surface water runoff. The flat terrain with small slopes causes slow runoff processes, weak development of erosion and insignificant drainage. All these conditions, as well as the shallow occurrence of groundwater, cause intensive development of swamps.

The Tomsk region has large reserves of surface and groundwater. For domestic and drinking water supply purposes, both surface and groundwater are used. The main water consumers are municipal services, industrial enterprises, agricultural sectors, water transport, etc.

The Tomsk region plays an important role in the development of the industrial complex of Russia (Regions of Russia, 2022). Compared to many regions of Russia, the Tomsk region is distinguished by large reserves of various minerals. The leading place in oil and gas production (Lutoshkin, Morkovkin & Sadriddinov, 2020) allows the region to develop the chemical and petrochemical industries, oil refining and mechanical engineering (Filippova et al., 2019). In addition, the available fuel resources have become the basis for the development of a cheaper energy complex. Huge forests located in the region gave impetus to the development of the timber industry complex.

Despite the development of the industrial sector, the main specialization of the Tomsk region is meat and dairy cattle breeding and vegetable growing. The region is fully self-sufficient in pork, poultry and potatoes. Tomsk vegetables and berries are exported to many countries. Due to the presence of valuable forest species, especially cedar species, the region is a major exporter of timber.

The depths of the Tomsk region contain large reserves of groundwater of various types, including the resources of the aquifer complex of the West Siberian artesian basin. Fresh waters are used for domestic and drinking water supply, mineral waters and thermal waters are used for balneological purposes.
3 Results

The qualitative composition of water in surface water bodies of the Tomsk region is characterized by exceeding the maximum permissible concentration of pollutants for water bodies of domestic and drinking, cultural and domestic, as well as fishery significance.

For example, the hydrogen index (pH) takes values below the established norm (6.5...8.5), and an excess of phosphates, nitrates, manganese, and iron is also noted. At the same time, the concentration of manganese and iron is subject to noticeable seasonal fluctuations. Typically, in water bodies with high biological productivity during the summer and winter low water periods, there is a noticeable increase in the concentration of iron in the bottom layers of water (Zanotti et al., 2019).

The factors that determine changes in the concentration of manganese are the relationship between surface and underground runoff, the intensity of its consumption during photosynthesis, the decomposition of microorganisms and vegetation, as well as the processes of its deposition to the bottom of water bodies. In general, according to the WPI values according to the maximum permissible concentrations of household, drinking and cultural-domestic significance, the quality of surface waters belongs to various classes, ranging from clean to moderately polluted. The load on water bodies has tended to increase in recent years.

To determine the level of anthropogenic load on water bodies of the Tomsk region and standardize water use conditions for the purpose of optimal use of water resources, it is necessary to perform a detailed analysis of moisture resources over a long-term period and the state of water use in river basins (Marisa & Christy, 2022).

The reliability of the characteristics of heat and water balance elements obtained by calculation depends on the temporal and territorial hydrometeorological knowledge. Compared to other components of nature, precipitation is one of the most studied; therefore, more reliable values for the water content of a territory, in conditions of an insufficiently developed hydrological network, can be obtained by analyzing the variability of precipitation and its distribution.

To study atmospheric precipitation, as the main component of moisture resources, data obtained at meteorological stations in the Tomsk region were reviewed and studied. Correct analysis of annual data for 1996...2021. allowed us to draw a conclusion about the reliability of the results of the measured time series of annual amounts of atmospheric precipitation (AP). In this case, average values of atmospheric precipitation, modular coefficients, deviations from average values, as well as ordinates of reduced summary curves were used as calculated characteristics. Calculations were performed for all weather stations within the Tomsk region.

The use of the obtained values in the course of studies of the temporal variability of atmospheric precipitation makes it possible to analyze retrospective data on moisture resources (Mezentsev & Karnatsevich, 1969), as well as determine their forecast values, which, undoubtedly, is of great economic importance.

As a result of the analysis of chronological graphs, we can conclude that the sequence of dry and wet periods throughout the territory is not the same, the duration of continuous dry periods can reach 5...8 years, and wet periods - 3...5 years. In addition, in most of the periods considered, the annual values of atmospheric precipitation were slightly lower than the values of their climatic norm.

For a comprehensive analysis of atmospheric precipitation in any territory, it is of practical interest to determine the amount of precipitation in years of different percentage probability (5%, 20%, 80%, 95%). A histogram of precipitation amounts in years of different percentage coverage at typical meteorological stations of the Tomsk region is presented in Figure 1.
Fig. 1. Distribution of atmospheric precipitation (AP) in years of different percentage coverage for meteorological stations of the Tomsk region.

By analyzing the histograms shown in the figures, we can draw a conclusion about the amplitude of fluctuations in the amount of atmospheric precipitation in the territory under consideration over time. Weather stations were selected for the northern and southern territories of the Tomsk region.

The analysis of territorial variability of atmospheric moisture resources and the results of generalization of calculated precipitation values show the influence on variability, mainly of zonal features associated with the location from south to north.

Based on fixed values of atmospheric precipitation and heat resources (Tusupbekov, Ryapolova & Nadtochiy, 2021) at the weather stations of the study area over a long-term period, calculations of heat, power and water balance characteristics were performed. Table 1 shows the results of calculations of thermal energy resources of the climate and their water equivalents (LZк and Zк), thermal energy resources of evapotranspiration and their water equivalent (LZм and Zм), as well as the ratio of moisture and heat resources δн = AP/Zк and humidification coefficients Кн= AP/Zм.

<table>
<thead>
<tr>
<th>Weather station</th>
<th>AP</th>
<th>Zк</th>
<th>Zм</th>
<th>δн</th>
<th>Кн</th>
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<tr>
<td>Alexandrovskoe</td>
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<td>625</td>
<td>0.528</td>
<td>0.944</td>
</tr>
<tr>
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<td>620</td>
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<td>612</td>
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<tr>
<td>Napas</td>
<td>624</td>
<td>1120</td>
<td>627</td>
<td>0.557</td>
<td>0.995</td>
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<tr>
<td>Kargasok</td>
<td>668</td>
<td>1151</td>
<td>649</td>
<td>0.581</td>
<td>1.030</td>
</tr>
<tr>
<td>Parabel</td>
<td>557</td>
<td>1151</td>
<td>649</td>
<td>0.484</td>
<td>0.859</td>
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<tr>
<td>New Vasyugan</td>
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<td>1.015</td>
</tr>
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<td>699</td>
<td>0.433</td>
<td>0.757</td>
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</table>
4 Discussion

Analysis of the obtained results of calculations of thermal energy and water elements shows the latitudinal zonality of the distribution of water and heat resources. Despite the relatively low values of atmospheric precipitation of 500...590 mm, most of the region’s territory is in a waterlogged state (Tusupbekov, Nadtochiy, N.L. Ryapolova & Popova, 2022). This is mainly due to scarce thermal resources. The values of humidification coefficients throughout the territory do not fall below 0.8, and for some weather stations (Vanzhil-Kynak, Kargasok, New Vasyugan) exceed 1.0.

Due to the increase in industrial potential and growth in production volumes, the load on surface waters increases (Popova, 2000). Particularly vulnerable to pollution are water bodies located in areas where oil and gas production enterprises are located. The formation of runoff from the drainage basin, the amount of water resources and the nature of intra-annual distribution are influenced by logging enterprises.

Further intensification of anthropogenic activities directly on water bodies and the drainage basin should be linked to the stability of the ecosystem (Akimova & Haskin, 1994) and correlated with the nature of the stable functioning of ecosystems. Under conditions of excessive loads on the surrounding area, primarily located within oil production enterprises (Eder, Filimonova, Provornaya & Nemov 2017) and logging sites, it is necessary to observe the possibility of regeneration, taking into account the restoration of impaired functions over a short period.

5 Conclusion

Due to the increase in industrial potential and growth in production volumes, the load on surface waters increases. Particularly vulnerable to pollution are water bodies located in areas where oil and gas production enterprises are located. Forests influence the formation of runoff from the drainage basin, the amount of water resources and the nature of intra-annual distribution.

Thus, further intensification of anthropogenic activities directly on water bodies and the watershed should be linked to the stability of the ecosystem and correlated with the nature of the stable functioning of ecosystems. Under conditions of excessive loads on the surrounding area, primarily located within oil production enterprises and logging sites, it is necessary to observe the possibility of regeneration, taking into account the restoration of impaired functions over a short period.

The efficiency of regeneration of water bodies primarily depends on the correct identification of load sources, their seasonality and duration. An effective way to identify the intensity of changes in state are balance methods.

Considering the significant contamination of surface and groundwater with petroleum products, it is necessary to promptly and immediately carry out reclamation work on lands contaminated with petroleum products.

During logging operations, it is necessary to use methods that minimize possible disturbances to surface runoff.

It must be remembered that the costs of preventing pollution of water bodies are several times less than the costs of combating the consequences.
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