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ECOSYSTEM PROCESSES IN THE AREA OF THE TOMSK WATER INTAKE

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The influence of the Tomsk water intake on the ecosystems of the Ob-Tom interfluve is studied. It is revealed that the exploitation of the underground water field for almost 50 years has led to the transformation of the natural environment as a result of changes in the hydrological regime in the aeration zone. The most significant changes were observed in hydromorphic ecosystems located in the area of the first well line of the Tomsk water intake, which is associated with both the longest exposure and the feature of the lithological structure. A series of studies has been conducted here since 2000. the estimation of the ecosystems state was done, including the assessment of moisture of ecotopes via phytoindication method. To reconstruct phytocenoses that existed before drying (before 2000), the composition of plant macrofossils of the upper layers of peat was analyzed. There is noted the dependence of changes in the hydrological regime of ecotopes on the dynamics of groundwater levels associated with the operation of the Tomsk water intake against the background of cyclical climate variability. The main changes in the water regime on the territory of the Ob-Tom interfluve occurred at the first stages of the water intake operation in 1970s during the formation of a depression funnel in the area of the first well line (it was before the beginning of our research in 2000). Currently, the transformation processes have slowed down and there is a stable functioning of ecosystems in the new conditions of moisture, established at a more or less constant level, in accordance with the reduced volumes of water intake. Hydroclimatic calculations for the basin of river Poros have shown that the volume of groundwater renewal in the Ob-Tom interfluve exceeds the current volume of water extraction, which excludes or significantly slows down the further transformation of ecosystems.

Key words: water intake influence, Ob-Tom interfluve, drying of mires, method of hydrological and climatic calculations, phytoindication, indicator values of plants.

Исследовано влияние Томского водозабора на экосистемы Обь-Томского междуречья. Выявлено, что эксплуатация в течение почти 50 лет месторождения подземных вод привела к трансформации природной среды в результате изменений гидрологического режима в зоне аэрации. Наиболее значительные изменения отмечены в гидроморфных экосистемах, расположенных в районе действия первой очереди водозабора, что связано как с наиболее продолжительным воздействием, так и особенностью литологического строения. Здесь и проведен очередной цикл исследований, продолжающихся с 2000 года. Дана оценка состояния экосистем, а также увлажнения экотопа фитоиндикационным методом. Для реконструкции фитоценозов, существовавших до обсыхания (до 2000 г.), проведен ботанический анализ верхних слоев торфа. Отмечена зависимость изменения гидрологического режима экотопов с динамикой уровней подземных вод, связанной с работой Томского водозабора на фоне циклической климатической изменчивости. Основные изменения водного режима на территории Обь-Томского междуречья произошли на первых этапах эксплуатации водозабора и формирования в районе первой очереди воронки депрессии, до начала наших исследований в 2000 году. В настоящее время процессы трансформации замедлились и наблюдается устойчивое функционирование экосистем в новых условиях увлажнения, установившегося на более или менее постоянном уровне, в соответствии с пониженными объемами водоотбора. Гидролого-климатические расчеты для бассейна р. Порос показали, что объемы возобновления подземных вод Обь-Томского междуречья превышают текущие объемы водоотбора, что исключает, или существенно замедляет дальнейшую трансформацию экосистем.

Ключевые слова: влияние водозабора, Обь-Томское междуречье, обсыхание болот, метод гидролого-климатических расчетов, фитоиндикация, экологические шкалы.

INTRODUCTION

The discovery and commissioning of an underground water deposit in the immediate vicinity of the city of Tomsk in the Paleogene horizons on the territory of the Ob-Tom interfluve solved an important problem of providing the population with clean drinking water. By the early 2000s, the volume of water extraction reached 250 thousand m^3 per day with approved reserves of 260 thousand m^3.

However, in the first years of operation (since the early 1970s), an extensive depression funnel formed in the aquifers. The depth of the water level decrease reached 9–10 m in the wells of the first line, and for individual wells — up to 15 m [Popov et al., 2002]. The decrease in the level of underground water in the exploited Paleogene complex increased the flow of ground water from the overlying horizons, which led to a decrease in the level in the Quaternary aquifer complex and caused active drying processes in the landscapes adjacent to the water intake lines.

In some mires of the Ob-Tom interfluve, the drying to varying degrees was revealed — from insignificant on the periphery to complete drying of the peat deposit. The change of hydro — and hygrophilous plant species to less moisture-loving hydro-mesophilic ones was observed in the ground cover [Chernova, 2011]. In soils, a decrease in the level of soil-ground water and the formation of drying horizons were revealed [Dyukarev and Pologova, 2009, 2011].

Is drying up in areas with a wide distribution of hydromorphic and semi-hydromorphic landscapes considered a negative or positive phenomenon? In the second half of the 20th century, in the South of the taiga zone of Western Siberia, including the territory of the Ob-Tom interfluve, hydro-forestry measures were widely deployed, and mires were drained over large areas in order to increase forest productivity [Efremov, 1987; Panchenko and Dyukarev, 2015]. However, drainage did not produce the expected results and proved ineffective. Forest productivity has not increased much, but the risk of fires and associated negative consequences has increased significantly, including air pollution, a decrease in the resource and economic potential of the territory, and a deterioration in the recreational qualities of the territory. Given the negative consequences, in recent years not only in Russia but in other countries suggested the need to reduce reclamation works and to revive the mires that provide important biosphere functions, in particular biodiversity balance of water cycle, and carbon cycle [Williamson et al., 2017; Sinyutkina et al., 2018].

The purpose of this work is to assess the current state of the natural environment of the Ob-Tom interfluve, identify negative consequences associated with the operation of the Tomsk water intake, and forecast the further development of ecosystems in its zone of operation.

THE OBJECTS AND METHODS OF RESEARCH

The study area is the Ob-Tom interfluve. It is located in the South of the taiga zone of Western Siberia. The average annual temperature is -0.6°C. The radiation balance is positive — 20–25 kcal/cm^2. The sum of temperatures above 10 degrees is 1700–1750°C per year. The average annual precipitation is 517 mm. The hydrothermal coefficient is 1.1–1.2. The territory belongs to the zone of moderate humidification, where the probability of natural, climate-related drying is low [Climate of Tomsk, 1982]. In geological and geomorphological terms, the Ob-Tom interfluve has a complex structure, which is associated with historical factors of its formation. Here, the ancient plain, composed of loam deposits, is washed by ancient runoff hollows of different ages, composed of deposits of light granulometric composition from sorted sands to layered loam-sandy loam deposits [Dyukarev and Pologova, 2011]. The total paludified area is low — about 20%. The main areas of the mires are concentrated on terraces and in the hollows of the ancient runoff. Mire nutrition is generally atmospheric, sometimes with the participation of soil and ground water [Platonov, 1963].

The Ob-Tom interfluve is an economically active territory. Both forest management and agricultural land use are developed here, and the recreational load is high [Panchenko and Dyukarev, 2015]. Among the economic activities that contribute to hydrological transformations, the drainage of mires in 1960s and 1970s should be noted. At the same time the laboratory of Forest Institute for detailed field research of mire reclamation was created to develop drainage technologies and evaluate the results of applying these technologies in the territory of the Ob-Tom interfluve. But the most significant and profound factor affecting the natural environment is the commissioning of the Tomsk water intake in 1972. Water extraction is carried out from depths of more than 80 m. However the indicators of the chemical composition of the extracted drinking water show that the lack of water in the exploited geological layers is compensated by both the over- and the underlying aquifers [Popov et al., 2002].

Because of the high landscape heterogeneity of the Ob-Tom interfluve, the hydrological transformations, which detected here, were confined to different areas of the territory and to different types of landscape. Semihydromorphic and hydromorphic landscapes of ancient runoff hollows were the most susceptible to hydrological transformations [Dyukarev and Pologova, 2009]. To study the processes occurring in landscapes and identify the role of water intake in their transformation, we have laid a series of landscape-ecological transects. This paper presents the results of a study on the landscape-ecological transect laid down in the zone of the maximum drying (2.5–3 km from the first line of water intake wells), including all the elements of the relief of the ancient runoff hollow: ridges of different heights and inter-ridge depressions that differ in the thickness of accumulated peat (Fig. 1).

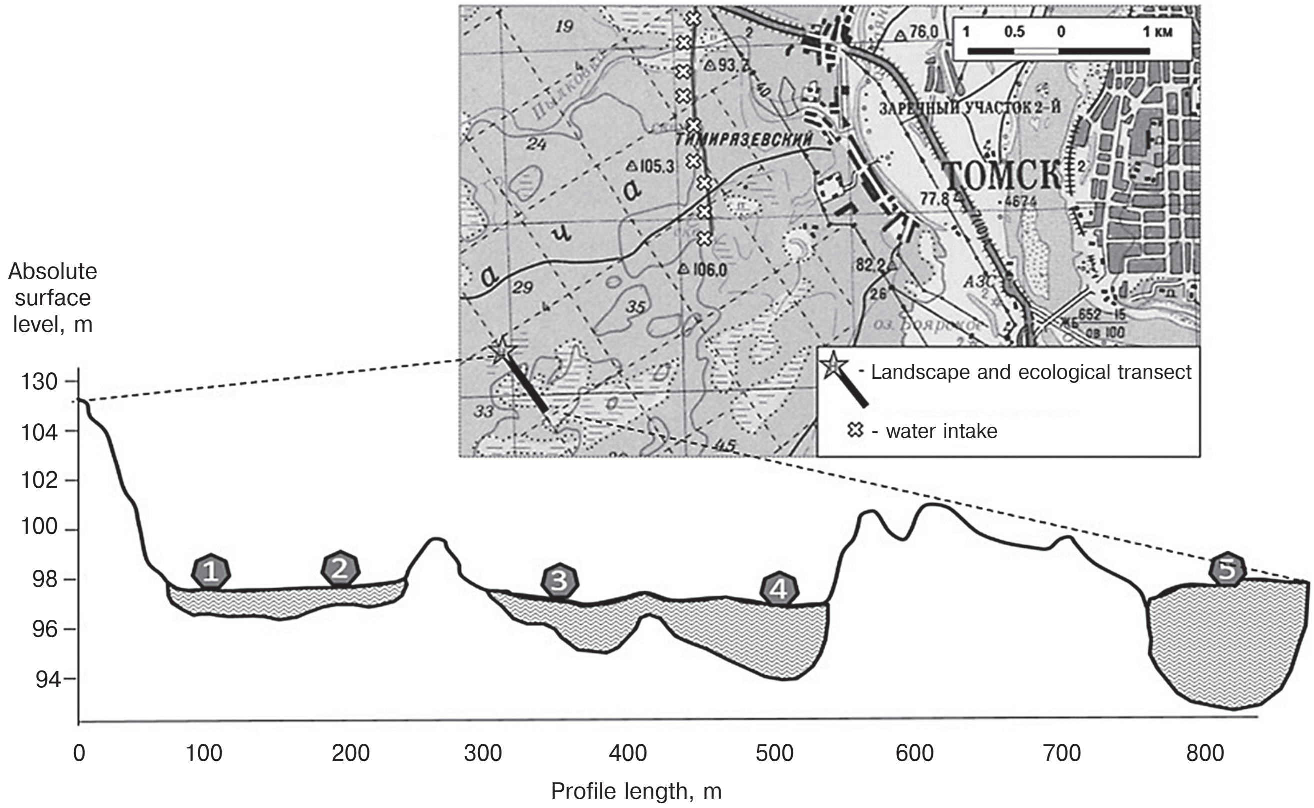

Fig. 1. Landscape and ecological transect in the area of operation of the Tomsk water intake. Numbers 1–5 indicate the points of peat sampling

Рис. 1. Ландшафтно-экологический профиль в зоне действия Томского водозабора. Цифрами 1–5 обозначены места отбора торфяных скважин

The transect with a total length of 820 m is oriented to the South-East and is laid along a clearing between 33 and 34 blocks of Timiryazevsky forestry. Geographical coordinates of the beginning of the transect 56°26'43" N 84°49'36" E. In routestudies [Dyukarev and Pologova, 2009], no drainage system of hydro-reclamation was detected near the site where the transect was laid. The nearest drained mire — Chaginskoe — is located 3.5 km to the North-East and does not communicate with the mires we studied.

In 2000, 2007, and 2018, the vegetation releves of all plant communities by terrain elements were carried out on the landscape-ecological transect. This paper focuses on the analysis of hydromorphic and semi-hydromorphic ecosystems of inter-ridge depressions that are most susceptible to hydrological transformations. To reconstruct the phytocenoses of mires that existed before the water deposit was put into operation and the beginning of drying, the composition of plant macrofossils in upper layers of peat was analyzed. The peat samples were taken in the central parts of the inter-ridge mires. (see Fig. 1, points 1–5). The assessment of the ecological structure of plant communities was carried out using ecological groups of species proposed for mires of the South-East of Western Siberia by E.D. Lapshina [2003]. Also, the soil moisture was calculated via phytoindication method using indicator values of plants, developed by L.G. Ramensky [Ramensky et al., 1956], which allowed us to trace the dynamics of moisture both before and after the start of drying. The calculations were maid taking into account the abundance of species and their indicator significance in accordance with the recommendations [Zverev and Babeshina, 2009].

Modeling of humidification conditions was performed using the method of hydrological and climatic calculations [Karnatsevich et al., 2011] based on data on daily precipitation and air temperatures for the period from 1936 to 2017 for the nearest weather station — Tomsk — from the VNIGMI-MCC database [Bulygina et al., 2019].

RESULTS AND DISCUSSION

Dynamics of plant communities associated with changes in the hydrological regime of the territory

Analysis of the dynamics of phytocenoses showed that the change in hydromorphic landscapes detected in the Ob-Tom interfluve occurred unequally both in space and time. The most significant changes occurred at points 1–3, where the thickness of the peat did not exceed 2 m before drying. At point 1, the initial thickness of the peat (reconstructed according to the peat density) was about 180 cm. However, by 2000, as a result of drying, compaction and partially mineralization of the peat, its thickness decreased to 1 m. To date (2019) the thickness of peat deposits has reduced to 35 cm. At the point 2 the thickness of the peat continues to decrease from 0.9 m in 2000, to 0.5 m in 2019 From the surface the peat has become loose, "dusty", lost the ability to absorb and retain moisture. The level of mireground water is detected only in early spring and then outside the peat layer. According to the composition of plant macrofossils in peat (table), previously there were herbal and herb-sphagnum fens with a predominance of aerohydro — and subhydrophytes – plants that prefer more or less watered habitats (*Carex limosa, Menyanthes trifoliata, Sphagnum subsecundum*). However, even before the start of monitoring studies (before 2000), soil moisture was significantly reduced (by 13–18 steps of the Ramensky's moisture scale) (Fig. 2), the peat deposit has dried up and compacted, sparse forests of pine and birch have formed on the site of the fens. These forests have the extremely poorly developed ground cover, in some areas — rarefied moss cover. Since 2000 no significant changes in soil moisture either up or down have been observed — the fluctuations of this parameter ranged from 0–1 to 3 (5) steps (Fig. 2). Accordingly, forest communities with a predominance of plants that prefer medium — moisture conditions – mesophytes and hydromesophytes (Betula pubescens, Pinus sylvestris, Pleurozium schreberi, Polytrichum strictum, Sphagnum angustifolium) and a smaller participation of subhydrophytes have been steadily preserved on the site of the former fen phytocenoses for almost 20 years.

In General, the the revealed in phytocenoses changes are similar to those observed after hydroreclamation of mires and have been described in detail by S.P. Efremov [1987] in the Ob-Tom interfluve. However, if the modern stand of trees, which formed during the initial phases of changes in the hydrological regime, looks almost normal, then the modern regrowth of *Pinus sibirica and P. sylvestris* is oppressed, which is because of a lack of moisture. With sufficient numbers for reforestation

Table 2 / Таблица 2

Transformation of hydromorphic ecosystems in the Ob-Tom interfluve

Трансформация сообществ болот на Обь-Томском междуречье

	Peat thickness, m	Before drying	After drying	
			2000 year	2018 year
1	1.0/0.65 (1.8)	herbal fen (*Carex limosa, Menyanthes trifoliata, Eriophorum vaginatum*)	Birch forest with extremely poorly developed ground cover (*Betula pubescens*)	Birch forest with extremely poorly developed ground cover лес (*Betula pubescens*)
2	0.9/05 (1.9)	herb-sphagnum fen (*Carex limosa, Scheuchzeria palustris, Sphagnum subsecundum*)	Pine dwarf shrub moss forest (*Pinus sylvestris, Chamaedaphne calyculata, Pleurozium schreberi, Dicranum polysetum*)	Pine dwarf shrub moss forest (*Pinus sylvestris, Chamaedaphne calyculata, Pleurozium schreberi, Dicranum polysetum*)
3	0.6/0.5 (1.1)	herbal fen (*Carex limosa, Menyanthes trifoliata*)	Pine moss forest (*Pinus sylvestris, Polytrichum strictum, Sphagnum magellanicum*)	Pine moss forest (*Pinus sylvestris, Polytrichum strictum, Sphagnum magellanicum*)
4	3.2	Pine-dwarf shrub-sphagnum bog (*Pinus sylvestris, Sphagnum angustifolium, S.magellanicum*)	Pine-dwarf shrub-sphagnum bog (*Pinus sylvestris, Chamaedaphne calyculata, Sphagnum angustifolium, S. magellanicum*)	Pine-dwarf shrub-sphagnum bog (*Pinus sylvestris, Chamaedaphne calyculata, Sphagnum angustifolium, S. magellanicum*)
5	5.2	Pine-dwarf shrub-sphagnum bog (*Pinus sylvestris, Sphagnum fuscum*)	Pine-dwarf shrub-sphagnum bog (*Pinus sylvestris, Chamaedaphne calyculata, Sphagnum angustifolium, S. fuscum*)	Pine-dwarf shrub-sphagnum bog (*Pinus sylvestris, Chamaedaphne calyculata, Sphagnum angustifolium, S. fuscum*)

Note. Peat thickness (m) in the numerator — 2000, in the denominator — 2019 (in brackets, the initial thickness of the peat deposit, calculated from the change in the peat density).

Примечание. Мощность торфа (м) в числителе — 2000 год, в знаменателе — 2019 год (в скобках приведена исходная мощность торфяной залежи, рассчитанная по изменению плотности сложения).

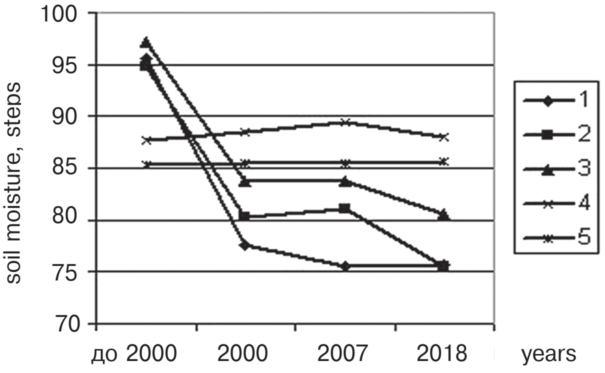

Fig. 2. Dynamics of soil moisture in the phytocenoses of inter-ridge depressions in the Ob-Tom interfluve. The point numbers as in Fig. 1 and in the table

Рис. 2. Динамика увлажнения почв в фитоценозах межгривных западин на Обь-Томском междуречье. Номера точек такие же, как на рис. 1 и в таблице

(12–20.5 thousand. units /ha) its average height is 42 cm, and the average age is 15–16 years, while the same regrowth from natural habitats [Nikolaeva and Panov, 2012] has an increase of 2–3 times higher. In addition, the formation of ground cover in the studied forests is very slow. This is probably because of the lack of moisture in the habitat after drying. T.T. Efremova et al. [2011] noted a decrease in the productivity of stands on dry peat soils when the level of soil and ground water drops to a depth of 50 cm. And in our case, it dropped to a depth of more than 2.5 m [Dyukarev and Pologova, 2009].

Mires with thicker (more than 3 m) deposits (points 4 and 5) have dried up to a lesser extent. There were no significant changes in habitat conditions, in particular soil moisture, in the central part (in the place of peat sampling) (Fig. 2). Both the composition of plant macrofossils of the upper layers of peat and modern observations indicate that there were previously, as at present, pine dwarf shrub-sphagnum communities (bogs) with a predominance of hydromesophytes and subhydrophytes (*Pinus sylvestris* (bog form), *Chamaedaphne calyculata, Sphagnum angustifolium, S. magellanicum, S. fuscum*) (table.). Signs of drying were found only on the periphery of these bog massifs. At point 4, they were expressed in the formation of a narrow strip of pine-birch forest with an extremely poorly developed ground cover along the edge of the bog, confined to areas of dried peat deposits. At point 5, the changes were weaker — the peat was not dry on the periphery, but the ground cover was dominated not by hydromesophytic mosses (*Sphagnum angustifolium, S. fuscum*), but by mesophytic mosses (*Pleurozium schreberi*). All these signs of drying were detected at the very beginning of the research (in 2000), and no further changes had been observed in the vegetation cover. However, there was an increase in peat subsidence in the marginal part of the bog (on the border of the bog and mineral ridge), which continues at the present time.

Thus, the dynamics of phytocenoses in the inter-ridge depressions occurred as follows. Maximum drying occurred before 2000, and from 2000 to the present time, no significant changes were observed either in habitat conditions (in particular, soil moisture) or in the structure of phytocenoses (species, ecological). Only the subsidence phenomena on the border of the bog and the mineral ridge increased somewhat.

Dynamics of hydroclimatic conditions

Based on data from the Tomsk hydro meteorological station [Bulygina et al., 2019] we analyzed the dynamics of the hydrothermal regime for the period from 1936 to 2017 (Fig. 3). In addition to the dynamics of annual moisture content (Fig. 3, a) the moisture content for MayAugust was analyzed separately (Fig. 3, b), since, according to [Kolomyts, 2018], it is the summer moisture content of the soil that serves as the main link in the transmission of hydrothermal signals from the global level to the regional and local level. A slight trend was detected (Fig. 3, a) from 0.88 to 0.92, caused by an increase in precipitation relative to heat-energy evaporation resources (evaporability). However, the increase in precipitation is more typical for the winter period and primarily contributes to the growth of high water, so the moisture of the active layer for the growing season May-August (Fig. 3, b) does not reflect this trend, which indicates the stability of climatic conditions for vegetation in the long-term mode. O.V. Mezentseva and co-authors came to similar conclusions. Mezentseva et al. [2010], who studied the spatial and temporal dynamics of the characteristics of natural heat and moisture supply in Western Siberia, came to similar conclusions.. They showed the absence of a reliable climate trend of the humidification coefficient, and received multidirectional linear trends in the characteristics of natural moisture and heat supply, which give the right to doubt the unidirectional climate process in recent decades. The absence of a long-term (multi-year) unidirectional change in the moisture coefficient indicates that the reason for the change of plant communities observed in the Ob-Tom interfluve was not the dynamics of the hydrothermal regime.

It should also be noted that the depth of soil and ground water increased by more than 2 m during drying of mires in the inter-ridge depressions (from the depth of 0.1–0.2 m, typical for mesotrophic fens according to [Lapshina, 2010], to 2.5–3.0 m

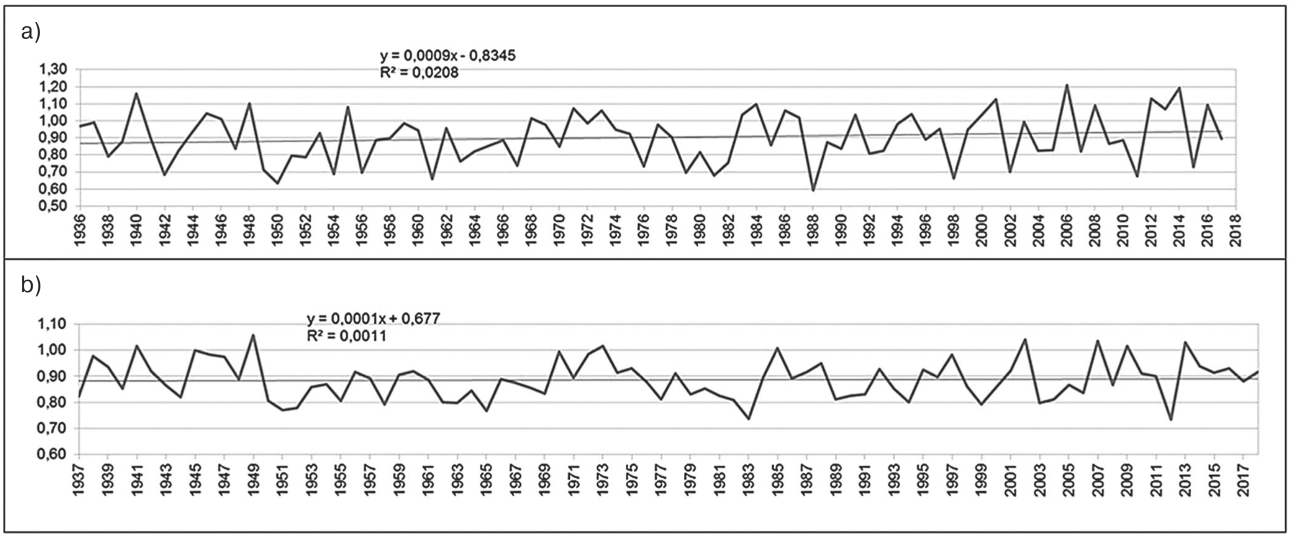

Fig. 3. Dynamics of moisture coefficient (precipitation/evaporation) (a) and relative moisture of the active layer for May-August (b)

Рис. 3. Динамика коэффициента увлажнения (осадки/испаряемость) (а) и относительной влажности деятельного слоя за май-август (б)

according to the observations of A.G. Dyukarev and N.N. Pologova [2009]). This change is significantly greater than the amplitude of natural mire water level fluctuations detected during monitoring in years with different weather conditions, which did not exceed 15–20 cm [Dyukarev and Pologova, 2009].

Therefore, it can be argued that the dynamics of moisture and vegetation conditions detected in the Ob-Tom interfluve were caused not by climatic processes, but by an anthropogenic violation of the hydrological regime because of long-term water intake activity and corresponding changes in plant growth conditions. This conclusion is supported by the spatial unevenness of ecosystem drying. While the moisture content of inter-ridge depressions decreased significantly, no such changes were observed in the ridges. This indicates that the identified drying processes are related to the dynamics of groundwater levels. There were no significant changes in the ecosystems formed on ancient plains composed of loamy deposits. Other researchers also noted negative processes associated with the Tomsk water intake activities [Popov et al., 2002]. When it was put into operation, this influence largely overlapped the course of natural dynamics of groundwater. In the research of O.G. Savichev and Yu.V. Makushin [2004] in different wells in the Tomsk region that are not affected by anthropogenic factors, there was a gradual increase in groundwater levels from the 1960s to 1970s. At the same time, since the beginning of the Tomsk water intake (1972), a natural decrease in water levels has been observed in wells of the Ob-Tom interfluve together with the formation of a vast depression funnel [Popov et al., 2002]. It is important to note that the change in groundwater levels was not gradual, but rather abrupt. Their main decrease was noted in the 1970–1980s. — from 7–9 m to 12–16 m for the first most exploited well line [Popov et al., 2002; State of..., 2017, p. 97]. Then, after establishing a certain more or less constant volume of water extraction by the Tomsk water intake, minor fluctuations in levels were observed — within 1–2 m, associated with the operation mode of water intake wells and climatic factors [Savichev and Shmakov, 2012; State ..., 2017]. Thus, the dynamics of groundwater levels in the Ob-Tom interfluve, caused by the work of the Tomsk water intake, has the same character as the dynamics of changes in habitat moisture, revealed by the phytoindication method. The close relationship between the drying of mires in the Ob-Tom interfluve and the operation of the Tomsk water intake is also confirmed by the territorial proximity of the maximum drying zone to the center of the underground water depression funnel [Dyukarev and Pologova, 2011].

The underground water deposit of the Ob-Tom interfluve is a renewable natural resource, since the water supply of the Paleogen complex operated by the Tomsk water intake is infiltration [Popov et al., 2002]. Calculations of the distribution of climate runoff in the Ob-Tom interfluve allowed us to estimate the annual volume of groundwater renewal. As a model for calculations, we used the river Poros — the left tributary of the river Tom. In the work of L.I. Dubrovskaya and N.A. Ermashova [2001], based on the data of 1973–1998, there is a tendency to reduce the flow of the river Poros, possibly related to an increase in the use of the upper water supply for feeding the aquifer of “Kochkovskaya” formation, the level of which near the valley of river Tom has significantly decreased because of the operation of the Tomsk water intake. But based on the data up to 2001 [Savichev et al., 2003] it is concluded that changes in the water regime of the river Poros are related to not only anthropogenic factors. If we consider the observation period from 1974 to 2015, the average water consumption in the river Poros insreases by 8%, compared to 1974–2001, to the value of 0.49 m/s. This increase is 3% higher than the accuracy of hydrometric flow metering. Thus, the flow of water in the river Poros is weakly dependent on the amount of groundwater intake, which indicates its weak hydrological connection with the groundwater aquifer, since it is formed on the territory of an ancient plain, which is composed of loamy and clay deposits. This is also evidenced by the fact that, since 1997, according to [Savichev and Shmakov, 2012], the study area has seen an increase in the level of groundwater.

The average annual climatic runoff in the river Poros catchment area near the village of Zorkaltsevo modeled by the method of hydroclimatic calculations is 158 mm, and the measured hydrometric runoff layer is only 49 mm. Therefore, the average annual infiltration supply of groundwater is 109 mm per year. Such a significant amount of water supply is explained by the abundance of wells, mostly funnel-shaped, which are zones of active replenishment of underground water reserves by macropores [Kopysov, 2015]. The average annual renewable underground flow of the Ob-Tom interfluve, taking into account the area drained by the Tomsk underground water intake (1500 km^2), can be estimated at 650 thousand m^3 per day. Only a third this volume should be extracted, i.e. 215 thousand m^3 per day, which is 20% less than the approved reserves. If in the early 2000s the volume of water intake reached 250 thousand m^3 per day, in 2018 the Tomsk water intake pumped out only 119 thousand m^3 per day [State ..., 2019, p. 103]. Currently, the volume of water extraction is much less than the estimated volume of groundwater renewal and has recently been maintained at a stable level. This also indicates the stabilization of the ecological conditions of plant growth in the territory of the Ob-Tom interfluve, which means that further catastrophic growth of hydro transformation areas, as previously assumed [Dyukarev and Pologova, 2011], is not expected.

CONCLUSION

The study of forest and mire ecosystems in the Ob-Tom interfluve showed that a significant change in habitat conditions that caused the drying of the territory occurred before 2000 and affected mainly the hydromorphic ecosystems — bogs and fens. Then, in the course of long-term monitoring of dried-out forest-mire complexes, started in 2000, no further significant changes in habitat conditions and, consequently, ecosystems were detected. We consider such dynamics of drying against a background of relative constancy of climatic conditions (hydrothermal regime) in long-term perspective, as the result of the dynamics of groundwater levels in the Ob-Tom interfluve, caused largely by the commissioning of the Tomsk water intake — the increase of the volume of water extraction and the corresponding decrease of the groundwater levels in the 1970–1980s, and then a relative stabilization of the volume of water extraction by the 2000s, and even a slight decrease in water withdrawal in recent years.

The currently established volumes of water extraction in the Ob-Tom interfluve are significantly less than the volumes of annual renewal of groundwater. Therefore, further strengthening of drying of the territory is not expected. The hydromorphic ecosystems of the Ob-Tom interfluve that were previously dried out now function stably in the conditions of the newly formed level of ground, soil-ground and mire waters.

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