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Research Article

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Selenium in Peat Soils and Humic Acids of Forest-Steppe Zone of Northern Zauralye

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ABSTRACT:
The article describes the results of studies of selenium content in peat soils and humic acids of forest steppe zone of Northern Zauralye. The objects of study were soil of major fen peat fields Borovoe and Tarmany. The botanical composition of the field Borovoe is relatively heterogeneous. Sedges and reeds are widely represented here. Most of this peat field is characterized by a high degree of decomposition (R>30%) and acidic reaction of the medium. Herbal and mossy peats are more abundant in the field Tarmany. Their botanical composition is characterized by different species of sedges, horsetails, hypnum mosses. The degree of decomposition rarely exceeds 30%. Concentrations of trace elements in various types and kinds of peats ranged from 332 to 1264 µg/kgs. Soils of peat field Tarmany, are characterized by the highest amount of selenium soils, they contained at an average of 814 µg/kgs. Peat deposit Borovoe has at an average 617 µg/kgs of Se.
Peat soils of forest steppe zone of the Northern Zauralye can be considered as selenium-saturated. A large part of the trace elements is associated with humic acids.

Keywords: selenium, peat, humic acids, forest steppe zone, Northern Zauralye.

INTRODUCTION

Currently special interest is drawn to the data about content of selenium in the environment, as it relates to minerals necessary for normal functioning of plants, animals and humans. It is noted that this mineral supports normal state of antioxidant, detoxifying and immune systems of the body [1-5]. Selenium is a very rare and dispersed element, its content in the earth's crust equals (Clarke) 5×10^{-6} % in mass [6]. The main links of the food chain transfer of selenium are soil – plants – animals – people. This scheme determines the dependence of the level of selenium content in human from geochemical characteristics of the soil and explains the existence of biogeochemical provinces of the deep deficiency and toxic concentrations of trace elements [7]. It is considered that the soils contain an average of about 400 µg/kgs of Se. [8]. Its concentration in soils of different genetic types usually varies from 10 to 1200 µg/kgs [9].

The content of selenium in peat soils is poorly studied. There are only sporadic reference in the literature that peat soils are quite rich in selenium [10,11]. Northern Zauralye, on the territory of which the main part of the Tyumen region is situated, is an integral part of the extensive West Siberian plain and is characterized by a high level of bogginess. Peat bogs of lowland type that, which have a sufficiently high potential fertility are most promising for the development. They can be used as pastures and hayfields in connection with intensive development of animal industry of Northern Zauralye. The use of peat soils and various types of peat fertilizers in agricultural production requires an assessment of the security of their plant nutrients, including trace elements. There is absolutely no information about the content of selenium in the peat bogs of the region.

RESEARCH SUBJECTS

The aim of this work was to obtain information, and assess the amount of selenium in peat soils and humic acids of forest steppe zone of Northern Zauralye.

RESEARCH METHODS

The objects of study were soils and extracted humic acid of the peat fields Borovoe and Tarmany. Peat field Borovoe is located in the Northern forest steppe area into located near a terrace slope of floodplain of the river Pyshma, it covers 645 hectares. The underlying rocks are sands and sandy loams. Terrain is flat, type of water regime is washing. Tarmany is a peat field located in two zones: subtaiga and forest steppe, it lies on an ancient above flood plain terrace of the left slope of the river valley Tura. Peats are underlied as layers of waterproof loams and clays which isolate peat deposits from major aquifers.Samples of peat were taken from the surface layer of 0-25 cm. Peat soils has been described by the botanical composition, decomposition degree and the overall agrochemical indices, which were carried out by established practice during the study. Selenium was fluorimetrically determined using 2,3-diaminonaphthalene [MKU 4.1 044−95].

RESULTS AND DISCUSSION

The results showed that the botanical composition of the peat field Borovoe is relatively diverse. Sedges, reeds, which in some cases are formed in pure form and entire sections of peat deposits in combination, are most widely represented. Along with them there are the remains of the buck-beans, horsetails, scheuchzeria, hypnum, birch and pine bark. The majority of the peats of the field Borovoe is characterized by a high decomposition degree (R,%), exceeding 30%, and in some cases reaches 50%. The bulk of peat refers to fine ash, i.e. the ash content does not exceed 12-15%. However, there are areas with high ash content reaching 20 or more percent in some cases. This is apparently due to hydrochemical characteristics of the area, contributing to the secondary mineralization of peat. Most of the peats of this field are characterized by a predominantly acidic reaction of the environment and high cation exchange capacity (CEC mg-eq/100g of peat) (table 1). Plant species composition of peat-forming plants of the field Tarmany is generally more aligned. There are practically no deposits of woody and woody-grass peats on its territory. Herbal and mossy peats are most common. Their botanical composition is characterized by the presence of different species of sedges, horsetails, hypnum mosses. The degree of decomposition of peat is rarely more than 30%. All studied samples of this field can be referred to fine ash. Peat soils of the field Tarmany have a slightly acidic or neutral reaction medium and a high cation exchange capacity (table 1).

Table 1– The content of selenium in the soils of peat fields Borovoe and Tarmany

Peat type	pH KCL	CEC mg-eq/100g of peat	Ash content in %	R, %	Selenium, μg/kgs
Borovoe					
Sedge	4,9	72,08	5,84	25	856
Sedge	4,7	67,02	7,05	40	332
Sedge	5,4	87,89	6,91	35	591
Grass	6,2	94,50	24,78	45	595
Sedge-hypnum	4,3	58,44	15,45	30	731
Sedge- scheuchzeria	5,9	99,49	14,80	50	525
Hypnum -sedge	5,7	99,30	8,02	40	776
Hypnum -sedge	4,5	68,58	10,80	35	548
Sedge-reed	4,9	89,68	4,05	35	679
Reed-sedge	5,8	89,77	6,73	30	642
Reed-sedge	5,2	89,90	10,02	35	534
Reed-sedge	4,9	90,36	12,08	30	390
Reed	7,6	-	21,81	50	674
Buckbean-reed	5,6	93,95	6,08	40	881
Woody-sedge	6,4	98,54	10,38	50	464
Woody-sedge	2,6	23,26	4,69	30	493
Woody-sedge	7,2	99,81	21,07	35	792
Pine-sphagnum	2,7	40,46	7,35	5	595
Tarmany					
Sedge-hypnum	5,9	91,09	5,50	30	912
Sedge-hypnum	6,2	90,60	6,34	30	932
Sedge-hypnum	6,7	96,48	10,07	15	395

Hypnum -sedge	6,6	96,95	4,89	15	658
Hypnum	6,1	92,61	8,40	15	720
Horsetail-sedge	6,7	98,76	11,78	30	1264

Note: R − degree of decomposition; CEC – cation exchange capacity.

The results of our work show that the content of selenium in the peat of the Tyumen region is heterogeneous. It varies among different peatlands from 332 to 1264 μg/kg. Peat soils of the field Tarmany formed on clays and heavy loam in conditions of excessive water saturation are characterized by the highest concentration of selenium. The average number of trace elements in peat is 814 μg/kg. Firm fixation of selenium contributes to slightly acidic, close to neutral reaction medium of peat of this field. A specific composition, mainly represented by sedges and horsetails plays an important role in the accumulation and retention of selenium. The peat, containing remains of horsetails are isolated with its anomalously high content (1264 μg/kg). Peat deposit Borovoe contains from 332 to 881 mg/kg of selenium, at an average of 617 μg/kg. There is no peat with abnormally high content of trace element in this field. In general, peat-bog soil of this field formed on sands and loams under washing conditions of water regime has lower levels of selenium than the peats of the field Tarmany. A certain role was played by the botanical composition and high degree of decomposition of peat (table 1).

We calculated the correlation coefficients between the content of selenium in the peat and pH (r=-0,26), degree of decomposition (r=-0,08), CEC (r=0,25), ash content (r=-0,29), which showed no dependence between these values.

The concentration of selenium in mineral soils is observed in the upper biogenic horizons, which is due to its biological accumulation. Trend to reduction of quantity of selenium in soil with depth is discovered for most types of mineral soils. We observed these same patterns earlier for different types of mineral soils of Northern Zauralye [12].

In the peat soil organic matter also plays the role of the main striker of selenium. The amount of humic acids isolated from peat soil of these deposits ranges from 17.0 to 42,57%. As a rule, the absolute amount of selenium in humic acids is higher than in peats. The mean value of trace elements in humic acids equals 878 μg/kgs in peat Borovoe and 1026 μg/kgs in peat Tarmany (table 2).

Table 2 – Selenium content in humic acids isolated from peat deposits of the fields Borovoe and Tarmany

Peat type	Content of selenium, μg/kg		Content of HA in peat, %	Content (C), %
	Peat	HA		
Borovoe				
Sedge	856	1138	40,59	53,96
Sedge	332	613	35,63	65,78
Sedge	591	906	36,91	56,58
Sedge-hypnum	731	938	32,50	41,70
Sedge- scheuchzeria	525	932	42,57	75,57
Hypnum -sedge	776	896	40,50	46,76
Hypnum -sedge	548	823	34,75	52,19
Woody-sedge	464	726	41,00	64,15
Woody-sedge	493	842	17,00	29,03
Grass	595	1080	37,56	68,18
Reed	562	761	18,64	25,24
Tarmany				
Sedge-hypnum	912	1153	31,20	39,44
Hypnum	720	898	13,82	17,23

Note: HA− humic acids.

Knowledge of only the absolute selenium content in humic acids does not give a complete picture of their significance in the deposition of selenium in peat soils. In order to assess the role of humic acids in the fixation of selenium we counted what percentage of the total selenium in the peat is accounted for humic acids. The calculation was carried out taking into account their percentage in the peat by the formula $Д\% = \frac{aB}{C}$, where $Д\%$ − the content of humic acids in the fixation of selenium in %; a − the percentage of humic acids in peat; B − the percentage of selenium in peat; C − the content of selenium in the peat μg/kg.

Table 2 shows that the proportion of trace elements associated with humic acids ranges from 17.23% to 75,57% and it equals 58% at an average.

5. DISCUSSION

1. The content of selenium in peat soils of forest-steppe and subtaiga zones of the Northern Urals ranges from 332 to 1264 μg/kgs, which exceeds of the value of Clark at an average, and the data of the soil can be sufficiently secured in these trace elements.
2. The concentration of selenium in the studied peat soils does not dependent on Botanical composition, pH, degree of decomposition, CEC and ash content, which is confirmed by low correlation coefficients between these indicators.
3. The leading role in the deposition of selenium in the peat belongs to the humic acids. The proportion of trace elements associated with humic acids ranges from 17,23 up to 75,57%.

6. CONCLUSION

Thus the value of the content of trace elements in various peats ranged from 332 to 1264 μg/kgs. Soils of peat field Tarmany, which contained at an average 814 μg/kg are characterized by the highest amount of selenium soils. Peat deposit Borovoe has at an average 617 μg/kgs of Se. A correlation between the content of trace elements in peat and pH, degree of decomposition, ash content, cation exchange capacity has not been found. Amount of selenium in humic acids extracted from the data of peat deposits was higher than in the peat and is 878 μg/kgs in peatland Borovoe and 1026 μg/kgs in peatland Tarmany. On average, the content of humic acids account for more than 58%.

CONFLICT OF INTERESTS

The author confirms that the submitted data does not contain conflict of interest.

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