Assessment of Group Composition of Peat Organic Matter for Industrial Processing

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Abstract. The results of studies of the group composition of peat organic matter of low-lying deposits of the Northern Trans-Urals sub-taiga zone are presented. It is established that the number of bitumen in the sedge-reed peat of the Ernyakul swamp most often amounts to 6.2-6.8%. In the Usalskoe swamp, their number is in the range of 3.9 to 4.7 percent. The most mobile part of the hydrolysis compounds in the peat from the Ernyakul swamp is 3.4 to 5.5%. In the sedge-reed peat of the Usalskoe swamp, their maximum number (4.1-5.3%) is concentrated in the layer of 0.4 m, the minimum (1.9%) – at a depth of 1.0 m in the hypnum type of peat. 27.0-31.8% of substances, hydrolyzed by 2% HCL, is in the peat of Ernyakul swamp. In the Usalskoe swamp in the meter layer of peat, the average content of this group of substances is by 3.6% more than in the Ernyakul swamp. The minimum amount of humic acids (HA) (30.3%) in peat from the Ernyakul swamp is contained in the sedge type of peat with a decomposition degree of 25%. The number of HA increases to 34.5-35.8 percent with an increasing decomposition degree up to 35-45%. The ratio of HA and FA is 1.6-1.7 with the decomposition degree of peat of 15-25%; with an increase to 35-45%, it increases to 1.9-2.0. The maximum number (32.7 per cent) of the humic acids contained in the hypnum type of peat of Usalskoe swamp is 4.7% more than in the sedge-reed peat. The content of substances, which are difficult to hydrolyze with acids, in the peat of Ernyakul swamp, does not exceed 2.4% and 2.7%. The lowest (1.9%) amount of this group of substances in peat from the Usalskoe swamp is determined in a layer of 0.6 m of sedge-reed peat, the maximum – at a depth of 0.8-1.0 m of the hypnum peat type (3.6%). The amount of lignin in peat from the Ernyakul swamp fits into the interval of 4.5-5.0%, which is 1.5 times more than the cellulose content. The content of lignin in the Usalskoe swamp in the meter layer is 4.2%, which is 3.5 times more than cellulose.

1. Introduction

Rational use of peat should be based on deep knowledge of its nature, the laws of physical and chemical manifestations and other properties [1, 2]. The group composition of the organic matter of peat determines the water-air properties, buffering, ion exchange capacity [3-5]. Resistance to biochemical and chemical degradation depends on the composition of the organic mass of peat, which makes it possible to predict the erosion processes and the rate of peat mineralization [6]. The organic mass of peat has a complex and heterogeneous chemical composition: it includes groups of organic compounds that make up the original vegetable substance [7]. In the peat formation process, new specific substances are formed under the general name humus substances, which are divided into

humic and fulvic acids [8]. The chemical composition of peat plants has a decisive influence on the composition of peat [10-12].

The group composition of the organic matter of peat in the sub-taiga zone of the Northern Trans-Urals has not been studied sufficiently.

The purpose of the research is to study the group composition of the organic matter of peat in the sub-taiga zone of the Northern Trans-Urals.

2. Subjects and Methods

Researches were carried out in low-lying bogs (Ernyakul, Usalskoe) of a sub-taiga zone of the Tyumen region.

The Ernyakul swamp has an area of 11 hectares and is located in Yurginsky district in the watershed of the rivers Tobol and Vagay, which in a geomorphologic respect is a quaternary accumulative difference. The territory of this geomorphological level is highly swampy due to weak drainability. The group composition of the organic matter of peat was determined on the swamp, peat-forming plants which were sedge, cane, hypnum, etc.

The Usalskoe swamp lies on the second floodplain of the lake-alluvial terrace on the left Bank of the Tobol river. Peat is formed by sedge, reed and mainly by hypnotic mosses.

The peat samples for analysis were taken from the sections laid down in the Ernyakul and Usalskoe swamps.

The group composition of the organic matter of peat was investigated by the modified method «Institute of peat case».

3. Results

In the group analysis of the organic matter of peat by the method of "Institute of peat case a", the term "bitumen" refers to a set of substances extracted with alcohol benzene (1:1), which include wax, resins, lipids and related compounds. All of them to some extent have binding properties and hydrophobicity. Their number in peat of the Ernyakul swamp ranges from 6.2 to 8%. However, most often it is in the range of 6.2-6.8 percent. At the same time, there is no connection with the Botanical composition and the degree of decomposition of peat (table 1.). In peat of typical species of the Central part of Western Siberia, the content of bitumen is mainly 3-4% [13]. In the peat of Western Siberia, low-lying peat with high content of bitumen (more than 5%) is rare, and in the conditions of the Urals – such output of bitumen is observed in 70% of samples [14].

Water-soluble and easily hydrolyzed substances include various organic compounds: pentose, uronic acid, hexose. Their content can vary from 6.9 to 63% [15]. The analysis scheme involves separate determination of substances hydrolyzed by water at a temperature of 100 °C and 2% hydrochloric acid. The results of studies have shown that the most labile part of hydrolyzable compounds, represented by a group of substances soluble in hot water, is a small fraction (3.4-5.5%). This is similar to the content of these substances in peat in the Central part of Western Siberia.

The content in the peat substances, hydrolyzed with 2% HCL, is high enough. It is in the range from 27.0 to 31.8%, it is 28.5% of the soil profile on average. A certain dependence of the content of easily hydrolyzed compounds on the Botanical species and the degree of decomposition is not observed. Apparently, the substance hydrolyzed with acid is represented mainly by labile carbohydrates. The number of hemicelluloses in their composition reaches 15.7-17.1%. Their share ranges from 53.8% to 57.8% of the total.

Humic (HA) and fulvic acids (FA) represent the most specific portion of the peat compounds. They account for 44.1-54.0% of the organic peat part. Only the content of humic acids was determined directly in peat from the Ernyakul swamp. Fulvic acids were calculated only on the difference. The minimum number of HA is contained in Scheuchzeria peat (31.2%) with the decomposition degree of 10-15% and in sedge peat, respectively - of 30.3% and 25.0 percent. Down the profile of the peat deposit, the decomposition degree of the sedge-reed peat increases to 30-45%, and the content of humic acids-up to 34.5 – 35.8%. The average content of HA and FA in peat in the Central part of

Western Siberia is 32 and 15% [13]. In peat, surveyed by us, the content is in the range of 17.8-18.9%. The data obtained allow us to conclude that the Urals peat has a higher content of fulvic acids.

Connections, which are difficult to hydrolyze by acid, in the peat are largely represented by cellulose (52.3-64.0%). In the studied peat, the content of this group of substances does not exceed 2.4-2.7% and does not detect links with other components of peat.

Table 1. Group composition of peat organic matter

Depth, cm	Ernyakul swamp									
	In percentage on absolutely dry peat									
	Bitumens	Water soluble and easily hydrolyzed at 100°C		Hydrolyzed with 2% HCL		Humic acid	Fulvic acids	Hard hydrolyzed with 80% H_2SO_4		Lignin
		in total	including hemicellulose	in total	including hemicellulose			in total	including hemicellulose	
0-20	6.81	4.32	Trac.	29.30	16.69	31.21	18.87	2.63	1.66	4.38
20-40	6.20	5.21	Trac.	31.81	17.07	30.31	18.23	2.96	1.74	5.46
40-60	6.88	3.44	Trac.	26.96	16.78	34.67	17.81	2.62	1.37	3.96
60-80	7.50	5.50	Trac.	27.15	15.75	34.55	18.16	2.44	1.35	3.98
80-100	8.09	3.22	Trac.	27.21	16.55	35.76	18.12	2.75	1.76	4.58
Usalskoe swamp										
0-20	4.09	4.11	Trac.	34.56	13.89	36.22	10.62	1.83	0.84	5.21
20-40	4.09	5.28	Abs.	35.06	14.98	34.43	14.40	1.93	0.76	5.38
40-60	4.66	2.85	Trac.	36.65	14.73	38.07	10.39	2.10	0.88	5.99
60-80	4.27	2.31	Abs.	25.35	16.47	40.63	6.95	2.46	1.43	4.84
80-100	3.92	1.89	Abs.	28.76	15.81	39.03	11.52	3.61	2.23	5.00

In Tomsk region low content of hard hydrolyzed substances is noted in peat enriched with wood residues, high content of moss fraction [16]. In the investigated peat of the Tyumen region, an increased amount of this group of substances (3.1%) is also contained in peat with a high percentage of moss content [14].

The residue that is not subjected to hydrolysis with 80% sulfuric acid is considered to be lignin. It is similar in some properties to humic acids, but does not contain carboxylic groups. Lignin is the main source of aromatic structural units for the formation of biochemical stable aromatic nucleus of humic acids. The more lignin in peat-forming plants is, the more humic acids are formed in peat, and vice versa [1]. The amount of lignin (4-5.5%) in all studied samples of peat from the Ernyakul swamp was 1.5-1.7 times higher than the cellulose content. Variations in lignin content in the profile of peat deposits are within the range of 1.5-1.8 percent. The amount of non-hydrolyzable residue (lignin) can reach 26% [15]. The relationship between the non-hydrolyzable residue and ash content is high (r=0.74). The increase in non-hydrolyzable residue is often consistent with a decrease in compounds that are difficult to hydrolyze.

On the Usalskoe swamp, peat in a layer of 0.6 m formed by sedge, reed, then down the profile - deposits are mainly formed by gypsum mosses. The decomposition degree of sedge-reed peat is 35-40%. With a depth of 0.6 m, it is sharply reduced and ranges from 15-20%. Analysis of experimental data shows that the content of bitumens in the peat on the Usalskoe swamp almost no changes in the deposits profile and is in the range of 3.9 to 4.7 percent. The relation to the decomposition degree and Botanical composition is not found. The average bitumen content in the meter layer is 4.2%. This is 2.9% less than in peat on the Ernyakul swamp (7.1%). The obtained results correspond to the content of bitumen in peat of typical species of the Central part of Western Siberia (3-4%).

The maximum number (4.1-5.3%) of water-soluble and hydrolyzable at 100 °C organic compounds

is concentrated in the 0.4 m layer. Down the profile of peat deposits, their number sharply decreases and at a depth of 1.0 m, it reaches a minimum value of 1.9%. In general, the results showed that the most labile part of the hydrolyzed compounds in the peat of the Usalskoe swamps is a small fraction.

The definition of substances, which are hydrolyzed with 2% HCL, has shown a fairly high content. The average number of these substances for all meter layer of deposits is equal to 32.1%, which is by 3.6% more than in the peat of the Ernyakul swamp. A possible cause is differences in botanical composition and decomposition degree of peat on the considered objects. One should note the increased content of this group of substances in the layer of 0.6 m (34.6-36.5%). Starting from a depth of 0.6 m and to a depth of a meter, the content substances, which are hydrolyzed with 2% HCL, decrease to 25.3-28.8 per cent, i.e. by 8.3%. This fact is caused by constantly high humidity of peat. The share of hemicellulose from the total amount of substances, hydrolyzed with 2% HCL, in a layer of 0.6 m is 40.2-42.7%. Compared to the peat in the Ernyakul swamp, it is 13.5-19.5 per cent less. Down the deposit profile to a depth of 1.0 m, it increases to 55-65% and does not differ from their number in the Ernyakul swamp.

The share of humic and fulvic acids in the organic part of peat from the Usalskoe swamp is 48.7% in a meter layer. The ratio between the content of humic and fulvic acids ranges from 1.5 to 1.8. The maximum number of HA (32.7%) was found at a depth of 0.8 m in the hypnum peat type. It is 4.7% more than in a layer of 0.4 m of sedge-reed type peat. A comparative analysis shows that in the peat of the Ernyakul swamp in a meter layer, humic acids contain 3.0% more than in the Usalskoe swamp. The number of fulvic acids also varies significantly, amounting to 10.8 and 18.2%.

Compounds, which are difficult to hydrolyze by acids, in the peat of the Usalskoe swamp are represented largely by cellulose (39.4-61.8%). In the studied peat, the total content of this group of substances is 1.8-3.6%. The lowest content of substances which are difficult to hydrolyze by acids (1.9%) is set in a layer of 0.6 m of sedge-reed peat. In sedge-hypnum peat their number increases to 2.5 per cent (26.1 per cent). The maximum presence (3.6%) was recorded in a layer of 0.8-1.0 m of hypnum peat type. A similar situation can be seen with the content of hemicellulose.

The amount of lignin in the meter layer of peat is 4.2%, which is 4.5 times more than cellulose. Compared with peat of the Ernyakul bog, lignin content is significantly less, where its number in the meter layer is 5.3%.

4. Conclusion

1. The number of bitumen in the sedge-reed peat of the Ernyakul swamp most often amounts to 6.2-6.8%, what is significantly higher than in peat typical species of the Central part of Western Siberia. In the Usalskoe swamp, their number is in the range from 3.9 to 4.7 percent. The content of bitumen varies slightly on the deposit profile and does not detect a connection with the botanical composition and the decomposition degree of peat.

2. On the Ernyakul swamp, the most labile part of hydrolyzable compounds, represented by a group of substances soluble in hot water, is a small fraction (3.4-5.5%). There is no dependence between the botanical composition and the decomposition degree of peat. In sedge-reed peat of the Usalskoe swamp, a maximum number (4.1-5.3%) of water-soluble organic compounds are concentrated in the layer of 0.4 m. Down the deposits profile their content sharply decreases and reaches a minimum value of 1.9% at a depth of 1.0 m in the hypnum type of peat.

3. The content of substances hydrolyzable with 2% HCL in the peat of the Ernyakul swamp ranges from 27.0 to 31.8%. Substances hydrolyzed by acid are mainly carbohydrates. The number of hemicelluloses in their composition reaches 15.7-17.1%. A meter layer of peat in the Usalskoe swamp, the average number of substances hydrolyzable with 2% HCL, more by 3.6% than in the Ernyakul swamp. A possible cause - differences in botanical composition and decomposition degree of peat.

4. The minimum number of HA is contained in Scheuchzeria peat (31.2%) with the decomposition degree of 10-15% and in sedge peat, respectively, of 30.3% and 25.0 percent. Down the profile, the decomposition degree of sedge-reed peat increases up to 35-45%, and the content of humic acids – up to 34.5-35.8 percent. The content of fulvic acids is in the range of 17.8-18.9%. With the degree of

decomposition of peat 15-25%, the ratio of HA and FA is 1.6-1.7; with an increase to 35-45% it increases to 1.9-2.0.

5. In the Usalskoe swamp, the maximum amount of humic acids (32.7%) was found at a depth of 0.8 m in the hypnum type of peat. This is 4.7% more than in the layer of 0.4 m of sedge-reed peat. In the peat meter layer, the ratio of humic to fulvic acids varies between 1.5 and 1.8. In the peat of the Usalskoe swamp, the humic acid content is 3.0% less than in the Ernyakul swamp.

6. The content of substances, which are difficult to hydrolyze with acids in the peat of Ernyakul swamp, does not exceed 2.4% and 2.7%; 52.3-64.6% are represented by cellulose and do not detect connection with other components of the peat. In the peat from the Usalskoe swamp, the lowest content of this group of substances (1.9%) is determined in the layer of 0.6 m of sedge-reed peat. In the sedge-hypnum peat, their number increases to 2.5%. The maximum presence was recorded in the layer of 0.8-1.0 m (3.6%) of hypnum peat type.

7. The amount of lignin in the peat from the Ernyakul swamp fits into the interval of 4.5-5.0%, which is 1.5-1.7 times greater than cellulose content. In the deposit profile of the peat, its value changes slightly. The relationship between the non-hydrolyzed residue and ash content is high (r=0.74). In the Usalskoe swamp, the amount of lignin in the meter layer of peat is 4.2%, which is 3.5 times greater than cellulose. The relationship with the botanical composition and the decomposition degree of peat is not found.

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