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ESTIMATION OF MIRE WATER BALANCE IN WESTERN SIBERIA

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SUMMARY

Examinations of water balance were carried out on the territory of mire within the area of small waterlogged basin of river Klyuch in the north-eastern part of the Vasyugan bog. The determination of annual precipitation, snow cover water equivalent, evaporation amount and discharge were conducted separately for every dominant type of the raised bog biogeocenoses, and the monthly water balance model was used. As a result of this research it was noted that differences in the water balance of biogeocoenoses are defined by the vegetation structure, which defines the process of moisture accumulation in the bog peat deposit.

KEY WORDS: mire, water balance, investigation, Vasyugan bog, Western Siberia.

INTRODUCTION.

Bogs that occupy vast areas of the Western Siberia play the powerful role of the regional climatic factor, thereby facilitating the spatial distribution of thermal energy resources. Spatial and time dynamics of area water resources are in direct relation from many water balance factors – amount, intensity and distribution of atmospheric precipitation by area, evaporation and underlying surface factors. Climatic changes on this area are expressed in increase of precipitation approximately by 1-1,5 mm/10 years. Excessive moistening, which is typical for the taiga zone of the Western Siberia, contributes to its active swamping, and as a result, the process of bog formation goes on by means of covering adjacent areas, which in many ways explains their hydrological regime and specific character of geological and ecological situation in the region. The examination of moisture accumulation and consumption processes in river basins will allow estimating modern processes of climatic and hydrological condition changes in the Western Siberia and defining the influence of progressive bog formation on changes of land and underground drainage.

Examinations of water balance were carried out on the territory of mire within the area of small waterlogged basin of river Klyuch in the north-eastern part of the Vasyugan bog. The total catchments area based on the interpretation on satellite data is 76 km^2. Total waterlogged watershed is 77 % (Fig. 1).

MATERIALS AND METHODS

The determination of annual precipitation, snow cover water equivalent, evaporation amount and discharge were carried out separately for every dominant type of the raised bog biogeocenoses during the estimation of water balance components: high riam, low riam and sedge-sphagnum swamp and as well as in general for the whole catchment of River Klyuch. In addition, the monthly water balance model was used (Savichev et al., 2011) with an estimation of the total value of moisture, water loss from the snow (in spring), flow runoff, and also the statistical analysis of long-term changes of water balance elements.

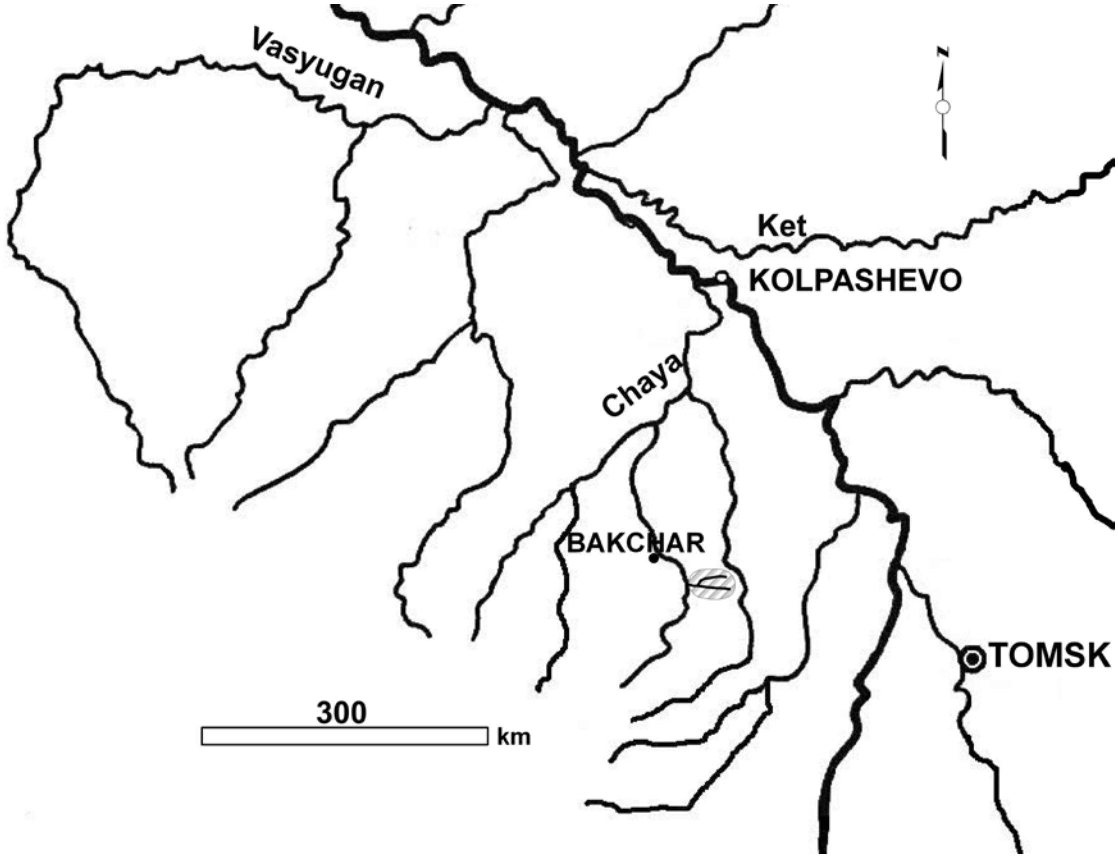

Figure 1. Investigation site marked as the small grey area close to Bakchar.

The total humidification of catchments area per month ***t*** considered as the sum of liquid precipitation ***X*** (average monthly rainfall in the air temperature T_a is more or equal to 0 ° C) and water loss from snow cover ***B***:

$$H_t = X_t + B_t \,. \quad (1)$$

When the average air temperature is less than 0° C, precipitation were regarded as the snow, which is not directly involved in the water feeding the river, and goes to the formation of snow cover ***S***

$$\frac{dS}{dt} = X - B - E_s \,, \quad (2)$$

where E_s – monthly evaporation from the snow (mm), in this paper is calculated by the equation of P.P. Kuzin:

$$E_{s,t} = 0.34\, m\, d_t \,, \quad (3)$$

m - number of days in the month; d_t - the average monthly deficit of moisture hPa. For an approximate calculation of the monthly moisture, content in the snow cover used an implicit finite difference scheme for solving equation (2).

Water loss from the snow cover ***B*** is approximately defined by (Popov, 1963; Vissmen et al, 1979; Befani, Kalinin, 1983, Gel'fand, 2007) in the air temperature is more or equal to 0 ° C and the presence of snow cover on the equation:

$$B_t = min\left(\frac{k_T\ T_{a,t}\ m}{1-k_B} + k_X \sum_j^m X_j\ T_{a,j}\ ; S_t\right),$$

$\boldsymbol{k_T}$ – snow melting rate mainly due to sun radiation; $\boldsymbol{k_B}$ - snow melting rate at which water loss begin; $k_X \sum_j^m X_j\ T_{a,j}$ - a month snow melt water depth. The total catchments moisture was calculated as a weighted average to wet in the woods and in open areas. The value of the total runoff loss ***P*** was defined as the difference between total moisture $\boldsymbol{H_t}$ and total runoff for the current month. Evapotranspiration from the catchments area was calculated by the method of V.S. Mezentsev [1982] and from the surface of mire – according to (Guidelines…, 1986).

The method of statistical analysis included: 1) random series of observations using the criterion of Pitman $\boldsymbol{\pi}$ and linear model of the form Y = a T + b, where ***Y*** - the quantity under investigation; ***T*** - year; ***a*** and ***b*** - empirical constants (Khristoforov, 1993). 2) homogeneity by using Student and Fisher criterion.

RESULTS

As a result of this study it was noted that differences in the water balance of biogeocoenoses are defined by the vegetation structure, which defines the process of moisture accumulation in the bog peat deposit. Accumulation of precipitation is observed in a pine forest with shrub-sphagnum ecosystems, but under conditions of intensive water drainage, the minimum level of moisture accumulation is observed considering powerful active layer. The less forested the lower riam is, the smaller is the snow cover water equivalent, but the level of annual evaporation would behigher reaching up to 479 mm being combined with a relatively high discharge module and the water level would be -1 cm in relation to the average peat surface level. Constantly high levels of bog waters, which are 3 cm higher than the average surface level, evaporation would reach an average of 399 mm and moisture accumulation in the peat deposit would be characteristic of the open area of sedge-sphagnum bog (Table 1).

Table 1**.** Relation of mire water balance elements in the basin of river Klyuch (1998-2009 years).

Observation point	Precipitation*, mm	Storage of water in snow pack, mm	Evapotranspiration, mm	Change of moisture, mm
High riam	490	141	348	-40
Low riam	490	143	479	24
Sedge-sphagnum swamp	490	110	399	16

Note: We used data from a weather station Bakchar.

Changing the mire water regime determines the ratio of the elements of the water balance and processes of water income and loss throughout the year. Analysis of long-term changes of bog water levels showed a statistically significant trend of increasing average levels (May-September) in the sedge-sphagnum swamp (Fig. 2). Positive trend was observed for the average water levels from June to September, most positive tendency was noted in July and August. In contrast, in May there was a tendency to reduce water levels in sedge-sphagnum swamp. For other ecosystems statistically significant trends in water levels was not detected. Keeping this in mind in the future, we should expect further distribution of bogs, which is one of the most stable components of the natural landscape.

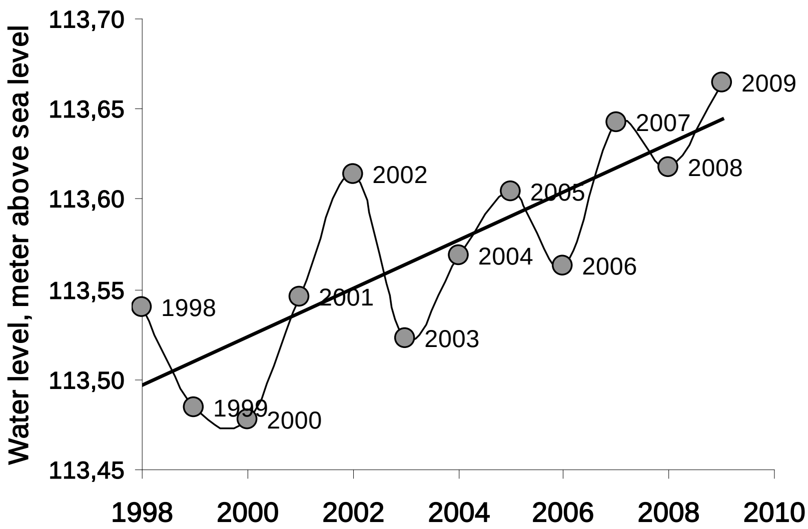

Figure 2. Long-term dynamics of the mean value of mire water level (May-September) in the sedge-sphagnum swamp

Close correlation was not found between the average mire water levels, river water levels and discharge of Klyuch River and the air temperature at nearby weather stations. The highest correlation was observed for water levels to the amount of rainfall and mostly only for the border parts of bogs occupied by pine-shrub-sphagnum raised bog ecosystem. This kind of regularity indicates complexity of the mire functioning, their autonomy in relation to the surrounding area, the capacity for self-development and creation of their own microclimate.

Analysis of long-term changes of water balance elements in the basin of Klyuch River has allowed violations of series homogeneity associated with an increase of the total humidification of the basin in the months March, June, July, September and October (Fig. 3). Reduction of the total basin humidification was observed in April-May and August. Changes in humidity values were observed in the period 1982-1990. Statistically significant trends in change of total catchment humidification had not been identified.

River Basin indicated a statistically significant trend of increasing losses in the June runoff, as well as a tendency to reduce runoff losses in May and August, which generally corresponds to the pattern of total moisture change in the studied area. Correspondingly, there is a violation of the homogeneity of the series in March, May and July, largely because of an increase in the

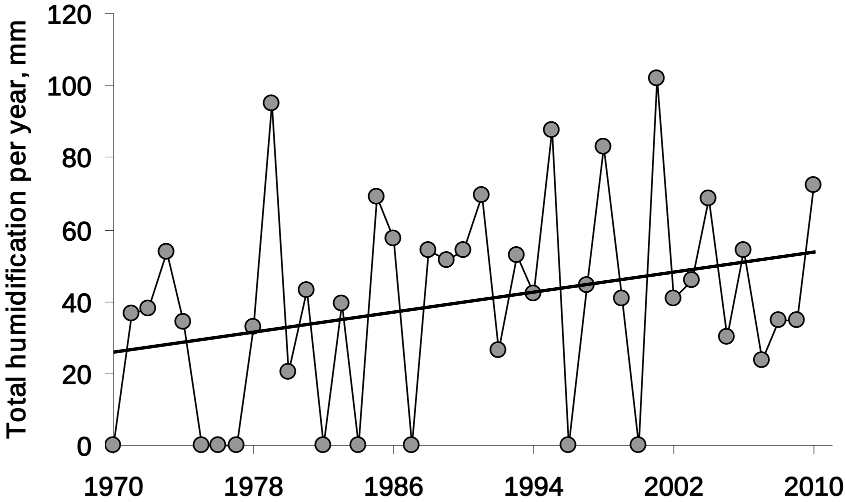

Figure 3**.** Dynamics of the total humidification (H) of Klyuch basin in October for a long-term period

volume of runoff losses. Thus, violations of the homogeneity of the series through the redistribution of moisture reservoir size over time and loss of flow, respectively is not observed over the year. Increased runoff losses were determined mainly by the increasing evaporation and moisture on the territory of certain periods of the year.

Analysis of data for evaporation from bogs in the basin of River Klyuch revealed a pattern of decreasing evaporation from March to June but increasing in the second half of the year. In general, for the year it was indicated a violation of series homogeneity associated with changes of the dispersion. In the long-term, observed changes of flow showed a pattern of decrease in April, May, June, November and December but with increase in August.

CONCLUSION

By the results of performed investigations, it was noted that differences in the water balance of biogeocoenoses are defined by the vegetation structure, which defines the process of moisture accumulation in the bog peat deposit. The accumulation of atmospheric precipitation is observed in a more forested pine-shrub-sphagnum biogeocenosis with high pines. However, in conditions of intensive water evacuation, a minimum level of moisture accumulation is observed considering the powerful active layer. The statistical analysis of the long-term changes of water balance elements allowed to mark the decrease of overall moistening in April-May, the gradual increase of evaporation in the autumn period, prolongation of transitional autumn-winter period and the corresponding minimizing of moisture content in snow cover in November-December. As a result, the hydrological regime redistribution, which is characterized by the definite flow decrease in November and December, April-June and increase in August-September is observed in the considered region. Nevertheless, annual characteristics of water balance remain statistically unchanged. Generally, favorable conditions for the development of bog formation and peat accumulation processes owing to excessive moistening in the warm period of year will be invariable in the nearest and midterm prospect.

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