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Role of Climate in Removing Dissolved Organic Matter from Cryolithozone Watersheds in Central Siberia

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Abstract—With reference to 2001–2005, the fluxes of dissolved organic matter (DOM) are analyzed in a water stream of the northern taiga subzone of continuous permafrost. Dynamics of hydroclimatic parameters is shown during a frost-free period. It is found that, in spite of a potential decrease in the DOM concentrations with the increased thickness of a seasonally thawed layer, one observes their direct dependence on the precipitation amount and part that enters the water stream. Seasonal variations in the DOM qualitative composition are determined. The basic DOM part exported from the watershed is observed during the regimes of a maximum water content (spring flooding and floods).

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INTRODUCTION

Presently, river waters are practically a sole source of water supplies to the area of continuous permafrost in central Siberia. A complex character and diversity of natural factors that determine the hydrochemical composition of the river waters in the region complicate the problem of their use and demand that their quality, tendencies to changes, and parameters be adequately and in-time assessed.

The basic problems connected with the river water quality (the rivers Nizhnyaya Tunguska and Kochechum) in the settlement of Tura (Evenkiya) are natural pollution with dissolved organic matter (DOM) during a frost-free period and increased salinity from November to May. The inflow of solutions of high DOM concentration to water streams is attributed to a shallow bedding of an impermeable permafrost horizon, when the atmospheric moisture contacts mainly the organogenic soil horizons. The percolation of solutions into mineral layers, where generally DOM is absorbed and undergoes microbiological degradation [15], is limited by the thickness of the seasonally thawed layer. Therefore, the DOM composition in the river runoff is sufficiently dynamic [23] and is characterized both by available organic compounds formed from plant debris destruction (mono- and polysaccharides, amino-acids, proteins, polyphenols, etc.) and by humification processes (humic and fulvic acids) [13, 15].

Analysis of current climatic changes and results of climate modeling in the 21st century at high latitudes of Siberia is indicative of the increase in the air temperature [3], precipitation amount and intensity [4], and river water flow rate [5, 21]. The influence of climatic parameters on the DOM content in the carbon cycle in the terrestrial ecosystems is rather well studied [10, 18, 19]. In particular, the increased rate of degradation of the accumulated organic matter (OM), besides the increased CO_2 emission, stimulates the DOM formation [19], which already now causes its increased concentration in the rivers at high latitudes of Europe and North America [9, 25]. A still higher inflow of DOM can be expected in the Arctic seas of Siberia due to the thawed permafrost and increased possibility of OM, earlier buried in permafrost, to microbiological degradation [20]. According to some estimates, up to 25–33% of the total soil organic carbon is concentrated in the cryogenic soils [12]. The temperature rise is expected to be maximal [1, 3, 24].

At the same time, the mechanisms of the influence of climate warming on the DOM transport from watersheds under permafrost conditions are not sufficiently studied. Presently, at relatively low rates of the soil OM degradation, high hydraulic conductance of organic soil horizons, and low adsorbing capacity of its mineral component, the DOM income to water streams in the cryolithozone is characterized by

Table 1. The distribution of air temperature *T* and precipitation *P* by months for summer during the observational period and the mean for 1936–2000

Year	June		July		August		Mean temperature, °C	Precipitation, mm
	T, °C	*P*, mm	*T*, °C	*P*, mm	*T*, °C	*P*, mm		
2001	13.6	102.3	18.4	90.0	12.9	117.3	15.0	309.6
2002	13.0	72.0	19.3	52.2	13.0	56.5	15.1	180.7
2003	14.9	49.2	16.4	66.5	13.8	59.0	15.0	174.7
2004	14.3	51.0	13.7	59.4	9.7	46.9	12.6	157.3
2005	14.7	43.5	17.6	31.7	11.5	36.3	14.6	111.5
Mean for 1936–2000	12.4	53.7	16.6	61.2	12.5	59.0	13.8	173.8

non-proportionally high values compared with their income in the temperate climate regions [11]. In case of warming, due to the increased depth of the active soil layer, the increased temperature and frost-free period, significant changes can be expected both in quantitative and qualitative DOM composition in the surface water [23]. A key factor modeling the DOM flux characteristics is the depth of a seasonally thawed layer (STL), which determines its prolonged retention in the soil, the high extent of microbiological mineralization, and transformation [13, 15]. In this connection, a number of authors suppose a significant reduction in allochthonous organic matter concentrations in water streams [17] and, consequently, a decreased removal of terrigenous organic carbon to the Arctic seas under conditions of global warming [23].

In this work, an attempt is made to determine quantitative and qualitative characteristics of the DOM removal with water streams in the permafrost zone of central Siberia and to estimate the influence of climate changes on these parameters. To that end, we analyzed interseasonal and interannual variability of the soil temperature, dynamics of melting of the seasonally thawed layer and precipitation amount over the forest watershed with continuous permafrost, and, correspondingly, DOM concentrations and composition in a stream that drains the basin. Thus, the investigations were aimed at determining the influence of the hydrothermal regime of a watershed on seasonal changes in the DOM flux and its composition in the water stream, required for developing measures for water treatment, and interannual variability of the DOM removal from the watershed basin for assessing scenarios for DOM changes during global climate change.

MATERIALS AND METHODS

The investigations were carried out in May–September 1998–2005 in central Evenkiya (64°18′ N, 100°11′ E). In order to assess the income of terrigenous DOM to surface waters a watershed of the stream Kulingdakan (a total area of 4200 ha) was chosen. The watershed is typical of the Syverma plateau with heights above sea level up to 590 m. The climate in the region is sharply continental. According to the data from the weather station of Tura, from long-term data (1936–2000) the mean temperature is 16.5°C in July, –36°C in January, and –9.1°C for the year as a whole. The annual precipitation total is 371 mm (230–548 mm); about half the precipitation falls in the summer months.

The precipitation income onto the watershed was measured in plantations with a differently closed canopy at slopes of the southern (maximum), and northern (minimum) exposures and at the open site, which made it possible to take into account the extent of its retention in the larch crowns. The water penetration into the soil was estimated with lyzimetric columns installed directly under a forest litter. The temperature regime at the same sites was measured with thermosensors (TR-51A, T&C, Co, Matsumoto, Japan) installed at a height of 1.3 m in debris horizons (Oi) and humification (Oa) of litters, and in the soil at depth 10 and 20 cm with a time spacing of 1 hour throughout the year. The thickness of the seasonally thawed layer was measured each week in June, and, later on, once in July and early September (121 cases). Water sampling and water flow rate measurements in the stream were daily performed for 10–15 days in May, June, July, August, and September according to the technique in [8].

The water samples taken were then filtered through a membrane filter (0.45 μm) and before the analysis were kept in the refrigerator at temperature –3°C. The dissolved organic carbon (DOC) concentration was determined with the TOC-VCSH analyzer (“Shimadzu,” Kyoto, Japan). The values of specific ultraviolet absorption (SUVA), which characterized the extent of aromatization of the substance [15, 23], were

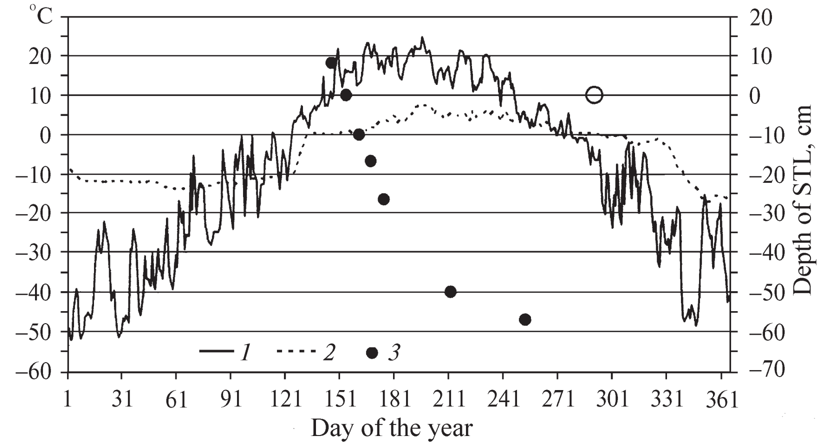

Fig. 1. Dynamics (*1*) of the air temperature and (*2*) humification horizon at the northern exposure slope in 2002. (*3*) Melting of a seasonally thawed layer is shown during June–September. The white point denotes the moment, when the soil surface transforms into a frozen state.

calculated dividing the optical density (A) value at 254 nm, measured with the UVIKON 930 spectrometer ("Bio-Tek Instruments," Highland Park, the USA) by a respective DOC concentration.

The qualitative DOM composition was analyzed on the lyophilized material, polyphenols and lignin according to the technique [13], with alkaline hydrolysis in the presence of CuO and identifying hydrolysis products after derivatization with a gas chromatograph GC-2010 ("Shimadzu"). Pyrolysis and identification of DOM-thermal degradation products were performed in accordance with the technique in [16].

RESULTS AND THEIR CONSIDERATION

Hydrothermal Regime over the Watershed Basin

The mean air temperature in the summer months of 2001–2005 was characterized by somewhat higher values (by 0.6°C) than in 1936–2000 (Table 1). The maximum warming occurred in June and July (> 1°C), while August was somewhat colder (by 0.3°C). The coldest period was the summer of 2004, when the air temperature in July and August was 2.9 and 2.8°C lower than in the previous 65 years.

The temperature above 0°C was generally observed in the first ten days of May (Fig. 1). The frost-free period in 2001–2005 was, on average, about 150 days, varying on the slopes of the northern and southern exposures from 140 to 160 days, respectively. At the same time, monthly mean air temperature and debris horizon (Oi) values did not exhibit any true differences between these sites. However, in the humification horizon and slope soil of the northern exposure, much lower temperature was observed throughout the entire frost-free period (Table 2), which was attributed to large accumulations of a heat-isolating moss-lichen cover and litter under these conditions [8]. It is worth noting that the litter temperature regime determines the rate of microbiological degradation of the plant detritus [18, 24] and, thus, determines the amount of the OM accumulated on the mineral soil surface. As a result, a negative feedback between the soil temperature and organic matter accumulated is observed on the slopes of the northern exposures and in the swamped valleys.

The maximum litter temperature is observed in July (10.6 and 6.5°C on the slopes of the southern and northern exposures), and the maximum soil temperature is in August (Table 2). In accordance with a generally accepted opinion [18], the temperature rise is responsible for the increased concentrations of dissolved organic matter in forest litters [19]. Earlier we demonstrated [8] that under conditions of better heating of the southern slopes, DOM fluxes to the soil are much higher than those on the northern slopes. At the same time, it is here that a positive relationship is observed between the DOM income to the soil and its temperature, while in the case of the southern slopes such a relationship is not found [8]. This fact can be attributed to the inhibited DOM formation under conditions of moisture deficit in dry periods. As a result, the temperature influence on the DOM formation in litters depends, under these conditions, on the amount of accessible moisture, which mainly consists of water from permafrost melting.

Table 2. Litter and soil temperature at the slopes of the southern (numerator) and northern (denominator) exposures over the Kulingdakan stream watershed

Month	Litter horizon		Soil depth	
	Oi	Oa	10 cm	20 cm
May	1.1/–0.6	0.0/–2.4	–0.8/–2.7	–1.4/–3.3
June	8.9/8.6	6.0/2.1	3.3/0.4	1.1/–0.1
July	12.9/12.0	10.6/6.5	8.2/3.9	5.8/2.9
August	10.6/9.3	9.5/5.7	7.9/4.1	6.5/3.4
September	5.7/3.9	5.8/2.9	5.1/2.2	4.8/1.8
October	–1.3/–1.1	–0.2/–0.1	0.3/0.3	0.8/0.2

The differences in heat-insulating cover accumulation on the slopes determine the heat peretration into the soil [1] and, consequently, the rate of melting of a seasonally thawed layer. On both slopes, the temperature of the humification horizon rises sharply in the second ten day period of May (Fig. 1). However, on the northern slope, as is shown in the figure, the horizon Oa remains frozen till mid-June (0°C), which is due both to a thicker (compared with the southern slope) forest litter accumulated (> 15 cm) and to a substantial ice amount it contains (> 20 mm in terms of precipitation). On the southern slope the lower litter moistening (< 10 mm) determines a higher rate of melting (> 1.5 cm/day), and by early June the depth of a seasonally thawed layer reaches 20 cm, and the Oi horizon temperature is 5°C, which suggests significant activation of microbiological processes.

As a whole, throughout June the increase in the thickness of a seasonally thawed layer is maximal (Fig. 1). This period is characterized by the fact that the frozen impermeable layer moves from organogenic horizons to mineral ones. This movement, according to [17], supposes significant changes in sources and in the amount and composition of matter in the water stream that drains the slopes. In July–September, the rate of melting decreases, which agrees with the data given for Yakutiya [6]. The thickness of the seasonally thawed layer is maximal in September. On the southern and northern slopes, it is 60 and 100 cm, respectively. The soil feezing starts in late October. The frozen fronts move from above, from the surface and from below, from permafrost grounds. The soil is completely frozen in December.

It is worth noting that the differences between slopes in the seasonally thawed layer thickness determine the time of retention of precipitation in the soil of these habitats and its inflow to a water stream in the form of lateral discharge from above the permafrost. In this connection, a spatial inhomogeneity of the thickness of the hydrologically active soil horizon and soil properties in the watershed, as well as precipitation amount and its intensity over the surface, have a large effect on the formation of a substance flux to a water stream due to its source changes, for example, from the slopes of different exposures.

The total summer precipitation amount and its distribution by months demonstrate, according to the Tura weather station data, significant interannual variations (Table 1) varying from 112 mm in 2005 (60% of the mean) to 310 mm in 2001 (180%). Vice versa, the year of 2003 can be characterized as the one closest to the mean for 1936–2000, both by the precipitation sum for the entire summer period and by its distribution by months.

During the observational period it was found that only part of precipitation participates in the formation of the DOM flux to the soil, and then to the water stream. Compared with the open area, the tree canopy over both slopes retained about 10% precipitation for the entire season, which is lower than the values given for other regions [2]. It is attributed to the open larch crown canopy in the northern taiga. Compared with other climatic zones, a thicker moss-lichen layer and a forest litter have a large effect on the precipitation retention. In individual years, the direct water inflow to the mineral soil was from 20 (2005) to 70% (2001) of the total precipitation amount for the frost-free period. A significant variability is attributable to precipitation intensity and spatial inhomogeneity of the thickness of the accumulated layer of the forest litter. For example, at precipitation intensity up to 2 mm/day the atmospheric water on northern slopes generally did not reach the soil surface.

The least precipitation penetration into the soil is observed in July. The significant moisture deficit (soil moistening < 30%) was observed on the southern slopes, where the maximum thickness of the seasonally thawed layer and maximum water consumption for evapotranspiration were detected, and vertical water migration (according to lyzimetric studies) in the soil profile was limited by only the upper 10-centimeter layer. Similar regularities were earlier found for central Yakutiya [6]. In this connection, under such

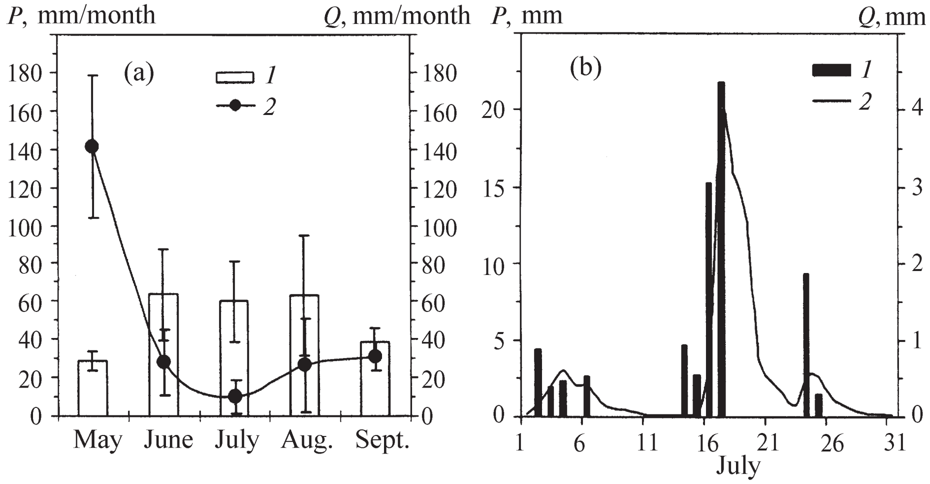

Fig. 2. (a) Distribution (*1*) of precipitation amount *P* by months and (*2*) river Kulingdakan runoff *Q* from May to September in 2001–2005, and (b) dynamics of the water flow rate and precipitation fall in July 2003.

forest-vegetation conditions, the matter was not removed hydrologically outside the soil profile. On northern slopes, a lateral water discharge from above the permafrost, at shallow bedding of a frozen impermeable horizon, occurred throughout the entire observational period, but the flux increased sharply after the precipitation fall above 10 mm. As a result, the formation of hydrochemical water composition of the stream is mostly determined by soil solutions from northern slopes and other places similar to them in a hydrothermal regime: eastern slopes, swamped stream valleys.

Continuous permafrost determines the flood regime of the water stream recharge and no ground water inflow, which is attributed to its relatively short-term discharge period (May–October). Depending on the year, 40–70% of the river runoff *Q* is part of the spring flooding (in May) (Fig. 2). In June, the discharge decreases sharply, and its ratio to the atmospheric precipitation amount is, on average, 0.44 (Table 3). In the early month, a significant part of the consumed stream water is formed due to melting ice accumulated in litters in the last autumn. Therefore, besides the current year precipitation, the stream water content in that period is also determined by the moisture amount accumulated earlier in the watershed.

The minimum river discharge is characteristic of July. It amounts to 20% of the total precipitation fallen during a wet year (2001) and only 2% in a dry year (2005). At the same time, this period is characterized by most significant fluctuations in the stream flow rate due to shower rains. With a reference to 2003, Figure 2b shows hydrograph peaks just the precipitation fall. As a result, the absolute flow rate values in July vary from several liters to 1.5 m^3/s. In a dry period, the permafrost melting, not than ground waters, recharges the stream, which is indicated by a relatively low specific electrical conductance (SEC $\leq$ 80 μS/cm). During floods, the SEC values drop to 40–25 μS/cm, which is attributed to fluxes poor in electrolytes of solutions that come from organogenic horizons. Precipitation intensity is a key factor of redistribution of part of the surface discharge and intrasoil water sources in the stream.

In August when the air temperature falls, the mean flow rate in the stream increases to 0.5 m^3/s, while the *Q*/*P* ratio reaches 0.42 (ref. Table 3). A similar regularity is observed in colder July 2004. Thus, in spite of the increased thickness of the seasonally thawed layer and soil ability to retain water, the decreased diurnal air temperature affects the water amount that is consumed for evapotranspiration and, consequently, the increase in *Q*. In September, due to a sharp temperature fall and the end of the vegetation period, the water flow rate in the stream increases to 80% of the amount of the precipitation fallen.

COMPOSITION AND DYNAMICS OF ORGANIC MATTER IN THE WATER STREAM

During the entire observational period (May–September 2001–2005) the DOM concentration in the water stream varied from 9 to 32 mg C/l. The maximum concentrations are characteristic of the spring flooding: May–early June (Fig. 3a). Because of a significant stream water flow rate, the DOM removal from the watershed in this period is above 140 mg C/m^3 day (Table 3), which in total is above 40% of its value for the entire frost-free period. The contact of thawed waters in this period only with organogenic soil horizons results in the increased organic matter concentrations in the surface water [17]. Because of low

Table 3. Averaged hydrological parameter values, dissolved organic matter concentrations, and removal in the Kulingdakan stream for May–September 2001–2005

Variables	May	June	July	August	September
Precipitation P, mm	28.4 ± 5.0	63.6 ± 24.2	60.0 ± 21.2	63.2 ± 31.5	38.6 ± 7.0
Water flow rate Q, mm	141.0 ± 37.4	28.3 ± 17.2	10.2 ± 8.5	26.5 ± 24.2	31.0 ± 7.6
Q/P	4.97	0.44	0.17	0.42	0.80
DOM concentration, mg C/l	29.5 ± 2.4	19.6 ± 2.7	15.3 ± 4.0	15.7 ± 1.3	17.4 ± 3.5
DOM export, mg C/m^2 day	136.5 ± 24.7	58.6 ± 18.9	6.5 ± 4.1	17.0 ± 6.6	55.7 ± 26.2

microbiological activity, a substantial amount of the removed DOM depends on its accumulation for the autumn-winter period in freezing–melting cycles.

The qualitative DOM composition (Table 4) consists of compounds of vegetation origin (polysaccharides (> 40%), lignin and other polyphenol compounds (about 26%)), products of microbiological synthesis (carbohydrates and uronic acids (<1%) and humification (6%). Above 20% is presented by aromatic hydrocarbons formed due to DOM pyrolysis and about 5%, by nitrogen-bearing compounds.

As a whole, the DOM in the spring period is characterized by substantial aromatization (SUVA ≥ ≥ 3.5 l/(mg C) m, Fig. 4), which is indicative of a weak microbiological transformation of organic matter of vegetation origin that enters the water stream [15]. The water content of the hydrolysis products of the dissolved lignin (with prevailed coniferous lignin) amounts to about 0.6 mg/l (Table 4), which, along with absolute domination of a hydrophobic fraction, supposes a sufficient DOM resistance to biodegradation [22].

Thus, water pollution with organic matter during spring flooding is connected with its accumulation in watershed soils in the autumn–winter period and it can decrease only in the case of a significant reduction in the reserves of organic detritus in their areas. Such changes, as is expected, can be stimulated by the air temperature rise and, consequently, an increased rate of OM mineralization [25], but they are impossible in a short-term perspective. At the same time, according to the analysis of climate changes for the last 40 years (1965–2005), the earlier terms of the flooding and water content increase in of water streams (due to the increased amount of winter precipitation (0.55 mm/year)) are quite possible. However, the increased amount of the thawed water from watersheds can lead to decreased DOM concentrations, since the pool of the potentially usable matter formed in the autumn-winter period is exhaustible because of the absence of microbiological activity. It is proved by indirectly relatively stable DOM concentrations in the water stream (29.5 ± 2.4 mg C/l) in May.

In summer, monthly mean DOM concentrations in the water stream decrease with the increased thickness of the seasonally thawed layer and with increased time of solution retention in the watershed soils (Fig. 3a). The result obtained is connected both with the increased sorbing soil capacity and with increased microbiological DOM mineralization in these soils [13]. However, the precipitation significantly influences the concentration level in the water streams in this period. Low water permeability of mineral soil horizons that are characterized by a high content of a clay fraction (> 40%) and a shallow bedding of a water-resistant permafrost horizon determine the surface runoff and its enrichment in DOM. Consequently, the surface runoff increases with the increased precipitation amount, which leads to an increase in DOM concentrations in the water stream (Fig. 3b). As a whole, a positive relationship between a stream water flow rate and DOM concentration in the water stream is observed. However, this relationship has some interannual features (Fig. 3c) related with a specific character of hydroclimatic conditions of the year: precipitation amount and temperature.

In dry periods characteristic of July (minimum in 1998, 10 mm/month), the monthly mean DOM concentrations decrease to 9 mg C/l, which is indicative of the prevailing intrasoil water sources due to permafrost melting. The increase up to 23 mg C/l, as was found in 2001, is connected with the increased part of solutions of forest litters in the water stream. It is confirmed by changes in the qualitative DOM composition with the increase in the stream flow rate: increased aromatization (from 2.0 to 2.5 l/(mg C) m, Fig. 4) and increased lignin concentration (from 0.21 to 0.46 mg/l). The amount of polysaccharides of vegetation origin is more than doubled (from 6 to 13 mg/l), but their relative content changes little (from 40 to 46%). The content of humus compounds does not change, being about 1.5 mg/l, but in relative units it diminishes by a factor of 2 (from 10 to 5%).

It is worth noting that up to 70% of the total DOM is removed from the watershed in summer with short-term floods. For example, whereas the terrigenous DOM removal during a low water is less than

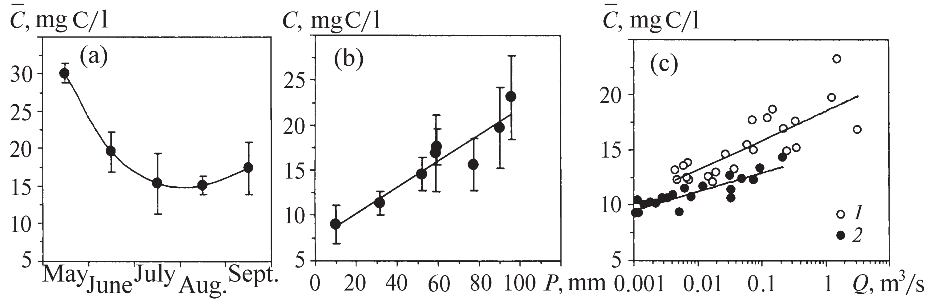

Fig. 3. (a) Changes in mean C concentrations of dissolved organic carbon (DOC) in the Kulingdakan stream from May to September in 2001–2005 and (b) relationships between monthly mean MOC concentration in the stream and precipitation amount for July 1998–2005 ($R^2 = 0.879$) and (c) stream water flow rate in July 2003 (*1*) and 2005 (*2*).

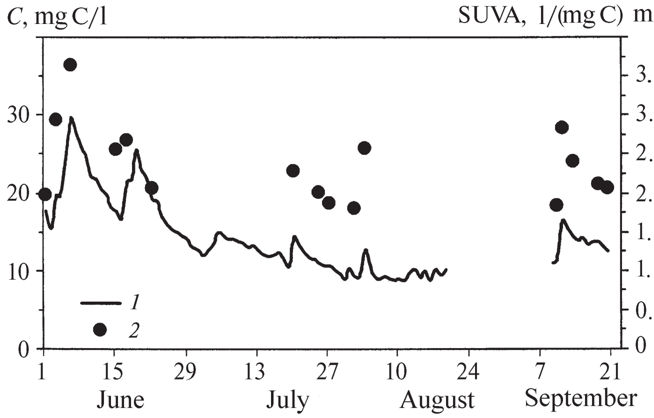

Fig. 4. (*1*) Dynamics of dissolved organic matter concentration and (*2*) specific UV absorption (SUVA) in 2005.

0.1 mg C/m^2 day, in the case of the flood it can reach more than 100 mg C/m^2 day. The DOM removal values, averaged over July in 2001–2005, were 0.20 ± 0.12 g C/m^2 day. In August, in spite of DOM concentrations close to those of July, the increased water consumption in the stream due to the decreased evapotranspiration determined its increased removal from the watershed up to 0.5 g C/m^2 month (0.15–0.88 g C/m^2 month).

The results obtained confirm the hypothesis about the decrease in DOM concentrations in the water streams during the permafrost degradation due to anthropogenic climate warming [15, 17, 23]. At the same time, the precipitation amount substantially modulates the DOM concentration and its composition, as well as its total income to water streams, reducing the negative effect of the increased seasonally thawed layer. Therefore, the predicted growth of the precipitation amount [3, 4] can potentially stimulate the increase of the DOM removal to the surface water at high latitudes. At the same time, the analysis of meteorological data for 1936–2005 in the region of study showed a decrease in precipitation in July (–0.3 mm/year) and its increase in August (0.2 mm/year). This effect is indicative of the precipitation redistribution within the season, and, as a result, some reduction in the surface water pollution with dissolved organic mater in July and its increase in August can be expected.

The early autumn period (September) is characterized by the increased income of DOM to the water stream (ref. Table 2), which is determined by the increased part of the surface discharge due to the soil excess moisture, when the vegetation transits to a dormant state, at temperature fall, and, consequently, at decrease evapotranspiration. Furthermore, a certain role belongs to the increased DOM concentrations in forest litters in this period for the soil micro-flora activity [7]. In this connection, the total DOM removal from the watershed basin for a month was about 1.7 g C/m^2, which was three times larger than its removal in August. Changes in the qualitative DOM composition include a total increase of aromatization (Fig. 4), which in particular is connected with higher lignin concentrations (0.33 mg/l). The composition of the latter also undergoes changes. Part of vanillyl derivatives increases, and the extent of their oxidative

Table 4. Seasonal changes in the qualitative DOM composition in water streams in accordance with the analysis for lignin content and DOM pyrolysis

Season	Lignin			Groups of DOM pyrolysis products				
	total, mg/l	V_{ac}/V_{al}	V, %	PS	PhS	AHC	HS	NS
Spring flood (May)	0.552	1.01	67.7	14.2/42.0	8.7/25.6	7.1/21.1	2.1/6.3	1.7/5.0
Early summer (June)	0.363	1.13	64.5	13.5/42.5	8.4/26.3	6.4/20.0	1.8/5.8	1.7/5.4
Summer low water (July)	0.210	0.95	62.9	6.3/40.5	4.4/29.2	2.2/15.1	1.6/10.6	0.7/4.5
Summer flood (July)	0.459	1.46	49.0	13.7/45.7	7.8/26.2	5.7/18.9	1.5/5.0	1.3/4.2
Autumn flood (September)	0.329	0.93	61.1	–	–	–	–	–

Note: V_{ac}/V_{al} is the vanillyl/aldehyde acidic derivative ratio; V is part of vanillyl derivatives in lignin; PS = polysaccharides; PhS = phenol substances; AHC = aromatic hydrocarbons; HS = humus substances; NS = nitrogen-bearing substances; for these groups of DOM pyrolysis products in numerator, mg/l; in denominator, %.

transformation (aldehydic forms prevail over acidic ones) decreases. This fact confirms the increased part of solutions from organogenic soil horizons, where a less extent of microbiological transformation (compared with the mineral soil) is characteristic of the organic matter [10, 12, 15]. For the entire frost-free period, an averaged DOM removal from the basin watershed amounts to about 6 g C/m^2, varying from 3.0 g C/m^2 in a dry year (2005) to 10.3 g C/m^2 in a wet year (2001), which amounts to 2–7% of net ecosystem production [14] and below 0.1% of total reserves of organic carbon in forest ecosystems over the watershed.

CONCLUSION

1. Analysis of properties of DOM sampled from the water stream in the spring, summer, and fall periods showed a rather high degree of aromatization and hydrophobicity of its components, which makes it possible to use a wide spectrum of sorbents for its removal. Biological treatment systems seem now ineffective because of a poor quality of organic matter for microbiocenosis activity. The most problematic periods from the viewpoint of water quality are spring and fall, which are characterized by maximum DOM concentrations. In summer, the main problem is the low water content of water stream.

2. In spite of the increased DOM formation in organogenic soil horizons at the air temperature rise, the influence of this factor is much limited by moistening conditions. The most significant effect of warming in the high latitudes of Siberia is the soil thawing, which determines both the amount of allochthonous organic matter entering the river system and its physicochemical properties.

3. Under conditions of temperature rise, in the case of a “dry” scenario for warming (without changes or when the summer precipitation amount decreases), it can be expected that DOM removal to the hydrographic network will decrease with the increase in the seasonally thawed layer. The qualitative DOM composition will change: the income of more transformed in microbiological processes OM that can be utilized in water ecosystems will increase.

4. In the case of a “wet” scenario for climate warming (increased precipitation amount), one will observe increased DOM concentration and its removal in water streams with prevailing degradation-resistant aromatic compounds of vegetation origin. Moreover, the temperature rise connected with the increased precipitation amount will affect the increased DOM formation and its flux in places with a significant accumulation of organic matter (for example, northern slopes and swamped valleys).

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