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Editors

Biogenic—Abiogenic Interactions in Natural and Anthropogenic Systems

Springer

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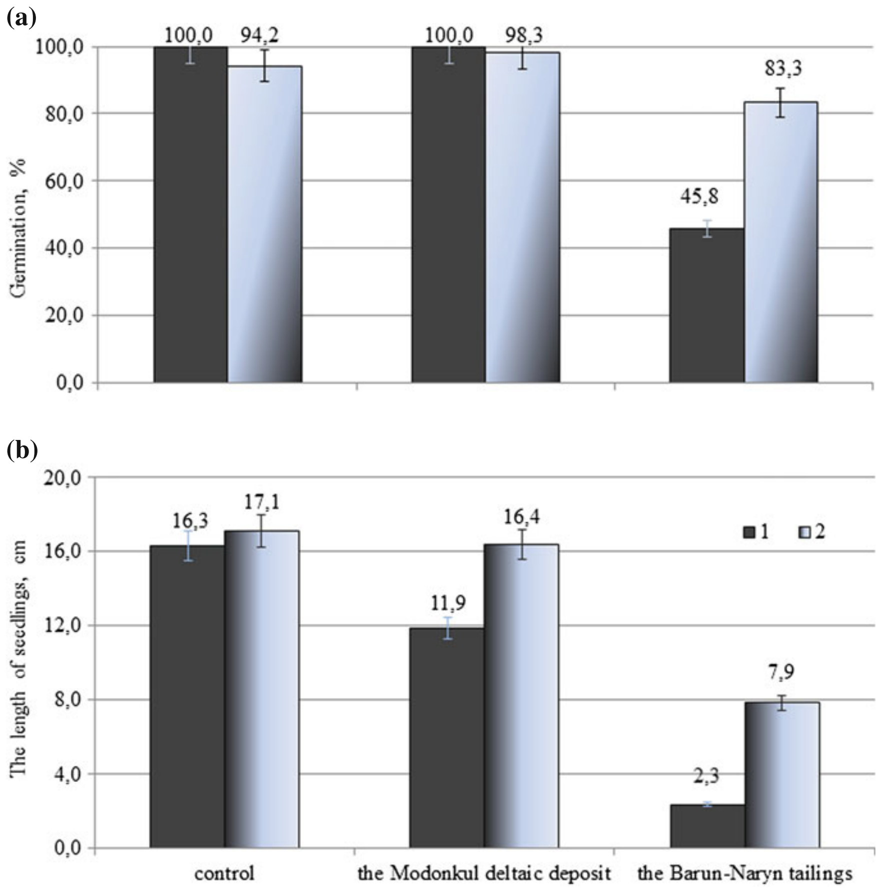

Fig. 3 The influence of technogenic sands (*1*) and water extracts from technogenic sands (*2*) on the seed germination (**a**) and the length of sprouts (**b**) of oats

Due to the fact that the wastes of tailings dam with high degree of contamination by toxic elements were used in the experiment, plants of oats were analyzed in the presence of these toxic elements in the aboveground and underground parts (Table 5). Overall, during germination of oats on technogenic sands and their water extracts, the Zn, Cr, Ni, Co, and W concentrations in plants of oats exceed their worldwide average values. The contents of Zn, As, Cu, Cr, and Ni increase up to 5 times in aboveground and underground parts of oats compared to those in the control variant. Pb (in aboveground and underground parts 10 and 18 times higher than in the control, respectively), Mo (in the underground part 24 times higher than the control), and W (in aboveground and underground parts 57 and 95 times higher than in the control, respectively) were accumulated as much as possible during germination on technogenic sands of the Modonkul deltoid deposit. High accumulation of toxic elements was not observed during germination on water extract of

Table 3 Phytotoxicity of tailings dam of Dzhidinsky Tungsten–Molybdenum combine

Test function	Objects			
	The Modonkul deltoid deposit		The Barun-Naryn tailings	
	The technogenic sands	The water extracts from technogenic sands	The technogenic sands	The water extracts from technogenic sands
Germinating energy, B, %	100	98.3	35	83.3
Phytotoxic effect, PhE, %	27.4	4.05	96.1	49.7
Toxicity index, ITF	1.00	0.98	0.35	0.83
The toxicity class on ITF	V (norm)	V (norm)	II (high)	IV (low)

Table 4 The damaging effect of technogenic sands (first experiment) and water extracts from technogenic sands (second experiment) on the oats test-culture

Experiment	The Modonkul deltoid deposit		The Barun-Naryn tailings	
1	−	No damaging effect	++	Average damaging effect
2	−	No damaging effect	++	Average damaging effect

technogenic sands of the Modonkul deltoid deposit. Co and Pb were accumulated in the aerial parts of oats maximally (33 and 42 times higher than in the control, respectively) during germination on technogenic sands tailings Barun-Naryn. Maximum accumulation is characteristic only for Co (in aboveground and underground parts 29 and 53 times higher than in the control, respectively) during germination on water extraction of technogenic sands of the Barun-Naryn tailings. The index of total pollution of toxic elements is in the range from 11 (in the plant oats) to 85 (aboveground part) and 147 (underground part), which according to Kasatikov (1992) corresponds to the strong contamination in comparison with control.

Thus, the content of toxic chemical elements is extremely dangerous in the technogenic sands of waste sulfide-tungsten ores of the Barun-Naryn tailings and the Modonkul deltiod deposit. Although these technogenic sands belong to the extremely dangerous category of pollution with total pollution 425–500, the phytotoxicity with respect to oats are different: the technogenic sands of the Barun-Naryn tailings refer to II (high) toxicity class; the technogenic sands of the Modonkul deltaic deposit–V (normal) toxicity class. The water extract of technogenic sands of the Barun-Naryn tailings has lower phytotoxic effect than the technogenic sands and has IV (low) toxicity class. During germination on the technogenic sands of the Modonkul deltoid deposit of the maximum accumulated Pb, Mo, and W; on the technogenic sands tailings Barun-Naryn—Co and Pb. The plants oats are heavily

Table 5 The amount of chemical elements of I–III hazard classes in the aboveground (numerator) and underground (denominator) parts of oats (air-dry weight), ppm

Experiment	Variant	Zn	Pb	As	Cu	Co	Cr	Mo	Ni	W	Zc
1	Control	35.16/38.20	0.12/1.78	0.89/1.06	6.61/13.13	0.05/0.46	**1.17**/2.36	0.58/0.8	2.68/2.61	0.04/0.49	
	The Modonkul deltoid deposit	**49.69**/200.8	1.19/31.13	0.98/0.69	8.32/51.72	0.08/0.76	**1.46**/11.05	1.36/18.87	**2.97**/5.36	**2.29**/46.56	69.3/146.7
	The Barun-Naryn tailings	**97.69**/–	5.03/–	1.33/–	15.39/–	**1.66**/–	**1.93**/–	0.77/–	**6.81**/–	**0.22**/–	84.7/–
2	Control	31.04/39.52	0.17/3.06	0.85/0.79	8.08/15.75	0.02/0.08	**0.90**/1.18	1.20/0.97	2.73/2.35	0.03/0.31	
	The Modonkul deltoid deposit	45.0/86.7	0.43/4.11	0.88/1.29	8.38/15.75	0.09/1.18	**1.02**/1.46	1.12/1.01	**4.46**/5.73	**0.16**/1.51	11.6/11.1
	The Barun-Naryn tailings	**69.63**/153.35	0.65/4.53	0.93/0.48	10.0/31.71	**0.58**/4.25	**3.29**/2.5	0.63/0.50	**4.76**/5.89	0.08/0.55	38.4/60.9
The volatility of average amount in the worldwide plants (Kabata-Pendias 2011)		12–47	0.36–8.0	0.009–1.5	1.1–33.1	0.03–0.57	0.02–0.2	0.33–2.3	0.13–2.7	0.01–0.15	

Note The dash—no data, bold—the excess of average amount in the worldwide plants polluted with toxic elements in comparison with control. The obtained data indicate that along with the determination of chemical pollution at estimation of their impact on the ecosystems (in particular the waste ores tailings) it is necessary to study the phytotoxicity of techogenic objects.

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Distribution of Organic Compounds in the System of Geochemically Linked Mires (the Spurs of Vasuygan Mire)

Lidia I. Inisheva, Alla V. Golovchenko and Lech W. Szajdak

Abstract Specific natural and geochemical conditions formed on Vasuygan Mire include a wide variety of vegetation, types of peat deposits, and peats composing them. The study of the Vasyugan Mire's biospheric functions and elaboration of the scientific bases of regional monitoring are important. Therefore, we investigated mire regimes under field conditions. The examined plot, which includes the biogeocenoses connected geochemically with the landscapes, is the model system for the Vasuygan Mire. According to our data, the age of this plot dates back to 2500–4800 years. Our work revealed peculiarities of biochemical processes that exert influence on the formation of hydrochemical runoff from the paludified territory in the peat deposits of the landscape profile. The chemical composition of mire water and the subsequently migrating stream are formed due to the mixture of atmospheric precipitation with swampy waters. The composition of swampy water is defined by the arrival of movable compounds from the peat deposit, which underwent a regular biochemical transformation. The total runoff of chemical elements during the course of the runoff were as follows: Ca^{2+}—1398, Fe_{total}—311, SO_4^{2-}—391, NO_3^-—236, NO_2^-—1, Pb—2.253×10^{-3}, Mn—317.29×10^{-3}, Zn—41.191×10^{-3}, Ni—8.151×10^{-3}, and Ti—29.651×10^{-3} kg/km^2. The annual runoff losses of dissolved organic matter were equal to 6945 kg/km^2. Our study of the concrete water objects and physical, chemical, and biological processes of the transformation of substance and energy flows on the catchment areas provide insight into the chemical constituents of georunoff.

Keywords Vasuygan mire · Landscape · Peat formation · Oligotrophic stage · Organic matter · Micromycete · Biomass · Migration · Mire water

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1 Introduction

The Vasyugan mire is the largest mire in the world, with an area of about 5,269,437 ha. It captured the Ob—Irtysh watershed and stretches out between 55° 40′–58° 60′N and 75° 30′–83° 30′E (Fig. 1). Its natural and geochemical conditions formed a wide variety of vegetation, types of peat deposits, and peats composing them.

This mire is not only the biggest one, but it is also the most unique in the mire territory of Western Siberia; by concentration of mires, their arrangement, and the intensity of paludification, this area has no analogs on the globe. Vasyugan Mire occupies the highest part of Western-Siberian lowland (Vasyugan Plateau) and is located in two natural and geochemical subbelts: southern taiga and forest-steppe. More than 200 rivers flow down from Vasyugan Mire. The central part of the raised moor is above the mire’s borders by 7.5–10 m.

Specific natural and geochemical conditions formed a wide variety of vegetation here, as well as types of peat deposits and the peats composing them. Vasyugan Mire is a unique place with a wide spread of transitional mires. The important factor here is the formation of the overmoistened Hypnum-sedge fen on the very top of the Vasyugan Ridge at the highest point for the West Siberian flat plain—146 m above sea level.

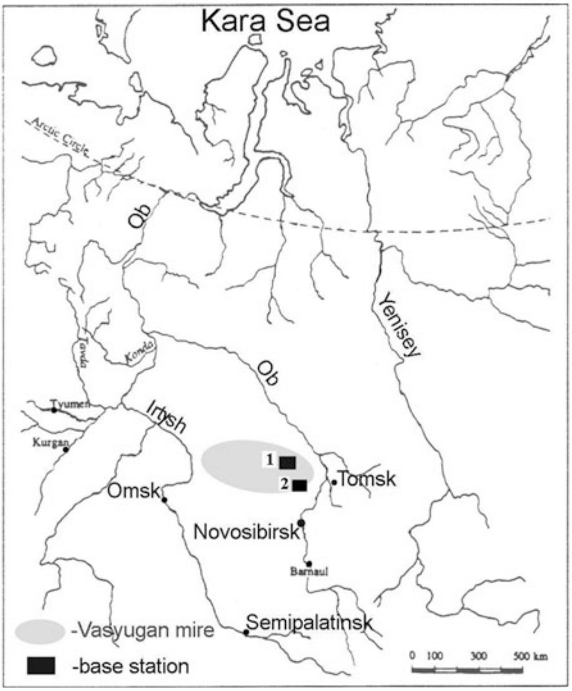

Fig. 1 Schematic map of Vasyugan Mire: *1*—field research station of Polynyanka, *2*—field research station in sources of rivers Shegarka and Iksa

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The study of its biospheric functions of the Vasyugan Mire and elaboration of the scientific bases of regional monitoring are important. Therefore, we investigated mire regimes under field conditions.

2 Materials and Methods

A special testing area was selected to carry out the regime observations, with several investigation objects on the plot of the northeastern part of Vasyugan Mire. Among these objects, the landscape profile (catena) was chosen as a model object in the basin of the River of Klyuch. The originality of the profile is in the accessibility to carry out the research on a small territory of the basin of a swampy river within the limits of 1 km, where there are practically all possible varieties of geomorphologic elements and biogeocenoses. This allowed us to carry out the studies of turnover by a balance method under Siberian conditions. The total area of swamp here reaches 50,000 ha.

The plot under study, which includes the biogeocenoses connected geochemically with the landscapes, is the model system for the Bakchar mire district (Liss et al. 2001). According to our data, the age of the mire dates back 2500–4800 years.

Point 2 (pine-undershrub-sphagnum biocenoses, high ryam; Fig. 2) is a border of the peaty mire. The peat deposit of tall ryam is 90 cm thick; its structure is forest-marshy. It is formed by five kinds of peats. Only two of them—fen sedge and pine-cotton grassy—are 20 cm thick (each of them accounts for as much as 29 % of

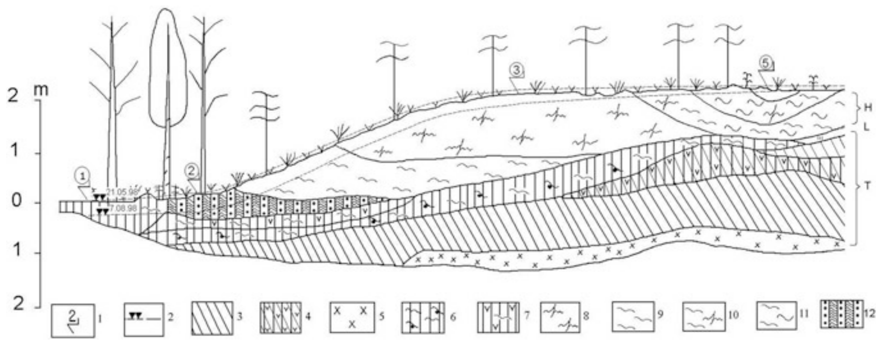

Fig. 2 Points of description of phytocenoses on landscapes of the River Klyuch basin. Criteria for the placement of observation points within landscapes of the basin of the River of Klyuch: *1*—observation points; *2*—mire water table. Kind of peat: *3*—fen sedge, *4*—fen wood-sedge, *5*—fen horsetail, *6*—transitional wood-sphagnum, *7*—transitional wood-grass, *8*—fuscum peat, *9*—magellanicum peat, *10*—raised complex, *11*—peat of mire depressions, *12*—raised pine-cottongrass. Observation points on mire phytocenoses: *1*—birch-pine-green moss paludal forest; *2*—high ryam; *3*—low ryam; *5*—sedge-sphagnum swamp. Types of deposits: *H*—raised; *L*—transitional; *T*—fen

the structure of the peat deposit). The remaining peats reach up to 10 cm in thickness (each of them amounts to 14 % of the deposit).

At point 2, the layer of fen sedge peat with a high degree of decomposition (65 %) is located in its foundation. Later, the mesotrophic stage becomes apparent in the development of the mire. At this stage, the plat groupings formed the layer of well-decomposed transitional peat of three kinds: wood-sphagnum, cotton grassy, and wood-herbaceous. The mesotrophic stage of development of the mire vegetation is changed by the oligotrophic stage, during which raised peat of two kinds was formed: pine-cotton grassy and peat-magellanicum. The raised peat is notable for the medium and low degree of decomposition. The mean degree of decomposition of the peat deposits amounts to 39 %. Therefore, the stratigraphic features of the peat deposit define the development of the border of the peat tract where plant associations of forest-marshy type were predominant for a long period.

Point 3 (spine-undershrub-sphagnum phytocenosis, low ryam) is spread along the profile (850 m) and is a typical ryam (Fig. 2). The structure of the peat deposit defines the most widely spread facies of the studied peat tract—i.e., ryam (see Fig. 2). The largest revealed thickness of the peat is equal to 3 m in this point; the deposit is of a mixed marshy type. The raised peat is represented by two kinds—fuscum of a weak degree of decomposition (40 % of participation) and magellanicum of a medium degree of decomposition (10 % of participation). These kinds of peat form a thicker layer of raised peat (1.5 m) as compared with the other points.

The layer of the fen peat is situated in the foundation of the peat deposit; its thickness is equal to 30 cm (10 % of the total) and a degree of decomposition accounts for 50 %. The thicker layer of the fen sedge peat (40–50 % of the total) is located above it. At the turn of two layers—raised and fen peats—the peat layer of the transitional type can be found, which was formed by mesotrophic plant communities that formerly existed here, such as wood-sedge and wood-sphagnum. The availability of most herbaceous remains among the fossil plants in the peat is the evidence of the decrease in moisture and climate warming at the mesotrophic stage of the mire development.

Point 5 is a peripheral part of the open sedge-sphagnum marsh. The layer of the raised peat defines the oligotrophic stage of the mire development, which is revealed in the successive change of peat kinds: hollow, raised complex, and fuscum ones (Fig. 2). The replacement of plant groupings occurred very quickly for transfer of the mire from the stage of ground feeding to that of atmospheric feeding; furthermore, the transfer did not reflect on the peat deposit. Therefore, transitional peat is not found here. The hollow forms the underlying layers from a depth of 120 cm, mostly by sedge peats (34.6 %). The average degree of hollow peat decomposition accounts for 35 %, with fluctuations of 25–40 % in different layers.

Therefore, the history of evolution of the mire tract in the basin of the River of Klyuch is clearly pronounced by the stratigraphy of the peat deposit, beginning with the predominance of the eutrophic herbaceous phytocenosis, such as horsetail and then sedge. The essential predominance of the eutrophic and mesotrophic stages is worth noting. The transfer to the oligotrophic stage is accompanied by the formation of pine-undershrub-sphagnum communities. Nowadays, the biggest part of the peat deposit of oligotrophic landscapes of the basin of the River of Klyuch changed to the oligotrophic stage of evolution; the thickness of the raised peat reaches 120 cm.

The botanical composition and the degree of decay were determined in the samples (State Standard 28245-89). The group composition of peat was researched by Instrof's method. Humic acid (HA) separation was made on the following scheme: from air-dried samples, water-soluble components and lipids were removed one after another by extraction of chlorophorm (1:3). Humic matters were extracted by decimolar solution of natrium hydroxide. The total micromycete number and biomass were determined directly through luminescence microscopy. The cells were preliminarily desorbed by means of ultrasonic dispersant. White calcofuor was used to stain the fungal mycelium and spores (Zvyaginzev 1991). Eukaryote microbe biomass was counted, taking into account the measured diameter of fungal spores and mycelium by formula ($0.836r^3 \times 10^{-12}$ g for spores and $0.628r^2 \times 10^{-6}$ g for mycelium) (Polyanskaya 1996). The number and taxonomic composition of soil micromycete were studied by the inoculation of acidified agar-containing Czapek's medium (Dudka 1982). The identification of species was performed by generally accepted determinants (Domsch and Gams 1993; Ellis 1971; Pitt 1979). The number and composition of yeast fungi were studied by the inoculation of must-agar medium acidified by lactic acid. The isolates were obtained at room temperature and identified by standard methods (Babieva and Golubev 1979) with the help of a determinant (Kurtzman et al. 1998).

The mire water was sampled in every well of swampy phytocenosis (points 2, 3, 5), as well as in the River of Klyuch and River of Bakchar before the Kyuch falls into it. The macrocomponents were analyzed by generally accepted methods (Lurie 1973). HA and FA were examined by the method described in Bazin et al. (1992). The determination of heavy metal concentrations was performed by the certified method of quantitative atomic emission analysis with the preparation of ash residue, according to the State Standard 27784-88.

3 Results

The general technical characteristics of the peats are given in Table 1. The upper layer of the peat deposit (point 3) consists of mossy peats; below this, the peat deposit is represented by fen herbaceous species. In the peat deposit of point 2, the transitional wood-herbaceous peats are most common. The individual plant associations, such as sphagnum mosses (fuscum, magellanicum), cotton grass, and sedges, are mainly developed. These define the degree of decomposition, which increases with the depth of deposition in transition from mossy peats to arborescent peats from 5 to 65 %.

Ash content in raised slightly transformed peats is low and amounts to 2, 1–5, 2 %. Transitional and fen peats are notable for the normal ash content, which

Table 1 Botanical composition of peats

BGS, research points	Depth (cm)	Peat kind, deposit type	Botanical composition (%)	R/A (%)
High ryam, p. 2	0–25	Pine-cotton grass-sphagnum, Rt	Pinus-35; Sph. Magellanicum-20; Sph. Angustifolium-10; Eriophorum-25; Undershrubs-10	35/5.8
	25–50	Wood-cotton grass, T	Pinus, Betula-30; Undershrubs-10; Sph. Magellanicum-5; C. Lasiocarpa-rare; C. Rostrata-10; Eriophorum-45	55/4.7
	50–80	Wood-cotton grass, T	Pinus, Betula-25; Undershrubs Sph. Magellanicum-5; Sph. Flexiosum-5; C. Rostrata-10; C. Lasiocarpa-5; C. Globularis-5; Eriophorum-40; Equisetum—rare.	55/6.8
Low ryam, p. 3	0–100	Fuscum peat	Undershrubs-solitary; Sph. Fuscum-90; Sph. Magellanicum-10; Sph. Angustifolium-rare,	5/1.5
	100–150	Medium peat	Undershrubs-5; Sph. Fuscum-25; Sph. Magellanicum-40; Sph. Angustifolium-25	10/3.1
	150–200	Pine-cotton grass-sphagnum, Rt	Pinus-25; Undershrubs-10; Sph. Magellanicum-15; Sph. Angustifolium-10; Sph. Fuscum-10; Eriophorum-30	50/4.6
	200–250	Sedge, F	Wood-solitary; Eriophorum-10; C. Rostrata-10; C. Lasiocarpa-35; Menyanthes trifoliate-10; Fern-5; Equisetum-units, Sph. Centrale-10; C. Limosa-solitary;	45/4.0
	250–300	Herbaceous, F	Wood-5; C. Rostrata-5; C. Lasiocarpa-20; Fern-35; Menyanthes trifoliate-5; Drepanocladus sendtneri-10; Meesia triquetra-rare; Sph. Centrale-10; Sph. Riparium-5; Carex sp.-5	40/6.2

(continued)

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Table 1 (continued)

BGS, research points	Depth (cm)	Peat kind, deposit type	Botanical composition (%)	R/A (%)
Sedge-sphagnum marsh, p. 5	0–50	Fuscum peat	Sph. Balticum-10; Sph. Jensenii-rare; Sph. Flexuosum-60; Sph. Fallax-10; Sph. Magellanicum-10; Eriophorum-5	0/2.3
	50–100	Complex, Rt	Sph. Majus-10; Sph. Jensenii-15; Sph. Obtusum-35; Sph. Papillosum-10; Sph. Flexuosum-10; C. Rostrata-5; C. limosa-solitary; Eriophorum-5; Equisetum-5	15/3.1
	100–150	Sedge-sphagnum, T	C. Rostrata-20; C. Lasiocarpa-10; Scheuchzeria palustris-5; Menyanthes trifoliate-5; Equisetum-10; Sph. Majus-solitary; Sph. Jensenii-5; Sph. Obtusum-20; Sph. Magellanicum-5; Undershrubs, Pinus, Betula-15	35/5.5
	150–200	Sedge, F	C. Rostrata-25; C. Lasiocarpa-15; Carex sp.-10; Wood-5; Menyanthes trifoliate-10; Equisetum, Fern-10; Sph. Fallax-5; Sph. Obtusum-10; Sph. Papillosum-5	50/5.8
	200–250	Herbaceous, F	Equisetum-5; Fern-35; C. Rostrata-10; C. Lasiocarpa-15; Carex sp.-solitary; Sph. Fallax-5; Menyanthes trifoliate-20; Sph. Obtusum-5	50/9.2
	250–300	Fern, F	Wood-10; Fern-60; Horsetail-5; Bogbean-10; Carex rostrata-5; C. asparatilis-5; Carex sp.-solitary; Sph. dusenii-solitary; Sph. apiculatum-5	40/6.8

Note: *Rt* raised type; *T* transitional type; *F* fen type; *R* degree of decomposition, %; *A* ash content, %; *BGS* biogeosystem reaches 10 and 9 %, respectively. Mineralization is greatly increased in the underlying grounds only.

The chemical composition of organic matter (OM) of the peats, which forms the peat deposit of the landscape profile, is also considered. The botanical characteristics of the peat exert an essential influence upon its composition. For example, the appearance of cotton grass defined the increase in bitumen content. If we comparatively analyze the composition of OM of the surface (oxidative conditions) and lower (reductive conditions) horizons, the essential differences can be noted in the content of HAs, lightly and sparingly hydrolysable substances (LH and SH). The process of humification is more clearly pronounced in the lower horizons. Therefore, the increase in LH and SH content is noted in the layer of 50–100 cm in point 3 (transit part of the profile) and point 2 (transaccumulative part) (Table 2).

At the same time, the high content of LH is observed in the water-unloading zone (point 2, geochemical barrier of the profile). The redistribution of water-soluble compounds can be seen in the horizon with the oxidative conditions; this fact is observed in most content of the transaccumulative part of the landscape throughout the whole landscape profile. This phenomenon also confirms the availability of the migration process of the substances.

Research on biogeochemistry of the peaty mires showed that the peat deposit contained considerable amounts of elements acting as a global sorbent (Table 3). If we compare the degree of element accumulation in the peat deposits of the landscape profile with the average background values that we obtained earlier for the oligotrophic peats (Inisheva and Tsybukova 1999), we can see the following: the contents of S, Br, and Sr are comparable to the content of the West-Siberian peats of the raised type. As for the content of Co, Zn, Sc, Cr, Sr, Hg, and La, a small excess is noted in comparison with the average background values. As a matter of fact, Ca and Fe are found considerably more in the studied peats. Their background values are 0.28 and 0.2 %, respectively, and the highest concentration is observed in the transaccumulative part of the landscape.

It is very interesting to examine the structure and stocks of microbe biomass in the peat deposits. This method, in contrast to that of inoculation, reveals the reserve of viable microbe biomass. The natural variability of the amount and concentration of microorganisms has been revealed throughout the entire depth of the peat deposit, but more clearly it is revealed in the active layer. The reserve of microbe biomass in the peat deposits of the landscape profile varies in the layer of 0–100 cm from 0.18 to 1.42 kg/m^2; it is also evidence of high microbiological activity in the peat deposits of the oligotrophic sequence. At the same time, the reserve of microbe biomass in the peat deposit of the sedge-sphagnum marsh is four times higher than in the deposit of the low ryam. The difference is noted in the main components of the microbe biomass in the surface and underlying horizons. The fungal mycelium is prevalent in the surface layer of the deposit (43–83 %), whereas fungal spores and yeast cell prevail down the profile (57–93 %). There are more spores and bacterial cells in the lower part of the peat deposit (9–42 %). Thus, the availability of active biochemical processes can be verified throughout the entire depth of the

Table 2 Total technical and chemical characteristics of peat deposits of biogeocenoses of landscape profile

Position in landscape profile	Layer (cm)	Botanical composition	R (%)	A (%)	Group composition of organic matter, % of mass					
					WS	LH	SH	HA	B	R
Autonomous part (sedge-sphagnum swamp)	0–50	Peat of Sphagnum hollows	5	10.9	0.4	43.0	12.3	31.3	0.6	12.4
	50–100		5	6.0	0.3	33.4	10.5	30.5	0.2	25.1
Transit partryam)	0–50	Fuscum-peat	5	2.7	0.9	30.6	15.2	25.1	2.6	25.6
	50–75		5	2.0	1.2	16.6	16.4	25.2	1.7	38.9
	75–100		5	2.1	0.4	32.6	14.3	19.8	0.6	32.3
Transaccumulative part (raised ryam)	0–25	Pine-Eriophorum-sphagnum raised	45	5.2	1.6	22.4	4.2	27.6	3.9	40.3
	25–50	Wood-Eriophorum transitional	55	6.5	1.6	28.3	8.1	22.7	3.6	35.7
	50–75		60	8.0	1.2	36.6	9.2	23.3	2.6	27.4
	75–100		60	9.8	0.4	32.7	11.0	39.8	0.9	15.2

Note: *R* degree of decomposition; *A* ash content; *WS* water-soluble; *LH* lightly hydrolysable; *SH* sparingly hydrolysable; *HA* humic acids; *B* bitumen; *R* residue

Table 3 Element content in the peat of landscape profile, 10^{-4} %

Biogeocenosis	Layer, cm	Ca[a]	Sc	Cr	Fe[a]	Co	Zn	Br	Sr	Hg	Ba	La	Ce	Sm
Sedge-sphagnum swamp	0–50	0.8	4.7	21.5	1.0	4.3	<6	27.9	<50	<20	<20	6.8	17.8	1.3
	50–100	1.8	1.6	16.5	0.9	3.7	68.5	54.4	279	20.1	97.3	2.3	7.0	0.6
Low ryam	0–50	0.7	1.1	20.9	0.6	2.0	148.0	33.4	84	72.8	58	3.4	7.0	0.6
	50–75	0.9	0.8	15.7	0.5	1.3	124.1	27.6	72	54.9	<30	1.4	3.8	0.3
	75–100	1.7	0.9	18.3	0.5	1.7	130.0	36.4	76	58.0	45	2.1	5.4	0.3
High ryam	0–25	1.4	2.4	18.1	1.1	2.8	41.4	25.2	303	92.8	129	3.4	9.9	0.3
	25–50	1.9	2.4	18.1	1.1	4.0	6.9	40.2	324	31.3	103	3.1	9.2	0.2
	50–75	2.6	3.0	18.3	1.5	6.2	<6	56.5	320	284.7	103	5.5	15.3	1.3
	75–100	2.1	2.0	16.4	1.5	5.5	31.0	55.5	396	<20	96	3.5	6.1	0.8
Background content		0.28	0.56	7.6	0.2	1.1	6.6	39.4	79.4	0.4	46.9	1.5	4.8	0.5

[a]Less than 6 %

peat deposit, but the direction of the processes is different in the surface and lower horizons of the deposit.

The peat deposits of the landscape profile differ in their micromycete concentration and character of the depthwise distribution of the fungal biomass. The total concentration of eukaryote microorganisms is higher in a thin peat deposit of high ryam (point 2) than in the peat deposits of points 3 and 5 (shallow ryam and sedge-sphagnum marsh); the highest concentration is observed in the upper layer of 50 cm thick. The distribution of these microorganisms is even within the limits of the profile in the peat deposits of points 3 and 5. The stock of the eukaryote biomass ranges from 200 g to 1.3 kg/m^2 in the deposit of 1 m thickness and from 300 g to 1.2 kg/m^2 in the deposit of 3 m thickness (Table 4). The stock of microscopic fungi is rather high (2–13 tons per ha), but it is insignificant in comparison with their enormous reserve of vegetative mortmass. The portion of carbon of microbial origin (eukaryote microorganisms) is not more than 3 % in the layer of 0–50 cm, 2 % in the 1-m layer and 1 % in the 3-m layer.

The structure of eukaryote microbe biomass (ratio of active compounds of the complex of microscopic fungi [i.e. mycelium] and those of inactive compounds [i.e. spores]) has its specific features in each peat deposit. Thus, fungal spores prevail throughout the whole profile in the peat deposit of the low ryam (point 3). Furthermore, their proportion was higher by 10–30 % than that of mycelium in the upper layers; in the lower layers, the spore prevalence became absolute (100 %). The peat deposit of the sedge-sphagnum marsh (point 5) occupies an intermediate position between the peat deposits of points 2 and 3, according to the morphological structure of the micromycete complex. Fungal mycelium dominates here up to a depth of 1.5–2 m and fungal spores in the deeper layers. It should be noted that fungal spores could not be practically distinguished from yeast cells in the electron microscope. Therefore, it can be supposed that the high number of eukaryote cells is determined more likely by the yeast-like cell rather than the fungal spores. Oligotrophic peat deposits are a favorable ecotope for this group of micromycetes due to the high content of plant residues, low pH value, and capacity of the yeasts

Table 4 Fluctuation in the concentration of microscopic fungi (A), fungal biomass reserve (B), and carbon of fungal biomass of total carbon pool (C) in peat deposits of landscape profile

	Layer, cm	High ryam	Low ryam	Sedge-sphagnum swamp
A (mg per g)	0–50	13–44	2–8	2–26
	50–100	16–56	10–21	5–30
	100–300	–[a]	13–24	11–36
B (kg/m^2)	0–50	0.2–0.9	0.05–0.1	0.05–0.7
	50–100	0.4–1.3	0.2–0.4	0.2–0.9
	100–300	–	0.3–0.5	0.5–1.2
C (%)	0–50	1–2	0.2–1	0.2–3
	50–100	0.5–1	0.4–0.8	0.3–2
	300	–	0.1–0.2	0.3–1

[a]Data are not given for the peatland thickness is equal to 1 m

for oxygenic metabolism. The yeast concentration in the peat deposit ranges from several hundreds to millions of colony-forming units per gram of the peat. The spreading of the yeasts is even in the deposit; their lowest number was noted only in the deepest layers of the peat deposit.

The yeasts are considered as a group, which is ecologically connected with the initial stages of the succession of plant residues. In fact, a negative dependence between the two parameters was discovered—that is, a yeast number and a degree of decomposition of the peat (correlation factor $r = -0.44$ at level of significance of $p < 0.05$). This dependence indicates the existence of the back connection (the lower the degree of decomposition, the higher the density of the yeast groupings).

However, 114 strains were singled out during the work. The collection was represented by 17 species (both banal cosmopolitan and those peculiar to the peat deposits (Golubev et al. 1981; Polyakova et al. 2001) from seven genera and a group of isolates of asporous yeasts of genera of *Candida, Cryptococcus,* and *Rhodotorula;* these are not identified in the composition of the known species (Table 5).

Three species, such as *Cryptococcus albidus* Skinner and "red" epiphyte *Rhodotorula glutinis* Harrison, *Sporobolomyces roseus* Kluyver et van Niel., prevailed in all communities in the study. It should be also noted that the isolation of the species of *Candida paludigena* Golubev et Blagodatskaya is considered to be ecologically connected with the raised mire ecosystems (Golubev et al. 1981).

The revealed peculiarities of the biochemical processes exert influence upon the formation of hydrochemical runoff from the paludified territory in the peat deposits of the landscape profile. It should be taken into account that chemical composition of mire water and subsequently migrating streams are formed due to a mixture of atmospheric precipitation with swampy waters. The composition of swampy water is defined by the arrival of movable compounds from the peat deposit, which underwent a regular biochemical transformation.

Geochemically, the influence of mires on the composition of the river and underground waters has not been practically studied. On the one hand, swampy ecosystems are a geochemical barrier (Glazovskaya 1983); they fix many

Table 5 Occurrence of yeast genera in peat deposits in oligotrophically connected landscapes

Genus	Number of species of the given genus	Occurrence
Basidiomycetes affinity		
Cryptococcus	5	67
Rhodotorula	6	71
Sporobolomyces	1	55
Trichosporon	1	19
Ascomycetes affinity		
Candida	4	19
Debaryomyces	1	7
Pichia	1	7

contaminants from the atmosphere and remove them from the biological cycle due to their absorbing capacity. However, on the other hand, the complex chemical composition of the peats in the peat deposit of swampy ecosystems, their physical structures, and colloidal structures form the proper hydrochemical composition of swampy waters. Atmospheric precipitation passes through the stage of mire genesis before coming to underground water-bearing horizons. The groundwater feeding mire is also transformed in organogenic medium of the peat deposit. As a result, freshwaters rich in carbonic acid, methane, iron, manganese, and swampy components are formed. A special kind of mire water is formed in such a way that composition and the processes of interaction have been studied incompletely.

All the processes of the interaction of water with the products of vital activity of biogeocenoses can be considered, to some degree, as a special regional thermodynamic system (sun-basin unit by Kaznacheyev and Anshin 1986), where the living substance is predominant. Furthermore, the raised bogs are autonomous in eluvial and geochemical respect; this fact permits one to follow the migration flow of the substances in the balance variant.

The removal of the elements of the River of Klyuch runoff was estimated by daily intervals. The consumption of every element was estimated based on concentrations of the respective elements and the average daily water consumption as a product of concentration and water consumption. The removal for the longer time intervals was counted by the summation of daily removal values.

The runoff volume, its dynamics, and the conditions of formation define the migration flow of the substances from the oligotrophic landscapes into swampy rivers. The data of chemical element concentration in the River of Klyuch show considerable variability in different years and hydrological stages of the runoff (Table 6).

The swampy origin of the small waterway of the River of Klyuch determines the lowered content of average values of ions in water, such as Ca^{2+}, HCO_3^-, and SO_4^{2-}. However, to some extent, the increased content of total Fe and NH_4^+, as well as the appearance of intermediate reduction products, such as NO_3^-–NO_2^-, can appear in reductive conditions only.

The water of the River of Klyuch is rich in OM, as confirmed by the high values of chemical oxygen consumption (ChOC) and HA and FA (Table 7). The chemical composition of the River of Bakchar, which springs from the swamps and flows through them, is to a greater extent of the same chemical composition as that of the River of Klyuch.

The analysis of the obtained data indicates the influence of mire waters of the active layer of the peat deposit, which passed through the biochemical cycle of the exchange processes in the peat-water, on the hydrochemical composition of the river. The highest concentration of practically all compounds is noted on the mire border in the paludified forest (point 2), which is a transaccumulative part of the landscape profile of geochemically connected landscapes. It also serves as a geochemical barrier for swampy waters running off from the autonomous part of the profile.