Oligotrophic bogs’ runoff effect on surface waters

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Abstract. The removal of organic matter, including carbon, from oligotrophic bogs is determined by the amount of decomposed organic matter in bog waters and the runoff intensity. This process has a pronounced seasonal dynamics and is determined by weather conditions and characteristics of the bog runoff. The maximum waterlogging is observed in the spring during snow thawing and in the autumn due to abundant precipitation and reduced evaporation. The amount of organic matter in bog water is determined by the air temperature of the previous period. Thus, the maximum carbon runoff from the bogs is possible in May-June and September, and the situation can vary considerably over the years, the weather being taken into account.

1. Introduction
Oligotrophic bogs in Western Siberia have a noticeable effect on surface waters: first, by changing their chemical composition, and second, by adjusting the runoff volumes. The removal of organic matter, including carbon, from oligotrophic bogs is determined by the amount of decomposed organic matter in bog waters and the runoff intensity. This process has a pronounced seasonal dynamics and is determined by weather conditions and characteristics of the bog runoff. The paper presents a basic scheme of this process. The maximum waterlogging is observed in the spring during snow thawing and in the autumn with abundant precipitation and reduced evaporation. The amount of organic matter in bog water is determined by the temperature of the preceding period. Thus, the maximum carbon runoff from the bogs is possible in May-June and September, and the situation can vary considerably over the years, taking into account the actual weather.

2. Results and Discussion
The water regulating role of wetlands is widely discussed in the scientific literature [1-4]. At the same time, the existing notion that the wetlands are reserves of fresh water does not take into account wetland water’s being not suitable for household and, moreover, for drinking. Wetland waters are characterized by acidic media and abundance of organic matter decomposition products. For example, take the value of COD (chemical oxygen demand), an indicator reflecting water contamination with organic matter decomposition products. For rivers with a fishery value, the MPC for COD is equal to 15 mgO₂/dm³. In the water of oligotrophic bogs, the COD values according to the materials of our research can reach 250-290 mgO₂/dm³ in settled, but not filtered samples. The positive role of wetlands in the formation of the river network and the runoff regulation is also exaggerated.

Consider the mechanism of wetlands influence on surface runoff. The snow cover in the wetlands is destroyed much earlier than in the adjacent forest areas. When there is still snow in the forest, there
are already huge areas of open water in the wetlands, which flows down the frozen surface to the periphery, flooding the territory of forested areas, where it partially goes into the underground runoff, and partially gets into the river network. This water, apparently, contributes to the acceleration of snow melting in the adjacent forest landscapes. In the area of the wetland itself, snow melt does not linger and does not pass into the underground runoff. The sequence of snow melting can be seen in the photographs in figure 1 a, b. The figure (photo from a helicopter) shows that there is snow in the forest, and there are already huge open water areas in the wetland, which also shows a high water level in the photo of the ridge-bog complex during a ground survey in April 2012, with almost complete absence of water on the surface of the hollows in the summer (Figure 2).

Oligotrophic bog abundance in the inter-river valleys accelerates melt water runoff from the central parts of the interfluve to the main river of the region. Thus, oligotrophic bogs do not slow down the surface runoff from the territory; on the contrary, they accelerate its entry into rivers, contributing to a short-term increase in the spring flooding peak. In the peripheral wetland strip, peculiar soil catenas
are formed, with waterproof layers [5], which slow down the vertical movement of water and increase the amount of spring surface runoff.

In order to study the perennial dynamics of wetland watering over the seasons of the year, we combined the ENVISAT altimetry point survey tracks (measuring frequency 18 Hz, which gives a spatial resolution of 380 m along the track) with a map of the Tomsk region wetlands. The calculations were done separately for the selected 14 types of bogs, the main area of which comprises oligotrophic bog massifs [6]. The statistics on the variability of the altimetric signal for different types of wetlands within the Great Vasyugan Mire were obtained according to the ENVISAT satellite data from 2002 to 2010. [7]. The water content and level of the water surface in all types of wetlands increase sharply from mid-late April, then there is a decrease in performance. Already in the middle of May, on oligotrophic and mesotrophic bogs, there is a significant decline in indicators, sometimes by early June, reaching values close to low water level.

The largest area in Western Siberia is occupied by oligotrophic bogs of inter-river plains and large above-flood-plain terraces. The chemical composition of surface waters depends on both the amount of water coming from the wetlands and the content of organic matter in it. It is obvious that both of these parameters strongly depend on the type of wetlands, and are subject to both annual and seasonal dynamics. Consider the potential impact of marsh runoff on organic carbon content in surface waters in different seasons of the year.

Winter low water (January-March): the rivers are mainly ground-fed, with the exception of the headwaters of the rivers flowing through the wetlands on the peat banks. The wetland runoff effect is minimal, only due to changes in the chemical composition of groundwater. The amount of organic carbon in the water does not depend on the degree of waterlogging in the catchment. The influence of precipitation and air temperature on the chemical composition is almost absent, but the end time of the period depends on the temperature.

The spring flood has two phases: 1 – a phase from the beginning of the rise of water to the peak, 2 – a phase from the peak to summer low water. The destruction of snow cover in wetlands begins earlier than in the forest. Full thawing of peat deposits occurs only in May-June [8]. Runoff from the wetlands flows over the frozen surface; snow water does not penetrate into the underground runoff and practically does not extract the bog organic matter. Flowing to the periphery, the melt water floods the adjacent forest landscapes, where it partly goes into the underground runoff, and partly into the river network. Thus, in the first phase of the flood, the amount of organic carbon in the water does not depend on the degree of waterlogging in the catchment or may be somewhat reduced as a result of dilution with melt snow water flowing from the frozen wetlands. The presence of large wetland massifs accelerates the “running around” of melt water from the central parts of the interfluve to the main river of the region. Bogs reduce the total amount of runoff during the flood period, but can lead to an increase in flood peak due to the combination of meltwater runoff from the swamp, with meltwater runoff from forest areas.

The second phase of the flood. Peat layer and wetland forest litter thawing results in the removal of organic matter increase. The amount of organic carbon in the water should depend on the degree of waterlogging in the catchment. Precipitation and temperature practically do not affect the chemical composition of surface waters, but they determine when the period ends. Although high temperatures together with heavy rainfall can increase the removal of organic matter at this stage.

Summer low water. Surface runoff from the wetlands almost stops. The situation is similar to the winter low water. The amount of organic carbon in the water should not significantly depend on the degree of waterlogging in the catchment. Precipitation and temperature have practically no effect on the chemical composition of surface waters (with the exception of brief discharges of organically rich marsh water into the river system during heavy rainfall), but they determine the period end time.

Autumn. The autumn “flood” strongly depends on the summer low-water season both in terms of the onset and in scale. In any case, during this period, the influence of the wetlands on the chemical composition of surface waters is maximal, since during the summer enough organic matter has accumulated. The maximum amount of organic carbon in water is reached during this period, and it
depends on the degree of waterlogging in the catchment. *Precipitation and temperature effect*: the more precipitation during this period and the higher the temperature in the preceding one, the stronger the influence of the bog runoff on the chemical composition of surface waters.

Wetland landscapes of river valleys have a certain water-regulating capacity, since, unlike the oligotrophic and mesotrophic bogs of watershed plains, they have large amplitude of fluctuations of the surface level. During the flood, the valley swamp arrays compensate for low-flow water deficit. But during a low water period the runoff from them feeds the surface watercourses. The opinion about the water regulating role of swamps, in terms of smoothing the peaks of the flood, is partly true only for eutrophic bogs. It is largely formed in the conditions of the European territory, where there are no large areas occupied by oligotrophic bogs, and all the elevated parts of the plains were plowed up or built up long time ago. Thus, in Belarus, the water flowing from the fields is accumulated in undrained swamps, stretching the runoff for 2-4 weeks [2].

3. Conclusion
Snow melting begins in the open areas of the bog in the second half of April and contributes to raising the level of bog waters on the slopes and periphery of the oligotrophic bog massif. Significant runoff is formed after the rise in the level of bog waters above the average surface of the microrelief and occurs over its frozen surface. Due to the later start of snow melting in the swampy forest zone, the melt water from the open bog is partially spent on the saturation of snow and the upper soil horizon, the rest goes to the channel network together with the forest melt water.

Oligotrophic bogs on the watershed plain lead to a decrease in the annual volume of flow to the river system of the region, but it may partially increase the peak of the flood in the rivers draining the territory. Eutrophic bogs smooth the peak of the flood, but also slightly reduce the total annual flow.

The amount of organic matter coming with the bog waters into the river network varies greatly through seasons. The maximum organic “pollution” should correspond to the period of the autumn water rise, and the minimum - the winter low water. In the summer, one-time brief “emissions” of organic matter from wetlands related to heavy rainfall are possible. The interannual variability of these parameters strongly depends on the weather conditions of the spring and summer periods for the current year and on the autumn reserve of moisture and snow cover, for the next year.

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