IJABR

International Journal of Advanced Biotechnology and Research (IJABR)
ISSN 0976-2612, Online ISSN 2278–599X,
Vol-10, Issue-2, 2019, pp474-489
http://www.bipublication.com

Research Article

UDC 631.445.12 (470.313)

Results of Monitoring Studies of Dried Peat Soils

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[Received: 07/04/2019; Accepted: 18/05/2019; Published: 20/05/2019]

ABSTRACT

The selection of sites for 4 ameliorative objects was carried out after analyzing the annual reports of VNIIGiM for 1952-2010. Studies were carried out according to generally accepted methods using the STATISTIK 10 program. Weather conditions were unstable. Analysis of the dynamics of the hydrothermal coefficient (HTC) showed increased dryness. The processes of secondary waterlogging and soil degradation of the studied objects were revealed: peat drawdown from 57 to 58 cm, decrease in total peat sediment by more than 1.2 times, the volume mass of peat soils on objects increased from 0.12 to 0.58 g / cm^3, the average peat ash content was from 15 to 22 %, pore space from 41 to 50 %, filtration coefficient from 0.2 to 0.5 m / day, which is typical of highly decomposed peat. The loss of organic matter was established from 2,843 to 2,724 t / ha. Peat soil from 1955 to 2018 turned into a humified mass, which with further use can lead to a complete drawdown of the peat soil. The content of cellulose-destructive bacteria was high, the degree of decomposition of flax linen was up to 99 %, the number and variety of microorganisms, including fungi, was not high. The studied soils were unfavorable for invertebrates - geobionts.

Keywords: ecology, monitoring, reclamation object, Mescherskaya lowland of Russia, peat soils, humus, humic acids

INTRODUCTION

Russia has enormous peat swamp resources. In the country, 21 %, or 369.1 million hectares, are marsh and wetlands, which include the Mescherskaya lowland [16].

Peat soils are ecologically unstable after drying: the organic matter is quickly destroyed, the peat deposit is reduced (drawdown) until it completely disappears, and fertility decreases. They are characterized by the fluctuation of the water regime of the root layer due to the nature of the structure and water properties of the soils themselves [7, 23]. Therefore, drained peat soils, as an object of agricultural production, need a partial load mode of their use [5, 10, 24]. At the same time, soils are the habitat of many organisms, and their qualitative condition affects the living conditions of microorganisms and invertebrates [11, 27-29].

Goal of study: The goal is to establish the current state of the reclaimed peat soils of the Ryazan Meshchera on the basis of monitoring studies. The relevance of monitoring studies of peat soils of the Ryazan Meshchera is due to the need to slow down the processes of mineralization (degradation) and increase the period of their use in agriculture based on the analysis and synthesis of scientific research.

In this regard, in order to accomplish this goal, the following objectives were set at four land reclamation facilities of the Ryazan Meshchera:

• measurement of groundwater level (GWL) and soil moisture (Ms) in the root zone,
• the study of water-physical parameters, including a comparison of theoretical and actual processes of peat depletion and sedimentation,
• determination of agrochemical and ameliorative properties of soils;
• the study of botanical composition, grass yield;
• the study of the activity of microorganisms and soil biota.

Scientific novelty is the monitoring of long-term used peat soils and the development of a methodology for assessing the allowable changes in reclaimed peat soils of the Ryazan Meshchera.

The practical significance of the results obtained is important for agricultural enterprises located in the zone of land-reclamation facilities.

MATERIALS

Mescherskaya lowland is a flat lowland with sandy marshy soils, large tracts of bogs, forests and numerous lakes [2, 3]. All these landscapes are interconnected in a single natural complex [14, 22, 25]. The territory is located in the center of the European part of the Russian Federation between the rivers Oka, Moskva, Klyazma, Sudogda and Kolpa, occupies the east of the Moscow region, the north of the Ryazan and the south of the Vladimir regions. Its area is 2.3 million hectares. About 39 % of its entire territory is used in agriculture, the rest of the area belongs to the state forest fund. The bogging of the land of Meshchera creates significant obstacles to the development of agriculture. The ameliorative fund of wetlands and over-wetted lands here is 456 thousand hectares. Drained and cultivated peatlands are potentially fertile soils for the cultivation of cereals, potatoes and forage crops [15].

The geographical position of the Mescherskaya lowland causes moderately continental climate with a relatively cold autumn, a moderately cold winter with a steady snow cover, a long spring and a warm, rarely hot summer [4, 12]. The annual total solar radiation here is 85-90 kcal / cm^2. Extreme temperatures are –45 ° C and +39 ° C. The duration of the frost-free period is 130-145 days, the duration of the period with positive air temperatures is 210-220 days from the beginning of April to the beginning of November, the duration of active vegetation of plants with temperatures above 10 ° C is 135-140 days. The sum of average daily temperatures for this period increases from 2,000 to 2,200 ° C from northwest to southeast. In general, the climate of the Mescherskaya lowland is characterized as moderately warm and unstable wet.

Weather conditions in both winter and summer are unstable [18]. An analysis of the dynamics of the hydrothermal coefficient (HTC) showed an increase in aridity. Over the past 30 years, the number of dry years amounted to 16, of which only 5 days were really dry, and the average value of the HTC was in the range of 0.89 units [9]. The consequences of changing weather conditions are frequent fires on peatlands, which are dangerous especially during the hot summer season within the drainage system [16, 26].

The reclamation site Tinky-II" is located on the territory of farm "Polkovo", 20 km from the regional center of Ryazan [8]. The land of the farm is 4,114.6 hectares, including 60 hectares of swamps, 40 hectares of the drainage system and 30 hectares of the drainage and humidification system. The pilot plot is a part of the ecopolygon. The drainage and humidification system was organized at the farm in 1955. Since 1982, it has functioned not only to drain excess water from the territory, but also to moisten drained land using the Frigate circular-sprinkling machines and DDA-100MA [27]. Irrigation by sprinkling has not been carried out at the farm since 2004, but 1/3 of the area has the water regime of the soil regulated by locking [21]. The ameliorative object had a drainage and humidification system with an open main canal and uphill-hunting channels, pottery drainage. When restoring the drainage system some pottery drains were replaced by plastic ones. The thickness of the peat layer of the Tinky-II soil is 90-110 cm. Peat is lowland and wood-sedge, the degree of decomposition is 35-45 %, the ash content of peat in the arable horizon ranges from 15 to 18 %. Agrochemical parameters of peat soil worked are as it follows: pH 5.5-6.5, content of N total 2.97-3.27 %, gross phosphorus - 0.28-0.36 %, gross potassium - 0.09-0.11 %. Cf (filtration coefficient) is 1.2 m / day, which corresponds to medium-grained ancient alluvial sand. The water-physical properties of the peat soil are as follows: volume weight is 0.35-0.46 g / cm^3 and maximum water holding capacity is 170-200 %. Groundwater level is 127 cm.

Drained Vozha and Nikitskoe facilities, also built in the 1950s, are located on the territory of the Klepikovskiy District. Main canals and collectors at sites are open, the drainage is tile. GWL is 118-122 cm. Digging a hole and profile description determined the soil as worked, gleyish and low-grade.

Reclaimed object Kalskoe is in village Laskovo and stretches up to village Zaborye of the Ryazan region. A powerful stratum of ancient alluvial sands rests on a multi-meter litter of seat clay. Until the 1950s, the territory was a woodless swamp area. The peat bog Gadovskoe refers to the lowland type and the forest-fenny subtype. In 1956, drainage measures began on the Kalskoe bog, a drainage network was built mainly for sowing perennial and annual grasses with a rare network of deep open canals. One of the reasons for the unproductive land use was insufficient drainage for sowing intensive crops; the need to increase the depth of all the channels into which they fall, and water inlets to ensure gravity-flowing drainage of water. GWL is 100 cm. The soil is peaty-gleyish and worked out.

METHODS

A detailed acquaintance with the multi-year data (1950-2018), provided by the Hydro-Meteorological Service of Ryazan, the Ministry of Environmental Management and Ecology, the management of Ryazanmeliovodkhoz was conducted. The selection of locations for 4 ameliorative sites for monitoring studies was carried out after analyzing the annual reports of VNIIGiM for 1952-2010. According to the synthesis and analysis of project documents over the past years, a survey route was drawn up.

Surveys were conducted on reclaimed objects of the Ryazan region, typical of the Ryazan Meshchera.

The methodology of the work included general and special methods - analysis, synthesis, comparison, geographical and dialectical. The methodology was based on the principle of comparing water-physical, ameliorative and agrochemical soil properties under the conditions of double regulation of water balance (drainage + moistening with sprinkling or locking) in 1955-2005, taking into account the agricultural use of land till the present, when the drainage system is deformed and does not fully perform its function.

When processing the theoretical review and its own results of landscape surveys, a geoinformation model created by the authors was used with a geographical database (GDB) and a map database (MDB). The core of the GBD and MDB system was the object model created using UML (Unified Modeling Language), which, with the help of CASE tools included in ArcGIS 9.2, was transformed into a physical GDB model capable of operating in any DBMS environment (personal MS Access type or MS SQL corporate type, Oracle, Informix, etc.). To fill the GDB and MDB data, the necessary cartographic materials were scanned, digitized, spatially referenced, and input attribute information was made. ESRI ArcGIS 9.2 product was used as software. The management structure of GDB and MDB is one of the constituent elements of GIS. The structuring of the facts involved the definition of interdependencies between the studied objects and their subordination (for example: facies → link → tract → area). Structurization was based on the concepts of essence → attribute → connection. The characteristics of geographical objects were represented in GBD and MDB by a set of attributes.

Meadow grasses were reagent cultures. In monitoring studies, the authors conducted the following surveys, observations, calculations and analyzes:

• Observations of changes in water-physical and agrochemical properties of peat soils were carried out when sampling of soils using the envelope method on conditionally selected typical areas of 10x10 m:

1. Criteria for assessing soil hydration were groundwater level (GWL) and soil moisture (Ms). GWL measurements with a plopper in open or closed observation wells once a decade and measurements of Ms with tensiometer were made every three days during the growing season.

2. The water yield was determined by A.I. Ivitskiy's formula:

$$\mu = 0.115k^{3/8} H^{3/4}, \qquad (1)$$

where μ is water yield (dimensionless quantity, in shares of unit);
k is filtration coefficient, m / day;
H is lowered groundwater depth, m.

3. Soil porosity ε as the ratio of the pore volume of the soil to the volume of the entire soil was calculated from the values of the soil density and its solid phase:

$$\varepsilon = (Vt - Vs) / Vt = 1 - (Vt / Vs) = 1 - \frac{\frac{ms}{ps}}{\frac{ms}{pb}} =$$

$$1 - \frac{ps}{pb}, \ (cm^3 / cm^3), \qquad (2)$$

where Vt is soil monolith volume;
Vs is the volume of the solid part of the soil in the composition of this monolith;
ms is soil mass;
ρb is the density of the soil solid phase;
ρs is soil density.

4. The durability of peat soils was determined by the formula of A.S. But-Gusaim (1978):

$$t = \frac{\ln\left(1 - \frac{H_0 - H_{\min}}{AH_0}\right) + a(z+q)}{b(z+q)}, \qquad (3)$$

where t is peat layer life, years;
H_0 is initial (before drainage) peat layer thickness, m;
H_{min} is the minimum peat thickness below which it ceases to exist as a type of soil (H_{min} 0.2 m),
A is the density coefficient, which is a function of the bulk mass of peat solids or its degree of decomposition and humidity;
z is the rate of soil drainage soil, cm;
q is the average excess of the groundwater level above the bottom of the canals and drains, equal to 0.2-0.4 m;
a is the coefficient of peat sedimentation rate in the first year of drainage, 1 / m;
b is the coefficient of peat sedimentation rate in subsequent years 1 / m per year.

5. The annual use of peat was calculated by the following formula:

$$h_c = \frac{A}{B^x} + C, \qquad (4)$$

where is peat drawdown, cm / year;
x is the exponent, directly related to the time elapsed after draining the swamp;
A, B, C are values depending on the type of agricultural land use.

6. The ratio of organic matter to mineral peat, depending on the duration of drainage, was determined by the formula of V.M. Zubets and V.I. Dubrava (1974):

$$\frac{\gamma_{org}}{\gamma_m} = \frac{20}{\sqrt{T+5}}, \qquad (5)$$

where γ_{org}, γ_m are weights of organic and mineral matter per unit volume of peat after T years, g / cm^3.

7. Ash content of peat in the topsoil, depending on the duration of drainage, was calculated by the equation of V.M. Zubets and V.I. Dubrava (1974):

$$A = \frac{3\sqrt{0.2T+1}}{a_0 + 3\sqrt{0.2T+1}}, \qquad (6)$$

where a_0 is organic to mineral ratio before draining.

The formula is applicable when the drainage time is up to 50 years ($T \leq 50$) and $11 \leq a_0 \leq 15$. In the process of calculation, the correction factor was introduced.

8. Loss of organic matter with infiltration (Chemical analysis of groundwater, practicum on agrochemistry 1995).

9. Hydrolytic acidity by Kappen (GOST 26212-91).

10.The density of the soil of undisturbed structure according to genetic horizons in triplicate was determined by the drilling method in field conditions with natural addition to soil caverns, cracks and voids inherent in the soil. The sample was weighed, the soil moisture was determined and the density was calculated using the formula:

$$\rho = \frac{m1x100}{(100+W)Vb}, \qquad (7)$$

where m_1 is soil mass from the borer, g at natural humidity W, %
Vb is the borer volume, cm^3.

11.The filtration coefficient was determined by the method of flooded areas with the establishment of square frames with an area of 2,500 cm^2 for external ones and 625 cm^2 for internal ones on the soil surface to prevent lateral spreading of water during filtration. Water flow was measured in time and the indicator was calculated for the time when the flow was set at one point. The absorption coefficient was calculated, and after 4 hours while maintaining a constant head of water of 5 cm, the filtration stage began, which was determined.

12. pH of salt extract (GOST 4649-76);

13. Humus - according to the method of I.V. Tyurin.

14. The amount of exchange bases by Kappen and Gilkovits.

15. The level of base saturation of peat grounds (calculation method).

16. Total nitrogen by Kjeldahl (Practicum on Agrochemistry, 1995).

17. Mobile phosphorus and exchange potassium - according to Kirsanov.

18. Determination of the power of peat deposits by soil sounding technique (probe, borer).

- Soil biological activity:

1. Putting linen cloths to a depth of 0-25 cm at 3 points of the site according to Zvyagintsev technique.

2. Microorganisms were taken into account by diluting and sowing on nutrient media in the laboratory of the center of the State Sanitary and Epidemiological Surveillance. The total number of bacteria was determined on MPA (meat-peptone agar) and SAA (starch-ammonia agar), the sporiferous were determined on a mixture of equal volumes of MPA and wort agar (MPA + WA - Mishustin's environment), after pasteurization of soil suspension, actinomycetes were determined on SAA and microscopic fungi on WA (wort agar). To count microorganisms a microbial colony counter was used.

3. For soil fauna research, a soil excavation method with manual disassembly of the selected land was used. The objects that were detected with the naked eye and under a magnifying glass were taken into account (earthworms, centipedes, white grubs, ground beetles, etc.) [1, 6, 17].

- Economic investigations:

1. Grass mowing with a lawn mower with the following collection in sheaves.

2. Productivity of meadow grasses - by weighing.

3. Botanical composition of herbs - with the help of botanical determinant.

- Economic efficiency (E) was determined by the following formula:

$$E = \frac{\Delta P}{K} = \frac{C * PC}{K}, \qquad (8)$$

where ΔP is additional profit due to measures;
C is the cost of the annual volume of additional products;
PC is the prime cost of the annual volume of additional products;
K is the cost of work.

- Statistical processing of research results:

The reliability of the research is confirmed by processing the results using the computer program STATISTIK 10.

RESULTS

Optimal humidity and aeration in the root zone are created with an average groundwater level during the growing season for perennial grasses equal to 60–80 cm from the soil surface [15]. The rate of drainage changes over time, it must provide, on the one hand, the necessary soil aeration and the associated food and thermal regimes, and on the other hand, soil moisture sufficient for plants (especially during dry periods). The soils on all reclaimed objects had vivid signs of degradation and secondary waterlogging.

The monitoring results showed that during the use of peat soil on all the land-reclamation objects under study (70-74 years), there was a drawdown of peat, droughts appeared, indicating secondary waterlogging, the ash content increased, and sand deposits spread to the surface. The diversity of soil cover within the same area was formed: the average depth of the peat was 41 cm on average, the minimum value was 26 cm and the maximum was 80 cm. Since 1952, the surface of the peat deposit has dropped by

1.9 m. When analyzing the annual reports of VNIIGiM for 1952-2018, the maximum peat depletion was established in the areas of land-reclamation facilities of Vozha, Nikitskoe and Kalskoe. The studied area of Tinky-II facility had a little lower peat depletion.

Thus, the peat drawdown calculated by the formula (4) showed the following values: h_c = 54 cm at Tinky-II, h_c = 68 cm at Vozha, h_c = 65 cm at Nikitskoe and h_c = 67 cm at Kalskoe. That is, the peat drawdown was 0.77 cm per year and this rate of peat destruction is lower than, at other objects: 1.0 cm at Vozha and Nikitskoe sites and 1.08 cm at Kalskoe object. Peat depletion at Tinky-II facility was significantly less (by an average of 28 %), in our opinion, due to the support of the soil by bilateral regulation of the water regime (irrigation until 2005 and sluice till present). The actual reduction of peat precipitation over 8 years by 1.2 times has been established, which means there is a reserve for land reclamation farming. The calculation of peat processing by the formula (3) showed a ratio of 1.2: 1.0 compared to theoretical and actual values, which is explained, in our opinion, by the creation of a looser structure when applying fertilizers and double moistening at Tinky-II.

The ploughed horizon, which is subjected to mechanical action during processing, has been most changed. An integral parameter characterizing changes in the physical properties of peat is the bulk mass. It includes the influence of most of the remaining soil parameters: the degree of decomposition of peat, ash, mode of soil use and moisture reserves. After draining, as a result of the discharge of excess water and a decrease in the level of groundwater, a significant increase in the bulk mass of the soil occurs. In the course of development and subsequent agricultural use, this process slows down, but does not stop at all, and the strengthening of peat mineralization processes becomes one of the main factors for increasing the bulk mass. In the period from 1950 to 2018, the bulk weight of the upper part of the profile at Tinky-II section occupied by meadow grasses increased from 0.20 to 0.58 g / cm^3 due to salinity and compaction of the upper layer. The change in bulk density at Vozha and Nikitskoe ameliorative sites was from 0.12 to 0.42 g / cm^3 and that at the Kalskoe facility was from 0.18 to 0.47 g / cm^3. The density of basic nutrients depends on peat density: the higher the density indicators, the higher the supply of macronutrients in a unit volume.

The average ash content of peat at Tinky-II facility in 2018 was 22.1 % in a layer of 0-5 cm, at Vozha and Nikitskoe - 15 and 17 %, respectively, and at Kalskoe - 19.5 % with significant fluctuations in the horizons, which is typical of transitional peat. The ash content of peat is higher at Tinky-II facility, therefore, its density is also higher: in the 0-50 cm layer it reached 462 kg / cm^3. At objects of Vozha, Nikitskoe and Kalskoe the figures were respectively 160 and 168; 204 kg / cm^3.

The optimal values of peat soil indicators are as it follows: the degree of decomposition is from 20 to 50 %; ash content is from 11.5 to 14.5 % and bulk density is from 0.15 to 0.23 g / cm^3. Values greater than 50 % are critical, the peat soil turns into a humified mass, which further degrades more and more up to the full drawdown.

A moving average of ash values was established, which expressed the dynamics of the process change based on actual data (Figure 1).

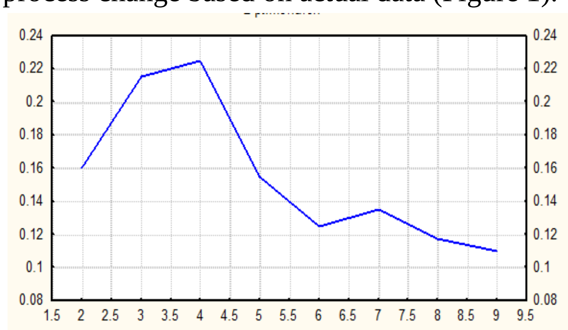

Figure 1 - Dynamics of the moving peat ash

The equations of regression-correlation analysis of the dependence of the ash content (AC) on the duration of the use of peat soil at Tinky-II facility is as it follows The equations of regression-correlation analysis of the dependence of the ash content (AC) on the duration of the use of peat soil at Tinky-II facility is as it follows:

$$AC = 0.12 - 0.005x, \qquad (9)$$

The porosity ε was, respectively to objects, 50; 42 and 48; 41 % of soil volume in a layer of 0-20 cm. Durability (t) of the meter layer of peat soils, calculated by A.S. But-Gusaim's formula

(3), at Tinky-II object, showed t = 170 years, those at Vozha and Nikitskoe sites were t = 132 and 140 years, and that at Kalskoe was t = 138 years. Considering that reclamation systems have been abandoned for about 20 years, and there is no agriculture in the territories, the longevity of peat soils at facilities, in our opinion, will not decrease. The thickness of the peat layer, determined by the sounding method, at Tinky-II facility was 156 cm in 1955, 138 cm in 2000 and 116 cm in 2018; that at Vozha facility was 132 cm in 1960 and 106 cm in 2017; that at Nikitskoe facility was 129 cm in 1960 and 96 cm in 2017; that at object Kalskoe was 138 cm in 1960 and 116 cm in 2017.

The filtration coefficient Cf has changed greatly. Due to compaction of the upper layers of peat, it has decreased by 20 ... 40 times. At facilities of Tinky-II, Vozha, Nikitskoe and Kalskoe Cf ranged from 0.2 to 0.5 m / day, with minimum values characteristic of the last three objects. Such values are characteristic of highly decomposed peat in accordance with the classification of Agalina M.S. Soils in the studied areas now have the ability to absorb a very large amount of water: the maximum water holding capacity (MWHC), determined by the method of flood pads, reaches 190 % (Kalskoe object) and 270 % (Tinky-II object) of absolutely dry weight. There is a decrease of almost 50 % compared with the first years of using the drained soil. The available moisture in the meter top layer is significant. The soils differ in their ability to firmly hold a significant part of absorbed water, their hygroscopic humidity reaches 18-20 % of absolutely dry weight, and the permanent wilting point or a part of absorbed water that is practically unused by plants reaches 36-40 % of MWHC.

Water loss amounted to μ = 5.18 ... 6.02 at Cf 0.2 ... 0.5 m / day.

The main factor in the loss of organic matter becomes mineralization, the dynamics of which is presented in Table 1. In particular, over 58 years, the loss of organic matter mass was 46 ... 98 t / ha. Agro-industrial properties of peat soils of lowland marshes are 80-91 % composed of organic matter of different degrees of decomposition: weak - 20 %, medium - 20-40 % and good 40-50 % and higher. They contain a lot of humus and humic substances - 40-60 % or more. In this regard, the absorption capacity reaches 70-120 mill equivalents per 100 g of soil.

Table 1 - Changes in organic matter of drained peat soils

Reclamation object	Peat deposit, cm		Peat capacity decrease per year, cm	Mass of organic matter, t / ha		
	1960	2018		1960	2018	Average annual loss, t / ha
Tinky-II	151.6	119.3	0.6	2843	2797	2.4
Vozha	144.9	100.1	2.2	2822	2724	4.8
Nikitskoe	142.5	101.3	2.1	2919	2798	3.0
Kalskoe	142.8	99.5	2.5	2817	2766	2.8

The content of humus by layers of peat soil of the studied ameliorative objects is presented in Table 2.

Table 2 - Content of humic substances in peat soils

Reclamation object	Depth of layer, cm	Humic substances (C*2), % of org. mass	From humic substances, % of C_{total}
Tinky-II	0-10	49.5	58.6
	10-20	66.2	76.7
	20-30	78.8	80.0
Vozha	0-10	76.1	83.5
	10-20	66.4	65.4
	20-30	69.2	62.0
Nikitskoe	0-10	72.8	88.5
	10-20	68.3	67.3
	20-30	69.8	63.2
Kalskoe	0-10	66.7	82.0
	10-20	70.3	85.2
	20-30	64.2	73.5

Analysis of Table 2 made it possible to trace the changes down the profile of the amount of humic substances. The high content of humic substances, noted in the horizon of 20-30 cm at the site of Tinky-II object, is probably due to the increased content of grass peat-forming agents in the botanical composition of the soil and double regulation of the water regime.

Humic acids predominate in humus, as shown in Table 3. Their maximum amount is noted in the soil of Tinky-II reclamation facility under perennial grasses. An increase in the ratio of humic and fulvic acids is observed in lowland peatlands used for a long time in agriculture, which is associated with a more intensive accumulation of humic ones, as biologically stable under conditions of active development.

Table 3 - Composition of humic substances in soils

Reclamation object	Depth of layer, cm	C_{HA}	C_{FA}	C_{HA}/C_{FA}
Tinky-II	0-10	28.14	6.47	4.35
	10-20	25.07	7.98	3.14
	20-30	28.71	8.17	3.51
Vozha	0-10	21.99	16.30	1.35
	10-20	18.84	14.26	1.32
	20-30	25.07	9.82	2.55
Nikitskoe	0-10	20.64	16.83	1.23
	10-20	13.71	8.89	1.54
	20-30	20.10	8.02	2.25
Kalskoe	0-10	16.18	15.78	1.01
	10-20	20.81	13.51	2.03
	20-30	30.79	6.26	4.92

The greatest need for plants is observed in nitrogen, so the conditions for their supply with this element deserves special attention. Nitrate nitrogen is available for plants. Taking into account the variability of the nitrogen content in peat soil during the growing season, soil samples were taken at the end of August. The total nitrogen content in the soils of Tinky-II, Vozha, Nikitskoe, and Kalskoe averaged 305.5 mg / 100 g of dry soil, 148.8 mg / 100 g, 151.6 mg / 100 g and 169 mg / 100 g. The content of nitrate nitrogen was 144.5 mg / 100 g, 116.2 mg / 100 g, 121.0 mg / 100 g and 132.6 mg / 100 g of dry soil, respectively. The nitrification process is most intense in the arable and aerated horizon.

Calcium is of great importance in peatlands as an indicator of acidity and the peat formation process. Its concentration in Tinky-II, Vozha, Nikitskoe and Kalskoe facilities was 0.78; 0.42; 0.44 and 0.48.

The phosphorus content in peat soils is low. The proportion of P_2O_5 for a half-meter soil layer of 30-50 cm is 0.25-0.3 % of absolutely dry matter. Potassium in peat soils is very small - up to 0.03-0.05 %. In peat soils, there are also trace elements - copper, boron, manganese, etc., but in most cases their content is insufficient or inaccessible to plants.

Soil biological activity is very high (Figure 2).

The linen decomposition by microorganisms is very strong in the soils of Vozha, Nikitskoe and Kalskoe facilities due to secondary waterlogging, and at Tinky-II facility it is slightly weaker due to dual regulation of the water regime.

Earlier monitoring studies of drained peat soils of land-reclamation objects [2, 3, 7–11] revealed vivid signs of degradation and secondary waterlogging: peat depletion, the presence of wetlands, an increase in peat ash and surface sands. The diversity of soil continuum within one plot was created: the average depth of peat was 41 cm on average, the minimum value was 26 cm and the maximum one was 80 cm. Since 1952, the surface of the peat deposit has dropped by 1.9 m.

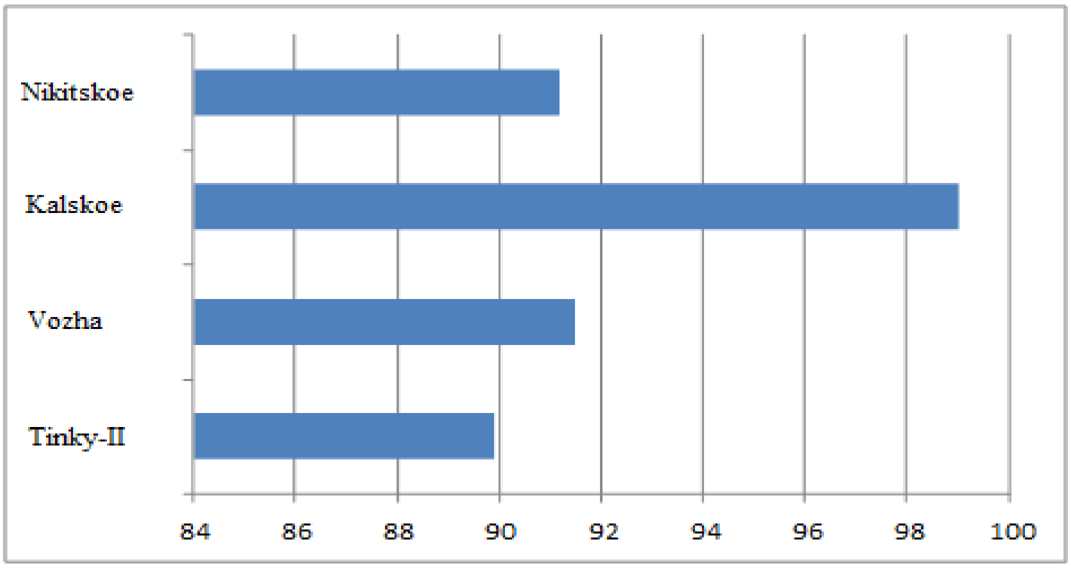

Figure 2 - Cellulose-destructive activity of the soil at the ameliorated objects

The study of soil fauna as an indicator of the degree of human disturbance of the biocenoses and the possibility of its restoration is of great importance.

For almost 70 years of land-reclamation objects functioning in the soil, there were certain changes in the structure of the soil micro-flora, in our opinion, because of the disturbance of the food and water regime of the studied soils. Bacteria-ammonifiers had a significant impact on the activity of the mineralization of soil organic matter [9]. Of all the groups of microorganisms, the bacteria that developed on MPA varied greatly in the soil. The activity of the ammonification process was largely due to this group of bacteria. The average number of ammonifiers during the growing season ranged from 1,254 to 1,816 thousand / g of dry soil. Moreover, the maximum number of microorganisms was observed in July in the soil at Tinky-II facility, then it gradually decreased by the end of the summer.

Changes in seasonal dynamics were also noted for bacteria assimilating mineral forms of nitrogen (SAA). Their number somewhat exceeded the content of ammonifying bacteria (MPA), making up 2,922-3,820 thousand / g of dry soil, and the maximum was noted in the soil of Kalskoe facility.

The ratio of the number of these groups of organisms indirectly characterized the degree of activity of mineralization of organic matter in the soil. The number of bacteria that assimilate mineral nitrogen (SAA) in the soil averaged 2.33 times more than the biota grown on MPA.

Spore-forming bacteria-bacillus characterizes the intensity of mineralization processes at later stages. Their activity is associated with the transformation of more stable organic compounds in the soil. This is facilitated by a more powerful proteolytic enzyme system (in comparison with bacteria that are not able to form spores). They are “indicos” of the orientation of the soil-forming process. This group of bacteria had a population of 190 to 286.4 thousand / g of dry soil. Their most intensive development was noted in the soil of Tinky-II ameliorative object, which was apparently due to the double regulation of the water regime of the soil and the greater solubility used by bacteria to nourish chemical elements. Along with the widely represented *Bacillus megaterium* species, *Bacillus mycoides* and *Bacillus cereus* were noted, which did not assimilate mineral nitrogen, but consumed nitrogen-containing organic matter.

Actinomycetes are widespread and unpretentious, intensively developed with a neutral reaction of the soil solution. They assimilate complex and inaccessible organic substances due to the presence of a powerful proteolytic enzyme system. Actinomycetes outnumbered bacterial spores, reaching an average of 1,103.4-1,79.6 thousand / g of dry soil. The course of the seasonal dynamics of these microorganisms in the soil was in many respects similar to the dynamics of spore-forming bacteria: from spring to the end of the summer their number gradually increased. Due to the activity of actinomycetes in the soil, the processes of mineralization and the release of nutrients from organic matter proceeded with a certain stability.

Microscopic fungi were inferior in number to all other microorganisms. Seasonal dynamics manifested itself in a minimum in spring, and by the beginning of summer their number grew to the maximum, again decreasing by the beginning of autumn. The dominant species of microscopic fungi was *Penicillium viridicatum*. The number of microorganisms in the soil is presented in Table 4.

Table 4 - The number of microorganisms in the soil layer of 0-20 cm, thousand / g of dry soil

Variant	May	June	July	August	September	At the average
The total number of bacteria on MPA						
Tinky-II	1,750	1,790	1,880	1,960	1,700	1,816
Vozha	1,200	1,290	1,400	1,220	1,160	1,254
Nikitskoe	1,280	1,380	1,490	1,380	1,210	1,348
Kalskoe	1,450	1,550	1,700	1,500	1,390	1,518
The total number of bacteria on SAA						
Tinky-II	3,300	3,800	4,000	4,200	3,800	3,820
Vozha	2,500	2,710	3,100	3,400	2,900	2,922
Nikitskoe	2,580	2,910	3,260	3,800	3,000	3,110
Kalskoe	2,700	3,130	3,380	4,000	3,400	3,322
Spore-forming bacteria						
Tinky-II	185	189	228	241	238	216.2
Vozha	166	170	180	206	194	286.4
Nikitskoe	169	178	185	218	200	190.0
Kalskoe	169	200	208	217	201	199.0
Actinomycetes						
Tinky-II	1,100	1,150	1,200	1,280	1,228	1,191.6
Vozha	1,000	1,080	1,125	1,199	1,113	1,103.4
Nikitskoe	1,060	1,110	1,158	1,202	1,176	1,141.2
Kalskoe	1,102	1,120	1,183	1,212	1,179	1,379.6
Fungi						
Tinky-II	28	40	20	14	23	25
Vozha	34	47	25	21	30	31
Nikitskoe	46	63	34	30	44	43
Kalskoe	50	61	36	25	43	43

The maximum cellulose-depleting activity was observed in the soil of reclamation object Tinky-II. The cellulose destruction activity on the Zvyagintsev scale was characterized as strong - very strong. The highest rates of linen decomposition were found in the soil of Kalskoe object - 98 %, which, in our opinion, was associated with the development of the secondary waterlogging of the territory. The smallest rates were in the soil of object Tinky-II with double regulation of the water regime during sluicing - 89 %.

The invertebrate population of the soil of reclaimed objects is monotonous and poor. Collembolans and oribrated mites dominate in numbers, however, due to the small size of these animals, their participation in the formation of soil zoo mass is negligible and less than 1 %.

Among the larger representatives of the soil mesofauna, earthworms dominate both quantitatively and by biomass and 4 species of them are found in the study area. Of these, *Allolobophora ealliginosa* dominates, which is characterized by dwelling in relatively deep soil layers, below the litter horizon. The participation of litter forms in the earthworm population is relatively small [19, 20]. Among this ecological group of oligochaetes, the relatively small *Lumbricus rubellus* predominates, which dominates both in numbers and in biomass. In general, earthworms account for 84.58 % of all detected soil mesofauna, and 98.39 % by biomass. On 1 m^2 there are 24.3 individuals of earthworms of all kinds. These rates are very low. They turned out to be rather close to the data obtained in previous studies for podzolic soils, salt marshes and highly closed forests with poor grass stand [17]. In more favorable for invertebrate soils, characterized by a high content of humus, the optimum values of acidity and humidity, the density of earthworms can be many times higher - up to 400-700 individuals per 1 m^2 [17]. Thus, it is obvious that for the predominant group of soil mesofauna — oligochaetes — the area under study is characterized by extremely unfavorable conditions

The second places after the worms are soil insects, which together account for 4.55 % of individuals and 0.7 % of biomass. These are ground beetles, shredders, cut worms, larvae and pupae of Diptera.

Among other soil invertebrates, woodlice, millipedes (millipedes, drupes and Geophilidaes), daddy long legs and spiders were found in the study area (Table 2). The numbers of all these invertebrates are extremely low, only woodlice were found with a density of 1 specimen per m^2, the population density of the remaining arthropods turned out to be significantly less, they were not found in every soil sample.

The characteristics of the fauna composition of the animal population of reclaimed peatlands (Table 5) indicate some violation of the trophic and water regimes of drained peat soils.

Table 5 - Invertebrate biota in drained peat soils of reclaimed objects

Invertebrates	Per 1 m^2	Share in soil fauna, %	Share in soil mesofauna, %	Mass fraction, %
Allolobophora ealliginosa	17.2	3.73	59.93	75.87
Lumbricus terrestris	0.9	0.20	3.14	8.81
Lumbricus rubellus	5.3	1.15	18.47	10.34
Dendrobaena octaedra	0.9	0.20	3.14	3.37
Carabidae sp., l.	0.1	0.02	0.35	0.03
Elateridae sp., l.	0.2	0.04	0.70	0.11
Carabidae sp., im	0.1	0.02	0.35	0.05
Staphylinidae sp. im.	0.3	0.07	1.05	0.13
Noctuidae sp., l	0.2	0.04	0.70	0.29
Diptera sp., pup.	0.1	0.02	0.35	0.02
Diptera sp., l	0.3	0.07	1.05	0.07
Oniscidae sp.	1.0	0.22	3.48	0.34
Lithobius sp.	0.9	0.20	3.14	0.07
Diplopoda sp.	0.3	0.07	1.05	0.13
Geophilus sp.	0.2	0.04	0.70	0.03
Phalangidae sp.	0.4	0.09	1.39	0.11
Aranea sp.	0.3	0.07	1.05	0.06
Oribatida sp.	320	69.46	-	0.09
Collembola sp.	112	24.31	-	0.08

The total biomass of invertebrates was 13,521.45 mg per 1 m^2.

The poor composition of the invertebrate inhabitants and their small number are explained by the low content of nutrients in the soils. Mechanical composition also has a serious effect, because the size of soil particles determines porosity, water permeability and aeration, particle cohesion and other soil properties that are of paramount importance for animals. The larvae of beetles, earthworms, pot worms and centipedes often serve as a sign of the soil richness with humus substances.

A clear link was observed between the vertical distribution of humus and soil animals (R = 0.78): nutrients are consumed by biota, and soil animals leave excrement, enriching deep horizons with organic substances [3, 4, 6, 9, 11]. In turn, the low number of invertebrate geobionts determines the low number of their consumers, in particular, insectivorous birds feeding in the land layer [1, 13], which in the study area is significantly lower than in stations with richer soils.

At ameliorative object Tinky-II in August 2018, a survey of vegetation was conducted to determine the botanical composition of meadow grasses, the degree of abundance and yield. The results are shown in Table 6.

Table 6 - Botanical summary of reclamation object Tinky-II

Species name: Russian	Species name: Latin	Average height, cm	Occurence	Drude abundance	Association name
Couch grass	*Elytrígia répens*	114	98	soc	Elytrígetum urtícetosum
Common foxtail	*Alopecúrus praténsis*	88	47	cop.1	
Common toadflax	*Linaria vulgaris*	46	49	cop.1 in blocks	
Common nettle	*Urtíca dióica*	89	68	cop.3	
Fowl bluegrass	*Poa palustris*	*60*	60	cop.3	Elytrígetum urtícetosum
Common oat	*Avéna satíva*	*67*	34	sol.-sp.	
Lady grass	*Phalaris arundinacea*	*80*	67	cop.3	
Common timothy	*Phleum pratense*	*78*	39	sol.-sp.	

The yield of green mass of meadow grasses in terms of 1 m2 was 5.236 kg at Tinky-II facility, 2.967 kg at Vozha, 3.892 kg at Nikitskoe and 4.066 kg at Kalskoe.

DISCUSSION

Under the influence of drainage, reclamation and use, peat soils undergo significant physical, chemical and biological changes. Peat is compacted, humified and mineralized. Ultimately, this leads to a decrease in the power of the peat layer.

The assessment of the compliance of the natural conditions of Tinky-II reclamation object determined the value of the aggregate fertility indicator of the peat soil. It indicates the poor condition of agricultural land and the presence of sharp drops in soil indicators.

Using the object classes of GDB "Landscapes", "Land Types", "Land Users" and GIS overlay operations, a resulting layer was obtained containing information about the composition and structure of peat soils. On its basis, a map of land-reclamation objects, their agricultural development and forest cover was compiled, allowing to judge the suitability of the landscape of the region for agricultural activities.

The results showed that the studied landscape is characterized by environmental stabilization factors: 15 % of unstable well-defined, 38 % of unstable, 38 % of relatively stable, 4 % of stable and 2 % of stable good condition.

Based on the stabilization factor, the ratio of stable and unstable ecosystems in the landscape can be regulated. In our opinion, forests, forest belts, meadows and aquatic ecosystems should occupy an important place, harmoniously fitting into the structure of the landscape and being its functional complement. One of the best options for implementing approaches to improve the functions of the study site is to take care of the forest belt and the site of ameliorative object with an unstable well-marked and unstable condition, occupying 53 % of the study area. It is recommended that the site is involved in agricultural production in order to prepare fodder from meadow grasses.

The research results indicate a deep relationship between the parameters of soil quality, the vital functions of soil microorganisms and geobionts invertebrates, which, in turn, by means of trophic relationships determines the structure of the ecosystem as a whole.

CONCLUSION

Drained peatlands were widely used in agriculture for growing feed and other crops. Currently, peat soils are not used in agriculture and degrade. This is due to their specific feature - after drainage and use during operation, they become environmentally unstable and subject to the destruction of organic matter until its complete disappearance. It is impossible to stop the depletion of organic matter of peat completely, even with any drainage mode and the use of peat soils.

Summarizing the results of monitoring studies, the following conclusions are made:

1. For a long time of using the peat soil, peat drawdown occurred, wet spots appeared, indicating secondary waterlogging, ash content increased, and sand deposits spread to the surface in some places, the diversity of soil cover was formed.
2. There was a decrease in the total peat sediment by more than 1.2 times.
3. The volume mass of peat soils on objects increased from 0.12 to 0.58 g / cm^3 due to salinity and compaction of the upper layer.
4. In 2018 the average ash content of peat at reclamation object of Tinky-II was 22.1 % in a layer of 0-5 cm, at Vozha and Nikitskoe - 15 and 17 %, respectively and at Kalskoe - 19.5 %. The density in a layer of 0-50 cm reached 462 kg / cm^3, 160 kg / cm^3, 168 kg / cm^3 and 204 kg / cm^3 according to the objects.
5. The peat soil from 1955-2018 turned into a humified mass, which degrades more and more with further use and it may lead to a complete drawdown of the peat soil.
6. Porosity in the layer of 0-20 cm was 50 %, 42 %, 48 % and 41 % of the soil volume, respectively to objects.
7. The durability of a meter layer of peat soils at Tinky-II object showed 170 years with theoretical calculations, 132 and 140 years at Vozha and Nikitskoe sites and 138 years at Kalskoe.
8. In 2017 the thickness of the peat layer at Tinky-II facility was 116 cm, at Vozha facility - 106 cm, at Nikitskoe facility - 96 cm and at Kalskoe facility - 116 cm.
9. The filtration coefficient at Tinky-II, Vozha, Nikitskoe and Kalskoe sites ranged from 0.2 to 0.5 m / day, which is typical of highly decomposed peat.
10. Total water capacity reached 190 % of absolutely dry weight (Kalskoe object) and 270 % (Tinky-II object), that is, decreased by almost 50 % compared with the first years of using the dry soil.
11. The water output approached 5.18 ... 6.02 with a filtration coefficient of 0.2 ... 0.5 m / day.
12. The loss of organic matter in soils at reclamation objects was detected from 2,843 to 2,724 t / ha. However, humic acids prevail over fulvic acids, which is favorable for plant growth and development.
13. The total nitrogen content in the soils of Tinky-II, Vozha, Nikitskoe and Kalskoe averaged 305.5 mg / 100 g of dry soil, 148.8 mg / 100 g, 151.6 mg / 100 g and 169 mg / 100 g. The content of nitrate nitrogen was 144.5 mg / 100 g, 116.2 mg / 100 g, 121.0 mg / 100 g and 132.6 mg / 100 g dry soil, respectively. The concentration of calcium at Tinky-II, Vozha, Nikitskoe and Kalskoe was 0.78, 0.42, 0.44 and 0.48, respectively. The content of phosphorus was 0.25-0.3 % of absolutely dry matter and that of potassium was up to 0.03-0.05 %.
14. Soil biological activity is very high: up to 91 ... 99 %.
15. The number of soil microorganisms is low and the studied soils are also unfavorable for invertebrates - geobionts;
16. A botanical survey of object Tinky-II showed the overgrowth of seeded meadows with natural herbs. Herbs are hydro and hygrophytes, which tolerate excessive soil moisture. An association called Elytrígetum urtícetosum was established.
17. The yield of meadow grasses herbage in terms of 1 m2 of soil was 5.236 kg at Tinky-II facility, 2.967 kg at Vozha, 3.892 kg at Nikitskoe and 4.066 kg at Kalskoe.
18. The geo-information model with databases shows that the studied landscape is characterized by environmental stabilization factors: 15 % of unstable well-defined, 38 % of unstable,

38 % of relatively stable, 4 % of stable and 2 % of stable good condition.

The rational nature management of peat bogs should be based on a scientific approach that allows an objective assessment of the dynamics of modern natural processes in peat-bog ecosystems in their natural state and under anthropogenic impact. It also makes possible to develop scenarios for optimizing the integrated use of peat bogs with environmental priority.

Environmental management activities should include protection, directed use, and restoration of the fertility of reclaimed objects. Thus, it is recommended to take care of tree lines and a plot of ameliorative object with an unstable well-formed and unstable condition, occupying 53 % of the territory under study, and involve the site in agriculture in order to harvest fodder from meadow grasses.

A special place is given to the agricultural use of reclaimed peat soils. In order to form the scientific principles for managing the mineralization of organic matter in peat, deep study of two little-studied aspects is necessary: the different quality of the composition and properties of organic matter in peat soils of different genesis and its transformation patterns in the process of soil formation.

REFERENCES

1. Baranovskiy, A.V. and Avdeeva, N.V. The number of birds in various forest types of the Meshchersky National Park. *Mod. high techn*, **2012**, 4: 9-11.
2. Bakhnov, V.K. Biogeochemical aspects of the swamp formation process. Novosibirsk, 1986.
3. But-Gusaim, A.S. Investigation of the durability of peat-bog soil. *Sc. conf. abstr. on the problems of mineralization and erosion of peat*. Minsk, Science and Technology, **1978**: 50.
4. Vilenskiy, D.G. et al. Systematic description of the soils of the Mescherskaya lowland. *Book* The study of the natural conditions of agriculture of Mescherskaya lowland. Moscow, MSU Publishing House, **1961**: 29-35.
5. Vinogradov, D.V.; Lupova, E.I.; Khromtsev. D.F. and Vasileva, V. The influence of bio-stimulants on productivity of coriander in the non-chernozem zone of Russia. *Bulgarian J. of Agric. Sc.*, **2018**, 24(6): 1078–1084.
6. Gilyarov, M.S. Methods of soil-zoological research. Moscow, Science, **1969**.
7. Golovko D.G. Farming on peat soils and drained flood lands. Moscow, Kolos publishing house, **1975**: 9-12.
8. Evsenkin K.N., Peregudov S.V., Nefedov A.V., Ivannikova N.A. Efficiency of fertilizer improver to increase the fertility of previous peat soils. *In Proc. scientific papers of the international scientific-practical conference.* Problems of the rational use of environmental systems of dry territories. Ryazan, **2015**: 36-39.
9. Zakharova, O.A. and Kostin, Ya.V. The mode of organic matter in the soil. Ryazan, RSATU, **2013**.
10. Zakharova, O.A. Resource-saving technology to restore degraded soils. Ryazan, **2004**.
11. Inisheva, L.I. The concept of the protection and rational use of peat bogs in Russia. Moscow, RAAS, **2005**. Access mode: http://sinref.ru/000_uchebniki/ 01600geografia/014 koncepcia_ohrani_i_ racianalnogo_ispolzovania _bolot_rossi_inisheva_2005/002.htm Access date 05.08.2018.
12. Kreshtanova V.N. Genetic features and fertility assessment of developed Russian peatlands. *Increasing the efficiency of land improvement of agricultural land.* Proc. of Int. sc.-pract. conf. Minsk, **2005**: 178-179.
13. International Agri-Environment Forum, May 21-23, 2013, St. Petersburg. *Materials in three volumes.* Rus. Acad. of Agric. Sc., North-West Regional Scientific Center of Russian Agricultural Academy, North-West Research Inst. of Agricultural Mechanization and Electrification of Rosselkhozacademy. V. 1, **2013**.
14. Maslov, B.S. Reclamation of peat bogs. Tomsk, Tomsk State Pedagogical University Press, **2006**.

15. Musaev, F.A.; Evsenkin, K.N.; Dobrachev, Yu.P. and Zakharova, O.A. Estimation of pollution of ameliorated agrolandscape with nitrogen-containing substances and methods for their reduction. Ryazan, **2014**.
16. Numerov, A.D.; Klimov, A.S. and Trufanova, E.I. Field studies of terrestrial vertebrates: study guide. Voronezh, VSU, **2010**.
17. Pivovarova, M.S.; Dobrodey, A.V.; Zakharova, O.A.; Odnodushnova, Yu.V. and Talanova, L.A. Vegeculture. Ryazan, RSAA, **2006**.
18. Information about the number of earthworms in the soil [Electronic resource] Access mode: http://portaleco.ru/dozhdevye-chervi-i-pochvoobrazovanie/svedenija-o-chislennosti-dozhdevyh-chervej-v-pochvah.html Access date 3.09.**2018**.
19. Khlebosolov, E.I.; Mitin, E.I.; Salnikov, S.V.; Marochkina, E.A.; Khlebosolova, O.A.; Ivanchev, V.P.; Cheltsov, N.V.; Babushkin, G.M.; Lobov, I.V.; Baranovskiy, A.V.; Shemyakina, O.A.; Fionina, E.A.; Zatsarinny, I.V.; Ananyeva, S.I. and Babkina, N.G. Birds of Ryazan Meschera. Ryazan, Voice of Gubernia, **2008**.
20. Davey Henry. The principles, construction, and application of pumping machinery: (steam and water pressure): with practical illustrations of engines and pumps applied to mining, town water supply, drainage of lands, etc. also economy and efficiency trials of pumping machinery. Charles Griffin & Company Limited, **1900**.
21. Heuperman, Albertus S.; Kapoor, Arjun S. and Denecke, Harry W. Biodrainage: principles, experiences and applications. Rome, IPTRID secretariat: FAO of the UN, **2002**, IX.
22. Irrigation and drainage. *The J. of the Intern. Commiss. on Irrig. and Drainage*. Bognor Regis, Wiley, **2002**.
23. Stuyt, L.C.P.M.; Dierickx, W. and Beltrán, J. Martínez. Materials for subsurface land drainage systems. Rome, FAO, **2000**, XIV.
24. Tulu, T. Estimation of crop coefficients for compilation of PET. *Intern. J. of Trop. Agric.*, **1990**, v. 8, no. 1: 49-53.
25. Wu Hengan Xu Yojiu. Allocation of incremental irrigation benefits. *J. of Irrig. and Drainage Engin.*, **1988**, v. 114, no. 4: 664-673.
26. Ilieva, A. and Vasileva, V. Effect of liquid organic humate fertilizer Humustim on chemical composition of spring forage pea. *Banat's J. of Biotechn.*, ISSN: 2068-4673, **2013**, IV (7): 74-79.
27. Shchur, A.V., Vinogradov, D.V. and Valckho, V.P. Effect of different levels agroecological loads on biochemical characteristics of soil. *South of Russia: ecology, development*, **2016**, 11(4): 139-148. (In Russ.) DOI: 10.18470/1992-1098-2016-4-139-148.
28. Shchur, A.; Valkho, V.; Vinogradov, D. and Valkho, O. Influence of biologically active preparations on Cs-137 transition to plants from soil in the territories contaminated as the result of Chernobyl accident. Impact of Cesium on Plants and the Environment. Springer International Publishing Switzerland, **2016**, vol. 51-70. DOI: 10.1007/978-3-319-41525-3.
29. Khabarova, T.V.; Vinogradov, D.V.; Kochurov, B.I.; Levin, V.I. and Byshov, N.V. Agroecological efficiency of sewage sludge and vermicompost in agrocenoses of cultivated oat. *South of Russia: ecology, development*, **2018**, vol. 13, no. 2: 132-143. (In Russian) DOI: 10.18470/1992-1098-2018-2-132-143.

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