Sys Rev Pharm 2021;12(3):477-488
A multifaceted review journal in the field of pharmacy

Mineralogical Composition Of The Oozy Matter In The Soils Of Polesye And Opolye In The West Of European Russia

ABSTRACT

This study is aimed at exploring the mineralogical composition of the oozy matter of the soils in the west of European Russia and assess the impact of intensive agrarian activities on this composition. The research object is the oozy matter of the

Umbric Albeluvisols Abruptic and Greyic Phaeozems Albic soils of the natural and agrarian environmental systems of Polesye and Opolye. The study is conducted by the comparative geographic, soil key, crossover, particle size, and mineralogic methods. The study results are that the oozy matter of the tested soils consists of hydromicas, chlorite, mixed-layer mica smectite and mica vermiculite formations, with feldspar and quartz as companion minerals. The oozy matter of the soil in the natural environmental systems in Polesye has an almost generic mineralogical composition. In the agrarian horizon of the intensive argarian ecosystems of Polesye and Opolye the mineralogical composition of the oozy soil matter transforms, which shows in the change in the type of particle arrangement, an increase in the smectite content as compared with the illuvial part of soil crossovers and matrix rocks. The conclusion is that in the agrarian horizons of the soil explored intensive

activities increase the smectite content and change the type of particle arrangement, except for grey forest soils with a second line of humus. At deeper soil levels the agrarian impact on the mineralogical composition of the oozy soil matter disappears.

Keywords: Greyic Phaeozems Albic, mineralogical composition of the oozy fraction, natural and intensive agricultural ecosystems, Umbric Albeluvisols Abruptic

INTRODUCTION

In most cases the dominant component of the oozy fraction in soils is crystallized agrillaceous minerals referred to the subclass of layered silicates the crystalline lattices of which contain silicon-oxygen tetrahedron as an indispensable component. The most widespread among these agrillaceous minerals are kaolinites, micas and hydromicas (micaceous clay), vermicullites, montmorillonites (smectites), and chlorites[1].

Because of their high dispersion, argillaceous minerals have enormous unit areas measured as tens and hundreds of square meters per g of mineral. These minerals also exhibit high chemical activity for their surface contains oxygen ions and/or hydroxyl groups that easily generate hydrogen bonds. In most argillaceous minerals the crystalline lattice is charged negatively; however, this negative charge is neutralized by positively charged particles called cations. A strong electric field forms around the cations on the argillaceous crystallite surface, which predetermines the manifestation of catalytic properties of argillaceous minerals.The high chemical activity of argillaceous minerals is also conditioned by the occurrence of mixed-valent ions, especially iron ones, in their crystalline lattices. This is why, argillaceous minerals can be both, oxidizing and deoxidizing for the environment.The molecules of water on the argillaceous mineral surface, especially those captured within the electric field of the cations on this surface, have several distinct features, including a strong dissociation property. In this case, the hydroxyl group remains near the cation and the hydrogen ion can dissociate, which endows water with clearly acidic properties.The exploration of the content and composition of argillaceous minerals in soils is essential. Usually, the content of these minerals ranges from several percents in light soils to 20 to 40 % in loamy and clayey soils. The reactions continuously observed on the argillaceous mineral surface are sorption and desorption, fixation and exchange of cations and other particles, hydration and dehydration.Kaolinites included in finely dispersed fractions have no favorable effect on soil fertility for their crystalline lattice contains no critical fertilizer elements for plants. If these elements are applied with mineral amendments in cationic form and incompletely absorbed by the plants, kaolinite absorbs a small part of the added compounds due to low cation exchange capacities (CEC), which is why these elements may leach out from the soil and enter subterranean waters and thus pollute the environment. Soils with a high kaolinite content have a low buffering ability with respect to most of the fertilizer elements found in cationic form in the soil solution. Micas and micaceous clays contained in the soil produce a positive effect on fertility and the interaction between the soil and certain pollutants. This is conditioned by the fact that their crystalline lattices contain potassium known as a critical fertilizer element; in addition, micas and illite are the main natural source of potassium compounds available to plants.The efflorescence of potassium and its release from crystalline lattices of trioctahedral micas and micaceous clays occur much faster than their efflorescence and release from dioctahedral structures, which is due, first of all, to the differences in the orientation of the OH-groups contained in the octahedral vertices inside the trilayer packet[2].

The occurrence of wedgy exchange positions, highly selective to big low-hydrated cations, in lateral shears of micaceous clay particles determines the capacity of such minerals for the reliable, nonexchangeable fixation of K^+ and NH_4^+ ions, which also heavily affects the conditions of the ammonium and potassic nutrition for plants.The side wedgy exchange positions of micaceous clays are highly selective to the absorption of hazardous radiocesium. It has been established that an increase in the content of the specified minerals in the soil heavily curtails the absorption of radiocesium from polluted soils by plants[3].

Montmorillonites contained in the oozy fraction have a major effect on soil features. Other things equal, soils with a high montmorillonite content are characterized by high CEC, large unit area, high swelling power and water-retaining capacity; in addition, montmorillonite can affect several agrochemical characteristics of soils and the supply of plants with fertilizer elements.

Montmorillonites contain many macro- and micronutrients in exchange form. These elements are released with the destruction of crystalline lattices and can be used by plants.

The result of a high CEC and a large unit area is that, when the fertilizer is added in cationic form to the soil rich in montmorillonites, some part of the elements is exchangeably absorbed by these minerals. While living organisms consume the fertilizer elements from the soil solution, their reserves in it are replenished with exchangeable forms. This is why, montmorillonites endow the soil with a high buffering capacity relative to cations[4].

The high CEC of montmorillonites allows them to increase the buffer value of soils on exposure to acid precipitation, especially for buffer reactions within a pH range of 4.2 to 5, whereas highly charged montmorillonites (0.4 to 0.6 units per basic cell) nonexchangeably fix the potassium and ammonium ions needed for plant nutrition.Vermiculites absorb from the soil solution the potassium and ammonium ions added with fertilizers, fix these ions in the crystalline lattice and, therefore, prevent them from being washed out from the soil into drain waters, and produce a major effect on plant nutrition. On the onwe hand, fertilizer doses are increased for soils with a high potassium- and ammonium-fixing capacity to maintain optimal concentrations of these ions, which increases the product cost. On the other hand, the nonexchangeable reserve of these fertilizer elements replenishes the content of their exchangeable and water-soluble forms in the course of absorption by plants[5]. In case of the interaction with acid precipitation the high CEC of vermiculites predetermines the soil's buffer capacity against hydrogen ions.Chlorites are a source of magnesium and some micronutrients for the nutrition of plant roots. If their additional octahedral layer is partially dissolved, the chemical activity intensifies and they can be used to absorb anionic and cationic radionuclides[6].

The occurrence of chlorites in the oozy fraction increases the buffering capacity of soils on exposure to acid agents for dissolution and other transformations of these minerals take place with the absorption of hydrogen cations, especially, when the neutralization of these cations occurs at $pH < 4.2$[7,8,9].

Thus the exploration of the mineralogical composition of the oozy fraction as the most active soil fraction is relevant to the understanding of peculiarities of agrotechnogenic soil formation. The influence of soil ooze minerals on the behaviour of various substances in the soil, including inbound ones, and on their mobilization fixation, and transformation is hard to overestimate. The mineralogical analysis of fime soil fractions is a must in validating the genetic specificity of a soil.According to the basic studies conducted by B. P. Gradusov[10,11,12,13,14,15,16,17,18], the oozy fractions of boreal soils in plain agricultural regions have the following polymineral composition: hydromicas, mixed-layer mica smectites, some kaolinite and chlorites. The high levels of soddy podzols and grey forest soils are depleted with an expanding smectite component. In this context, minerals play a critical role in the genesis of soils, manifestation of their ecological functions, and creation of efficient fertility, for example, in the ability to mobilize and fix fertilizer potassium and ammomium as well as various radionuclides, especially, cesium and strontium that enter the soil with the precipitates after atmospheric nuclear tests and technogenic accidents.In an abiotic medium argillaceous minerals participate as catalysts in various geochemical processes[19]. It is assumed that these minerals were involved in the origin of life on the Earth by participating in the generation of polymers from L, D, and LD forms of amino acids[20,21,22,23], Kaolinite clays catalyzed mainly the polymerization from L-isomers of amino acids[24,25,22].

The mineral matrix formed in the soil by mineral surfaces organizes around itself various substances and thus determines a lot of properties, such as moisture cantilevering, interaction with water, content and composition of exchange cations, shape and strength of structural aggregates, and others. The soil matrix has areas, where pollutants can be concentrated in amounts several times as high as their concentrations calculated per gram of soil. This is why, the MAC and other parameters of pollution assessment, that are expressed per unit soil weight, downplay the hazard of pollution by understating actual concentration levels[26].

The problems of soil mineralogy in agrotechnogenesis are formulated and exposed to an in-depth analysis in seminal studies writtten by N. P. Chiizhikova[27,28,29,30,31]. However, these works ignore the west of European Russia, where diverse Polesye and Opolye landscapes are located in close neighbourhood. These landscapes have long been used for intensive agricultural activities and have the highest content of Chernobyl radionuclide pollutants in Russia. At the same time, it is necessary to solve the problems of modern agricultural production must be solved and monitor and forecast the changes in the natural environment using information about distinct regional characteristics of the transformation of the most active mineral part of the soils.

MATERIALS AND METHODS

The research objects were soils of the key land sections (KLS) situated in the Bryansk oblast' in the west of European Russia. The Novozybkov and Klintsy KLS are situated in the east of Polesye[32], whereas Starodub KLS 1 and 2 are situated in the central southwest of Russian Opolye[33,34,35]. After the precipitation of ^{137}Cs the soils of the Novozybkov and Klintsy KLS were polluted by its concentrations of 555 to 1480 kBq/m^2 whereas the pollutant concentration in both Starodub KLS was 37-185 kBq/m^2.

Each KLS consisted of base soil sites of 25 to 30 sq. m in area. Those sites were located in the immediate neighborhood of each other, differed by the agrogenic impact on the soil and were called a natural ecosystem and an intensive agroecosystem. Sixty-to-seventy-year long fallow sites in the afforestation belts of the Novozybkov, Klintsy, and Starodub state strain-testing stations (SSST) in the Bryansk oblast' were used as the ecosystem models. The intensive agroecosystems were situated on the SSST fields and were characterized by ecological succession, powerful argarian impact on the soil, and inclusion in the biocycle of large amounts of substances not registered in those landscapes earlier.Three years after the precipitation of the radionuclides from Chernobyl, a full-profile soil section and several bypits were arranged. The bypits were used to conduct a detailed macro- and mesomorphological study of the crossovers by modern methodological approaches[36,34,37] and and select the soil monoliths that are kept at the geology and soil museum of the Bryansk state agrarian university and can be provided for further study.The mixed samples were taken from the soil section walls along the upper and in the middle of the other genetic horizons. The oozy fraction was extracted by the method elaborated by N. I. Gorbunov[38]. In V. V. Dokuchaev Soil Institute the oriented oozy fraction preparations were examined by the X-ray diffractometric method using the apps made by Carl Zeiss Jena (Germany). The operational settings of an XZG–4A general-purpose diffractometer are specified below: the tube voltage is 30 kV, the anode current is 30 mA, the goniometer rotation speed is 2º/min, the irradiation is copper and let pass through nickel as a filter. The X-ray diffractograms were recorded for air-dry samples saturated with glycol alcohol and annealed for 2 h at 550ºC. The semi-quantity content of main mineral phases in the oozy fraction was determined by the method elaborated by P.E. Biscaye[39]. The relative areas of diffraction maxima were measured in ranges of 7.0, 10, and 17–18 Å on the X-ray patterns of the preparations saturated with glycol alcohol, which corresponded to the intensities of the primary basal reflections of kaolinite and chlorite, hydromica and mixed-layer formations with a smectite packet. Then the areas of diffraction peaks were calculated to their sum, with allowance for structural factors. The recalculation coefficient used for hydromica, 7.0 Å reflection of kaolinite and chlorite and mixed-layer formation was 4, 2, and 1, respectively.

RESULTS AND DISCUSSION

According to the resulting X-ray diffraction patterns and the data about the distribution of diffraction peak intensities, the oozy matter of the examined soils of the Polesye and Opolye ecosystems has the following mineralogical composition: hydromica, chlorite, mixed-layer mica smectite and mica vermiculite formations, generated from chlorite-vermiculite packets and kaolinite. The companion minerals are feldspar and quartz (Table 1).

Table 1. Argillaceous minerals of the oozy fraction of the soils in the Polesye and Opolye ecosystems according to the Biscaye method

Sample no.	Soil, genetic horizon, and its depth, cm		Argillaceous mineral content, % from total		
			kaolinite + chlorite 7 Å	hydromica 10 Å	smectite component Å
Low-differentiated contact deeply gleyey sabulous medium-soddy low-podzolic soil on fluvial glacial cohesive sand underlaid with sabulous moraine					
24	A1	2-15	18.68	39.22	49.09
25	A2A1	15-23	35.96	38.20	25.84
26	B	23-57	28.57	38.96	32.47
27	Cg	57-91	25.53	42.55	31.91
28	Dg	91-145	13.04	43.48	43.48
Low-differentiated deep tilled cultivated contact deeply gleyey sabulous medium-soddy low-podzolic soil on fluvial glacia cohesive sand underlaid with sabulous moraine					
29	Aa	0-34	20.59	35.30	44.12
30	B	34-56	13.91	62.60	23.48
31	Cg	56-115	16.28	51.16	32.56
32	Dg	115-200	18.18	54.55	27.27
Medium-soddy deeply podzolic sabulous soil on fluvial gracial clay sand					
33	A1	2-15	20.00	40.00	40.00
34	A2A1	15-34	32.14	35.70	32.14
35	A2	34-65	19.44	50.00	30.55
36	B1	65-85	11.70	56.70	31.67
37	B2	85-115	16.94	54.24	28.81
38	C	115-162	20.45	45.45	34.09
Medium-tilled soddy podzolic sabulous soil on fluvial glacial clay sand					
39	Aa	0-30	25.64	46.15	28.21
40	A2	30-54	18.18	58.18	23.64
41	B1	54-74	19.80	55.44	24.73
42	B2	74-95	9.61	61.54	28.84
43	C	95-170	10.64	63.83	25.53
Medium grey forest light loamy deep effervescent soil on carbonate loess loam					
1	A1	1-16	16.95	61.01	22.03
2	A1A2	16-29	16.70	48.15	35.18
3	Bt	29-49	19.14	44.02	36.84
4	B	49-75	13.63	54.55	31.82
5	BC	75-106	22.39	44.78	32.84

6	Cca 106-123	12.50	50.00	37.50
Cultivated grey forest light loamy deep effervescent soil on carbonate loess loam				
20	Aa 0-30	13.16	52.63	34.21
21	Bt 30-51	16.70	33.30	50.00
22	B 51-73	19.51	43.90	36.60
23	BC 73-95	15.97	52.78	31.25
Light loamy grey forest soil with a second humic horizon on carbonate-free loess clay sand				
7	A1 2-13	13.79	55.17	31.03
8	A1 13-27	21.05	52.63	26.31
9	A1A2 27-39	6.06	51.52	42.42
10	A2Bh 39-70	-	-	-
11	Bh 70-103	19.35	64.51	16.13
12	BC 103-160	18.52	44.44	37.03
13	C 160-200	12.66	58.23	29.11
Light loamy cultivated grey forest soil with a second humic horizon on carbonate-free loess clay sand				
14	A1a 0-26	13.21	52.80	33.96
15	A1A2 26-47	13.33	53.33	33.30
16	BhA2 47-67	20.00	35.00	45.00
17	Bh 67-88	13.30	53.30	33.30
18	CBh 88-107	16.47	61.18	22.33
19	CB 107-150	26.70	53.30	20.00

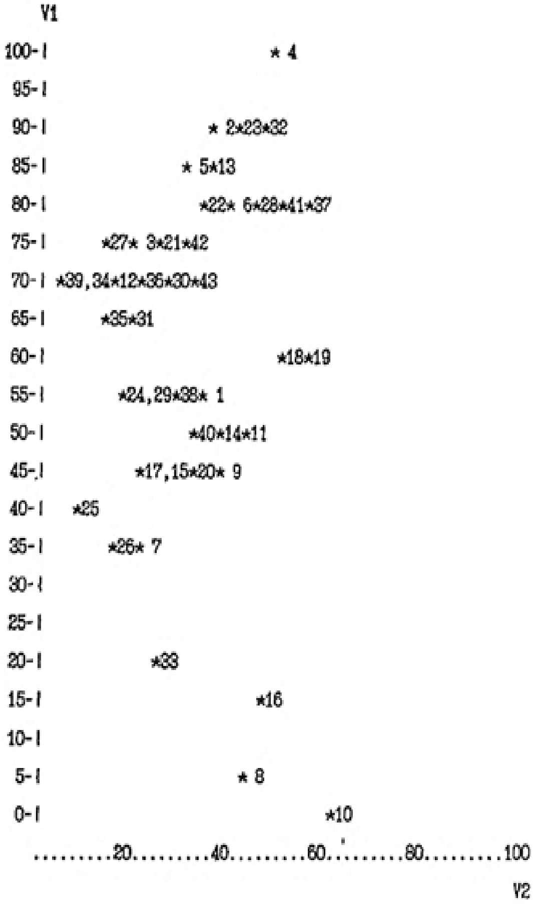
The intensities of the reflections of argillaceous and other minerals of the soil ooze were exposed to a detailed analysis for identifying the major trends for changes in both, its mineralogical composition and the structural features of the main minerals and mixed-layer formations. The resulting data include the intensity values measured as areas of the main basal reflections of argillaceous minerals with allowances for structural factors according to Biscaye; intensities of the main reflections of argillaceous and companion minerals as well as the general reflections at d/n 4,4 Å, measured as diffraction peak heights and recalculated by 100% (Table 2).

Table 2. Ooze minerals reflection intensities measured as diffraction peak heights

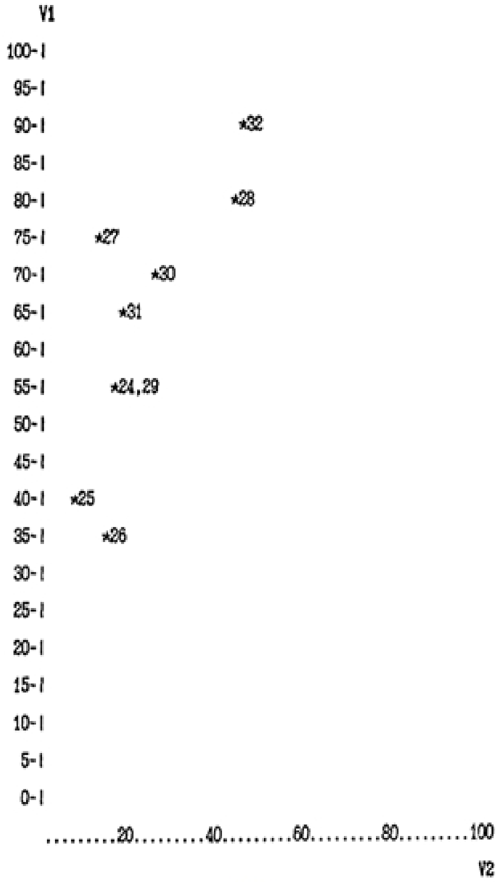
Sam ple no.	Soil, genetic horizon, and its depth, cm	% from total							
		4.2 Å	4.4 Å	4.7 Å	5 Å	7 Å	10 Å	12.5 Å	14 Å
Low-differentiated contact deeply gleyey sabulous medium-soddy low-podzolic soil on fluvial glacial cohesive sand underlaid with sabulous moraine									
24	A1 2-15	11.95	10.62	6.64	6.19	19.47	12.83	13.72	18.58
25	A2A1 15-23	19.02	10.55	4.77	4.52	17.59	9.04	11.56	22.87
26	B 23-57	17.18	12.40	5.63	8.17	18.02	3.39	10.14	16.06
27	Cg 57-91	8.05	3.81	5.51	6.36	22.46	17.37	15.25	21.19
28	Dg 91-145	8.47	5.65	6.21	7.91	10.73	17.51	20.90	22.60
Low-differentiated deep tilled cultivated contact deeply gleyey sabulous soddy podzolic soil on fluvial glacial cohesive sand underlaid with sabulous moraine									
29	Aa 0-34	11.31	9.19	2.83	4.95	16.16	18.02	15.55	21.55
30	B 34-56	10.06	4.14	4.73	8.28	17.75	26.63	14.20	14.20
31	Cg 56-115	12.50	6.77	4.17	8.85	10.94	31.77	17.71	7.29
32	Dg 115-200	5.14	4.67	7.94	8.41	15.89	24.47	17.29	15.89
Medium-soddy deeply podzolic sabulous soil on fluvial gracial clay sand									
33	A1 2-15	24.15	15.48	6.19	6.81	15.79	7.18	6.67	15.80
34	A2A1 15-34	10.59	7.06	7.06	8.82	17.65	8.82	13.53	26.47
35	A2 34-65	11.77	6.47	5.88	7.06	20.00	14.12	12.35	22.35

36	B1	65-85	9.22	6.45	5.53	8.29	17.03	23.96	15.67	13.82
37	B2	85-115	9.72	4.86	6.25	9.03	13.89	20.83	17.36	18.06
38	C	115-162	14.07	7.41	5.18	7.41	17.78	20.00	14.07	14.07
Cultivated medium-tilled soddy deeply podzolic sabulous soil on fluvial glacial clay sand										
39	Aa	0-30	8.79	6.04	5.49	6.04	20.88	12.09	14.83	25.82
40	A2	30-54	14.41	11.71	8.11	9.91	18.02	13.51	9.01	15.32
41	B1	54-74	8.19	3.88	6.47	7.76	17.67	25.86	16.81	13.36
42	B2	74-95	10.45	5.97	6.72	8.21	14.18	21.64	16.42	16.42
43	C	95-170	9.79	6.29	4.89	7.69	13.98	27.27	16.08	13.99
Medium grey light loamy deep effervescent forest soil on carbonate loess loam										
1	A1	1-16	12.76	11.22	5.36	7.91	13.77	21.17	15.56	12.24
2	A1A2	16-29	5.36	3.57	5.80	7.14	16.52	19.64	19.64	22.32
3	Bt	29-49	9.24	4.89	5.98	7.61	15.76	17.40	17.40	21.73
4	B	49-75	2.72	1.51	6.04	7.55	13.90	22.05	23.26	22.96
5	BC	75-106	5.08	3.55	5.08	7.11	19.29	19.29	19.29	21.31
6	Cca	106-123	8.49	3.77	4.24	7.07	15.57	23.11	18.87	18.87
Cultivated light loamy deep effervescent grey forest soil on carbonate loess loam										
20	Aa	0-30	16.67	12.92	5.83	8.75	14.17	17.50	14.17	10.00
21	Bt	30-51	9.52	5.44	4.76	6.12	16.33	19.05	19.73	19.05
22	B	51-73	7.81	4.17	6.25	7.29	16.67	17.71	18.75	21.33
23	BC	73-95	6.77	4.17	8.33	10.42	15.10	14.58	17.71	22.92
Light loamy grey forest soil with a second humic horizon on carbonate-free loess clay sand										
7	A1	2-13	15.89	15.23	3.31	5.63	14.57	18.21	14.57	12.58
8	A1	13-27	24.06	20.68	3.76	4.89	13.16	10.90	10.90	11.65
9	A1A2	27-39	14.55	14.55	4.09	6.36	10.45	20.00	16.36	13.64
10	A2Bh	39-70	21.54	26.70	5.13	6.15	11.28	13.84	9.23	6.15
11	Bh	70-103	11.96	12.21	3.56	7.63	17.56	21.37	13.49	12.21
12	BC	103-160	11.19	8.20	6.72	8.21	14.92	17.91	14.93	-
13	C	160-200	6.45	4.15	6.45	9.22	17.51	18.43	17.05	20.74
Cultivated light loamy grey forest soil with a second humic horizon on carbonate-free loess clay sand										
14	A1a	0-26	13.83	11.25	5.14	5.14	12.54	19.94	14.79	17.36
15	A1A2	26-47	14.88	13.27	5.50	7.44	15.53	14.24	15.86	13.27
16	BhA2	47-67	18.99	21.86	3.94	6.45	14.34	12.54	11.11	10.75
17	Bh	67-88	14.63	15.24	4.88	5.49	22.56	9.15	18.90	9.15
18	CBh	88-107	10.84	9.64	7.23	7.83	17.47	22.29	13.85	10.30
19	CB	107-150	12.17	12.17	7.83	13.91	13.91	18.26	10.43	10.30

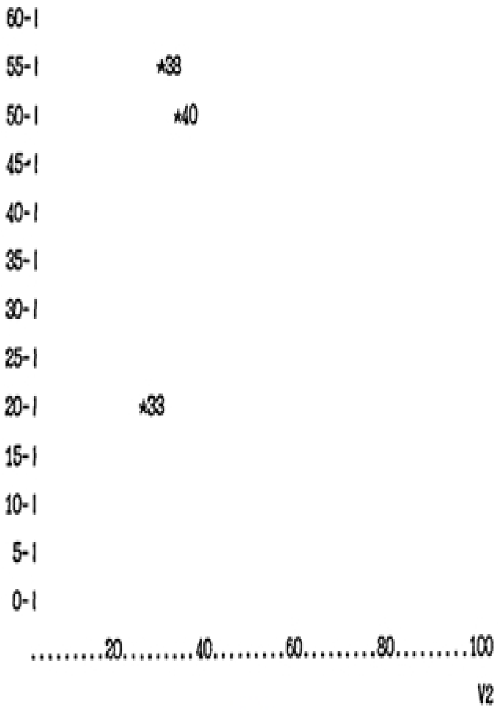
As shown by considering the data obtained in succession, the points in the scope of the main components technique (MCT, Fig. 1), that correspond to the values of intensity derived as peak heights, form a broad area without any visible signs of ordering.


V1
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
*4
*2*23*32
*5*13
*22*6*28*41*37
*27*3*21*42
*39,34*12*36*30*43
*35*31
*18*19
*24,29*38*1
*40*14*11
*17,15*20*9
*25
*26*7
*33
*16
*8
*10
20
40
60
80
100
V2

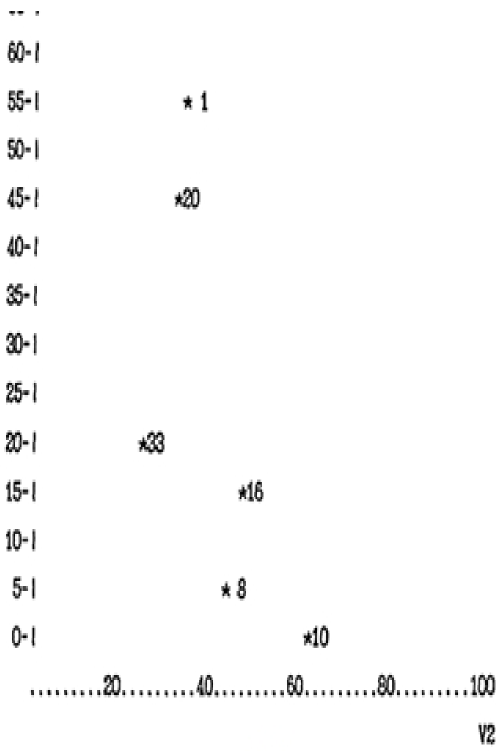
1.1


V1
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
*32
*28
*27
*30
*31
*24,29
*25
*26
20
40
60
80
100
V2

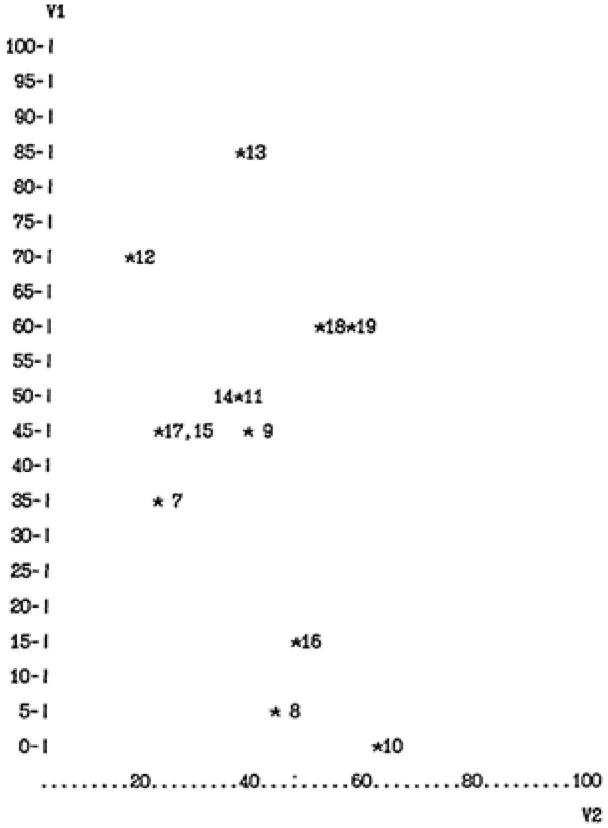
1.2


60
55
50
45
40
35
30
25
20
15
10
5
0
*38
*40
*33
20
40
60
80
100
V2

1.3


60
55
50
45
40
35
30
25
20
15
10
5
0
*1
*20
*33
*16
*8
*10
20
40
60
80
100
V2

1.4



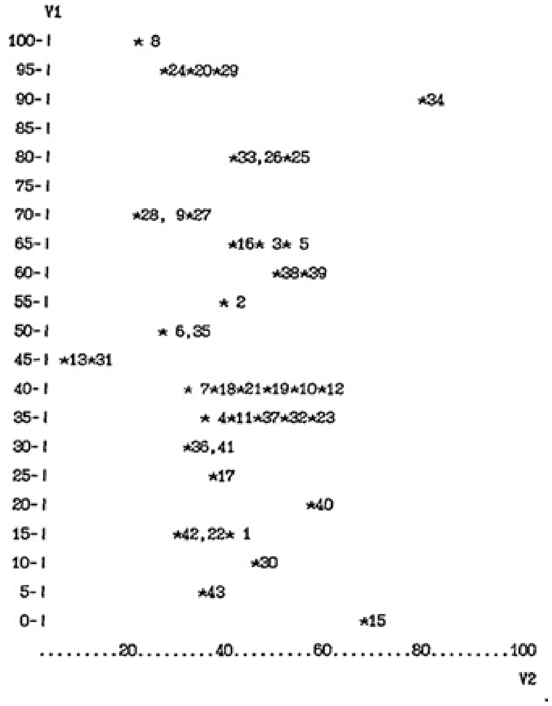
1.5

Figure 1. Characteristic of the mineralogical composition of the oozy fraction of the genetic horizons of the soils of the Polesye and Opolye ecosystems in the west of European Russia, studied with the help of intensities measured as diffraction peak heights:
1.1) is for all of the studied soils; 1.2) is for the soils of the Novozybkov KLS; 1.3) is for the soils of the Klintsy KLS; 1.4) is for the soils of Starodub KLS 1; 1.5) is for the soils of Starodub KLS 2

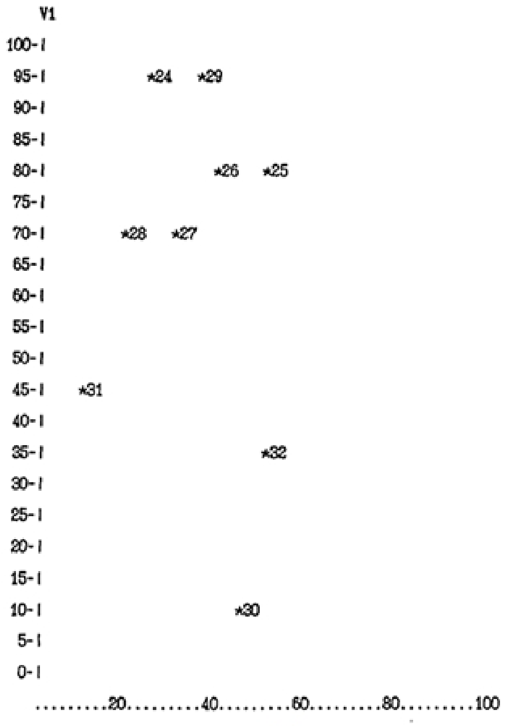
Since the respective dispersion of the data about the first and the second main component is 42 and 22% (Table. 3), it made sense to analyze the distribution of the points more thoroughly. Therefore, auxiliary curves (Fig. 2; 2.2–2.5) were drawn using the data from the MCT plot (Fig. 2; 2.1) for the following pairs of sections: soil of a natural ecosystem versus the soil of an intensive ecosystem.

Table 3. Eigen values (λ) and vectors of the correlation matrix of intensities measured as heights of the diffraction peaks of the oozy fraction of the soils from the Opolye and Polesye ecosystems in the west of European Russia

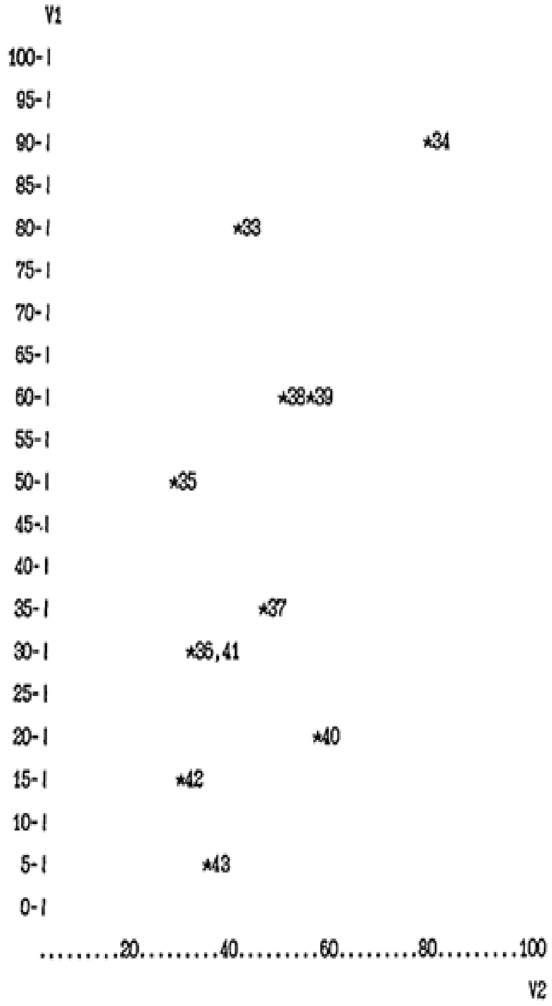
Feature/mineral	Intensities	λ	
		3.38	1.72
		42%	22%
Quartz	4.2 Å	-0.53	-0.02
Aggregate reflection of argillaceous minerals	4.4 Å	-0.52	0.07
Chlorite	4.7 Å	0.23	-0.08
Mica-hydromica	5 Å	0.20	0.28
Chlorite + kaolinite	7 Å	0.10	-0.58
Mica-hydromica	10 Å	0.28	0.56
Mixed-layer mica smectites (vermiculites)	12.5 Å	0.42	0.14
Chlorites	14 Å	0.32	-0.50


V1
100- I ★ 8
95- I ★24★20★29
90- I ★34
85- I
80- I ★33, 26★25
75- I
70- I ★28, 9★27
65- I ★16★ 3★ 5
60- I ★38★39
55- I ★ 2
50- I ★ 6,35
45- I ★13★31
40- I ★ 7★18★21★19★10★12
35- I ★ 4★11★37★32★23
30- I ★36,41
25- I ★17
20- I ★40
15- I ★42,22★ 1
10- I ★30
5- I ★43
0- I ★15
.........20.........40.........60.........80.........100
V2

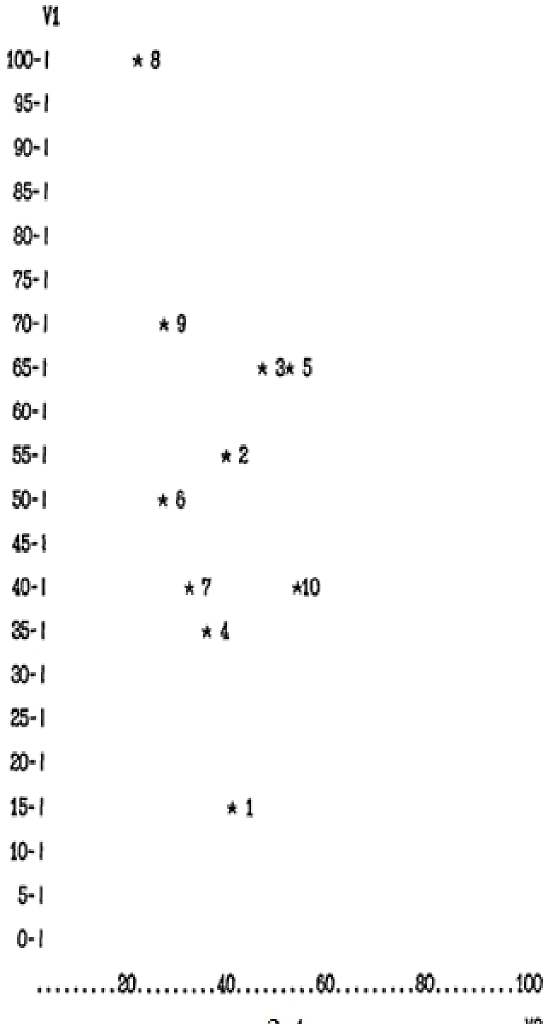
2.1


V1
100- I
95- I ★24 ★29
90- I
85- I
80- I ★26 ★25
75- I
70- I ★28 ★27
65- I
60- I
55- I
50- I
45- I ★31
40- I
35- I ★32
30- I
25- I
20- I
15- I
10- I ★30
5- I
0- I
.........20.........40.........60.........80.........100
V2

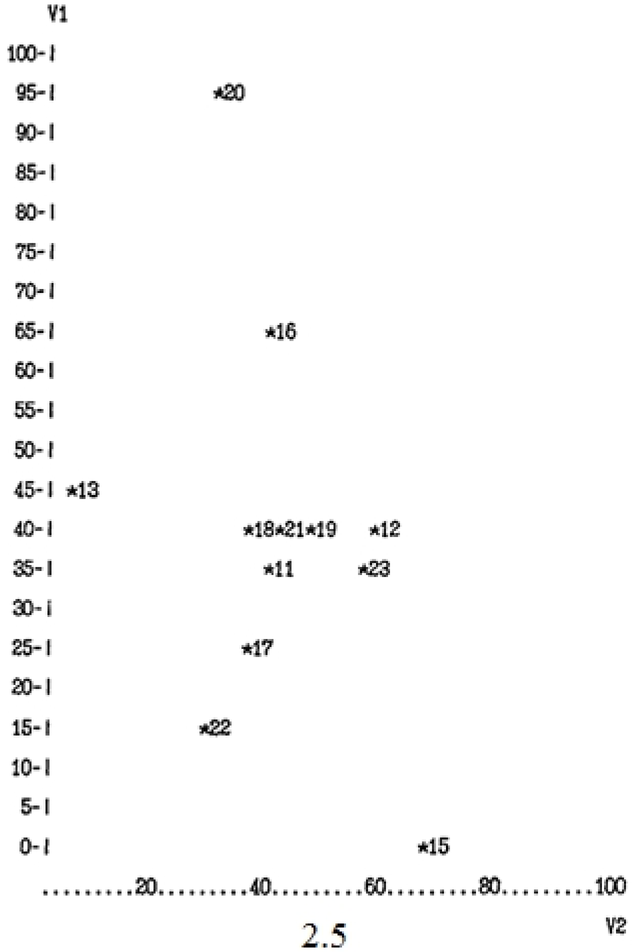
2.2


V1
100- I
95- I
90- I ★34
85- I
80- I ★33
75- I
70- I
65- I
60- I ★38★39
55- I
50- I ★35
45- I
40- I
35- I ★37
30- I ★36,41
25- I
20- I ★40
15- I ★42
10- I
5- I ★43
0- I
.........20.........40.........60.........80.........100
V2

2.3


V1
100- I ★ 8
95- I
90- I
85- I
80- I
75- I
70- I ★ 9
65- I ★ 3★ 5
60- I
55- I ★ 2
50- I ★ 6
45- I
40- I ★ 7 ★10
35- I ★ 4
30- I
25- I
20- I
15- I ★ 1
10- I
5- I
0- I
.........20.........40.........60.........80.........100

2.4 V2



2.5

Figure 2. Characteristic of the soils of the Polesye and Opolye ecosystems in the west of European Russia by the mineralogical composition of the oozy fraction, derived by the main components technique: 2.1) is for all of the studied soils; 2.2) is for the soils of the Nozybkov KLS; 2.3) is for the soils of the Klintsy KLS; 2.4) is for the soils of Starodub KLS 1; 2.5) is for the soils of Starodub KLS 2

The changes in the mineralogical composition and stryctural state of the minerals along the direction of the first main component are determined mainly by the correlation of an intensity of 17 Å of the smectite component reflection and a reflection of 12.5 Å of mixed-layer formations (positive values), and also with a quartz reflection of 4.2 Å and a reflection of 4.4 Å common to layered minerals. The differences in the mineralogical composition of the oozy soil matter for the second main component are determined mainly by the oppositely directed changes in the indicator for hydromica and chlorite.The materials from Table 1 and Figure 1 allow studying with greater attention the peculiarities of correlations in only the layered minerals of the oozy soil matter. The MCT plots are characterized by the following parameters: the respective dispersion for the first and the second main component are 61 and 39% (Table. 4). The points, corresponding to the features of the mineralogical composition of ooze by the content levels of smectite, hydromicas, and kaolinite with chlorite, form a broad area without any visible split-offs in communities.

Table 4. Eigen values (λ_t) and vectors of the correlation matrix of intensities of the content of the main mineral phases of the oozy fraction in the soils from the Opolye and Polesye ecosystems in the west of European Russia

Feature	λ_t – 1.84	λ_t – 1.16
	61%	39%
Kaolinite + chlorite, 7 Å	0.37	0.80
Hydromica, 10 Å	-0.74	0.05
Smectite, 17 Å	0.57	0.59

In the natural low-differentiated contact deeply gleyey sabulous medium-soddy low-podzolic soil on fluvial glacial cohesive sand underlaid with sabulous moraine the main differences in mineralogical composition in the section are expressed in the changes along the direction of the second component, that is, connected to a factor of 7 Å of the kaolinite and chlorite in the mineralogical composition of ooze. The oozy matter of the medium-soddy deeply podzolic loamy soil on fluvial glacial clay sand in similar by the ratio of layered forms. The oozy fraction of the upper horizon has an elevated content of smectite.

The light loamy grey forest deep effervescent cultivated soil on carbonate loess loam of the intensive agroecosystem differs from its natural counterpart by a higher content of smectite. The cultivated light loamy grey forest soil with a second humic horizon on carbonate-free loess clay sand changes in the direction of the first component. In this case, however, the smectite content in the agrohorizon is higher than in the illuvial part of the soil crossover and in the deep subsoil.The data about the changes in intensities as diffraction peak areas (integral intensities) were used for deriving from the MCT plot the patterns of distribution by the main genetic soil horizons (Fig. 2).

The differences among the soils by the mineralogical composition of oozy matter are insignificant. Only two trends can be highlighted: the first is an increase in the 17 Å factor of smectite in the illuvial horizons and the growing differences in the content of all of the components in the oozy matter of the upper humic horizons as compared with the deep subsoil; the other one is that, at the same time, the oozy matter of the tillage horizons forms a highly narrow range of values of the content of argillaceous minerals with a moderate amount of smectite, hydromica and 7 Å minerals.The changes in the mineralogical composition of the oozy matter occured in three pairs of soils different in agrogenic effects, including the soddy podzols of the Novozybkov KLS and the grey forest soils of the Starodub KLS. These agroecosystems are classified as intensive; in addition to an increase in the hydromica content in the soil ooze, they also exhibit the trend for the displacement of the point corresponding to the selected indicators, along the direction of the first main component towards an increase in the quartz content (by the diffraction peak height at 4.2 Å), and for the disordering of layered silicates, which shows in the increasing intensity of reflection from (hkl) at 4.4 Å.

In the soddy podzols of the Klintsy KLS the differences in mineralogical composition, structural features of the minerals, and the degree of their aggregation show along the direction of the first main component and are fraught with a minor increase in the smectite and chlorite content in tilled soils, which intensifies the reflections of 14 and 12.5 Å.

See Figure 1 for the points corresponding to the intensity levels measured as the heights of deep subsoil peaks. These points form a comparatively small field. The differences among the samples along the first main component are minimal and have to do with the change in the correlation of component 14, textural randomness levels

(reflection of 4.4 Å), and quartz content (reflection of 4.2 Å). The actual differences among the samples are insignificant, shown on the MCT plot mainly along the second main component, and determined mainly by the correlation of the mica-hydromica content and the sum of chlorite and kaolinite.On the whole, the considered parameters of the transitional genetic horizons of the soil crosovers are similar to the ones of the deep subsoils. A slight trend for the increasing significance of the quartz content and textural randomness is registered.Significant changes in mineralogical composition and particle arrangement have been registered in horizons A. The range of the points corresponding to these horizons is heavily shifted to the MCT plot region with medium and maximal quartz content and textural randomness levels.The greatest interest is stirred by the cloud, selection from horizons A1, A2, A1A2, Aa. Attention is called to a sharp expansion in the area of the points corresponding to the values of the parameters for these horizons as compared with all of the other horizons and deep subsoils. The differences in values of parameters 14 Å, that is, the content of smectite and vermiculite, are especially significant. The amplitude of the difference in the properties of hydromicas and chlorites along the second main component is significantly elevated as well.The considered indicators have allowed identifying distinct ranges in all of the three test sites. The points of the soddy podzolic samples from Polesye have minimal medium indicators of phases 14 Å and 12.5 Å. The upper horizon samples of the grey forest soils from Opolye are characterized by medium and maximal quartz contents, textural randomness, and medium hydromica and chlorite contents. To understand the peculiarity of the tilled soils, let us pay attention to the arrangement of the points corresponding to the agrohorizons. They have no big differences by first main component V1 and are characterized by medium indicator levels of 14 Å; 12.5 Å; 4.2 and 4,4 Å. The differences in the samples along the direction of second main component V2 have to do with the changes in the hydromica parameters and the chlorite/kaolinite combination.

CONCLUSION

The oozy matter of the soddy podzols of Polesye and the grey forest soils of Opolye in the natural anf agrarian systems in the west of European Russia have the following mineralogical composition: hydromica, chlorite, mixed-layer mica smectite and mica vermiculite formations, generated from chlorite-vermiculite packets and kaolinite. The companion minerals are feldspar and quartz .The oozy matter of the natural ecosystems of Polesye has a generic mineralogical composition. In low-differentiated contact deeply gleyey sabulous medium-soddy low-podzolic soil on fluvial glacial cohesive sand underlaid with sabulous moraine the main differences in mineralogical composition or crossover have to do with kaolinite and chlorite. The oozy matter of sabulous medium-soddy deeply podzolic soil on fluvial glacial clay sand is similar in terms of the layered form ratio. An elevated component of smectite is registered in the oozy matter of the upper horizons.In the grey forest soils of Opolye the oozy matter of the upper genetic horizons has maximal and average quartz content levels and textural randomness of particles, together with average hydromica and chlorite contents. The two trends registered are an increase in the smectite content in the illuvial horizons and the growing differences in the content of all of the components of oozy matter in the upper humic horizons as compared with the deep subsoils.In the intensive agrosystems of Polesye and Opolye the mineralogical composition of the oozy matter has changed. In addition to an increase of the hydromica content in the oozy fraction, the low-differentiated contact deeply gleyey sabulous medium-soddy low-podzolic soil on fluvial glacial cohesive sand underlaid with sabulous moraine and the grey forest soils of Opolye are also characterized by the trend for an increase in the quartz content factors and the disordering of layered silicates. Compared with the similar soil from the natural ecosystem, the grey forest soil has an elevated smectite content, whereas an opposite situation is true for the grey forest soils with a second humic horizon.Significant changes in the mineralogical composition and the kind of particle arrangement have been registered in the agrohorizons of the soils from Opolye and Polesye. In these soils the smectite content is higher than in the illuvial part of the soil crossovers and matrix rocks. The considered parameters are similar in the transitional genetic horizons of the soil sections and the matrix rocks. A slight trend for the increasing significance of the quarz content and textural randomness is registered.

REFERENCES

1. Sokolova, T.A., Dronova, T.Ya., & Tolpeshta, I.I. (2005). Argillaceous Minerals in Soils [Glinistyye mineraly v pochvakh]. Tula: Grif and Co. Publishers.
2. Basset, W.A. (1960). Role of Hydroxyl Orientation in Mica Alteration. *Bull. Geol. Soc. Amer*, 71(4), 449-456.
3. Thompson, M.L., & Ukrainczuk, L. (2002). Micas. In J.B. Dixon, & D.G. Schulze (Ed.). *Soil Mineralogy with Environmental Application*. Madison, Wisconsin, pp. 431-466.
4. Sokolova, T.A., Motuzova, G.V., Malinina,M. S., & Obukhovskaya, T.D. (1991). Chemical Basics of Soil Buffering [Khimicheskiye osnovy bufernosti pochv]. Moscow: MSU Publishers.
5. Prokoshev, V.V., & Deryugin, I.P. (2000). Potassium and Potassium Fertilizers (Practice Guide) [Kaliy i kaliynyye udobreniya (Prakticheskoye rukovodstvo)]. Moscow: Ledum.
6. Kohut, C.K., Warren, C.J. (2002). Chlorites. In J.B. Dixon, D.G Schulze (Ed.). *Soil Mineralogy with Environmental Application*. Madison, Wisconsin, pp. 531-553.
7. Rampazzo, N. & Blum, W.E.H. (1992). Changes in Chemistry and Mineralogy of forest Soils. *Water, Air and Soil Pollution*, 61, 209-220.
8. Thacker, D.I., Rutherford, G.K., Van Loon, G.W. (1987). The effects of simulated acid precipitation in the surface horizons of two eastern Canadian forest podzol soil. *Can. J. For. Res*, 17(9), 1138-1143.
9. Ulrich, B. (1987). Acid load internal processes and by acid deposition. Trans. 13 Congr. Int. Soc. Soil Sci. Hamburg, 13-20 Aug. 1986. Hamburg, 5, 77-84.
10. Gradusov, B.P. (1976). Minerals with Mixed-Layer Structure in Soils [Mineraly so smeshannosloynoy strukturoy v pochvakh]. Moscow: Nauka
11. Gradusov, B.P. (2010). Genesis, Geography of Nanoscopic Matter and Its Importance for Fertility and Ecological Functioning of Soils [Genezis, geografiya nanoskopicheskogo veshchestva i ego znacheniye dlya plodorodiya i ekologicheskogo funktsionirovaniya pochv]. *Dokuchaev Soil Bulletin*, 66, 17–28.
12. Gradusov, B.P. (2001). Cluster Analysis of Mineralogical and Grain Size Composition of Soil on Homogeneous and Nonhomogeneous Rocks [Klasternyy analiz mineralogicheskogo i granulometricheskogo sostava pochv na odnorodnykh i neodnorodnykh porodakh]. *Eurasian Soil Science,* 11, 1344–1356.
13. Gradusov, B P. (2007). Mineralogy of Soils in Adaptive Landscape Specific Agriculture [Mineralogiya pochv v teorii adaptivno-landshaftnogo zemledeliya]. *Agriculture* (Zemledeliye), 6, 2–4.
14. Gradusov, B.P. (2003). Mineralogy of Soils and Land Agronomy [Mineralogiya pochv i agronomiya zemel']. *Mineralogy of Technogenesis*, 4, 234–240.
15. Gradusov, B.P. (2011). Properties and Role of Solid Particles in Macroscale Heterodisperse Soil Aggregation [Svoystva chastits tverdoy fazy i ikh znacheniye v makroprotsesse geterodispersnoy agregatsii pochv]. *Mineralogy of Technogenesis,* 12, 292–305.
16. Gradusov, B.P. (2007). Phases of Evolution of Argillaceous Soddy Podzols [Stadii evolyutsii dernovo-podzolistykh suglinistykh pochv]. *Dokuchaev Soil Bulletin*, 59, 14–22.
17. Gradusov, B.P. (2005). Structural Mineralogical Aspects of Soil and Rock Formation in Humid Areas of Boreal, Subtropical, and Tropical Belts [Strukturno-mineralogicheskiye aspekty pochvoobrazovaniya i litogeneza v gumidnykh oblastyakh boreal'nogo i subtropichesko-tropicheskogo poyasov]. *Eurasian Soil Science,* 10, 1174–1182.
18. Gradusov, B.P. (1990). Fundamental Features of Mineral Part of Oozy Matter of Soils and Their Genetic Meaning [Fundamental'nyye osobennosti mineral'noy chasti ilistogo veshchestva pochv i ikh geneticheskiy smysl]. Problems of Soil Science: Soviet pedology to the 14th international congress of soil science [Problemy pochvovedeniya: Sovetskiye pochvovedy k XIV Mezhdunarodnomu kongressu pochvovedov]. Moscow: Nauka. pp. 202–209.
19. Zubkova, T.A., & Karpachevskii, L.O. (2001). Matrix Organization of Soils [Matrichnaya organizatsiya pochv]. Moscow: Rusaki.
20. Pakshina, S.M., Shapovalov, V.F., Chesalin, S.F., Smol'skii, E.V., & Korenev,V. B. (2019). ^{137}CS Removal from Contaminated Soil by Perennial Bluegrass Herbs Depending on Mineral Nutrition and Soil Water Availability [Biovynos 137Cs iz pochvy mnogoletnimi myatlikovymi travami v svyazi s mineral'nym pitaniyem i dostupnost'yu pochvennoy vlagi]. *Agricultural Biology* [Sel'skokhozyaystvennaya biologiya], 54(4), 832-841.
21. Degens, E.T., Jackson ,T.A. (1970). Template catalysis: asymmetric polymerization of amino acids on clay minerals. *Nature,* 227, 492–493.
22. Jackson, T.A. (1971). Preferential polymerization and adsorption of L-optical isomers on kaolinite templates. *Chemical Geology,* 7, 295–306.
23. Samsonova, V.P., Krotov, D.G., & Voronin, V.A. (2019). Pedodiversity On Soil Maps At The District Level. *Eurasian Soil Science*, 52(6), 610-618.
24. Belous, N.M., Smol'skii, E.V., Chesalin, S.F., & Shapovalov, V.F. (2016). Potassium fertilizers to reduce 137Cs accumulation and increase fodder crop harvesting on the radionuclide-polluted floodplain pastures [Rol' mineral'nogo kaliya v snizhenii postupleniya ^{137}Cs v kormovyye travy i povyshenii ikh urozhaynosti na radioaktivno zagryaznennykh ugod'yakh]. *Agricultural Biology*, 51(4), 543-552.
25. Pakshina, S.M., Belous, N.M., Silaev, A.L., & Smol'skii, E.V. (2017). Quantification of biological removal of Cs-137 from soil by above-ground part of bluegrass herbs following mineral fertilization [Kolichestvennaya otsenka biologicheskogo vynosa ^{137}Cs iz pochvy nazemnoy massoy myatlikovykh trav pri vnesenii mineral'nykh udobreniy]. *Radiation and Risk. Bulletin of the National Radiation Epidemiological Register* (Radiatsiya i risk. Byulleten' Natsional'nogo radiatsionno-epidemiologicheskogo registra), 26(4), 99-110.
26. Zubkova, T.A., Karpachevskii, L.O. (2003). Role of Soil Mineral Matrix in Technnosphere [Rol' pochvennoy mineral'noy matritsy v tekhnosfere].In *Mineralogy of Technogenesis-2003* [Mineralogiya tekhnogeneza-

2003]. Miass: Institute of Mineralogy, Ural branch, Russian Academy of Sciences, pp 222–233.

27. Chizhikova, N.P. (1994). Agrotechnogenic Transformation of Mineralogical Composition of Soddy Podzols [Agrotekhnogennoye preobrazovaniye mineralog-icheskogo sostava dernovo-podzolistykh pochv]. *Eurasian Soil Science*, 4, 81–91.
28. Chizhikova, N. P. (2001). Anthropogenic Degradation of Mineralogical Base of Soils [Antropogennaya degradatsiya mineralogicheskoy osnovy pochv].In *Ecological Analysis of Environment for Its Sound Management and Forecasting Changes* [Ekologicheskiy analiz okruzhayushchey sredy v tselyakh eye ratsional'nogo ispol'zovaniya i prognoza izmeneniy]. Moscow, pp. 215–228.
29. Chizhikova, N. P. (2002). Changes in Mineralogical Composition of Fine Soil Fractions under Influences of Agroengineering Genesis [Izmeneniye mineralog-icheskogo sostava tonkikh fraktsiy pochv pod vliyaniyem agrotekhnogeneza]. *Eurasian Soil Science*, 7, 867–875.
30. Chizhikova, N. P. 2003. Irreversibility of Evolution of Petrograph Miner-alogical Component of Soils under Agrotechnogenic Influences [Neobratimost' evolyutsii petrografo-mineralogicheskogo komponenta pochv pri agrotekhnogennom vozdeystvii] in: Proceedings of the 4th All-Russian Conference «Problems in Soil Science». Pushchino. Pp. 216–221.
31. Chizhikova N.P. (1991). *Transformation of Mineralogical Composition of Soils during Agrogenesos* [Preobrazovaniye mineralogicheskogo sostava pochv v protsesse agrogeneza]. Extended Abstract of the Thesis for a Doctor in Agriculture. Moscow.
32. Konishchuk, V.V., Andrienko, T.L., Bondar, A.O. et al. (2012). Polesian Ecological Convention — Gnoseology Paradigm in the Making [Polesskaya ekologicheskaya konventsiya – gnoseologicheskaya paradigma stanovleniya]. Section III. *Nature of West Polesye and Adjacent Territories* [Priroda Zakhidnogo Polissya ta prileglikh teritoriy], 9, 289–293.
33. Akhromeev, L.M. (2008). *Nature, Genesis, Evolution, and Landscape Structure of Opolye Areas in Central Russia* [Priroda, genezis, istoriya razvitiya i landshaftnaya struktura opoliy Tsentral'noy Rossii]. Bryansk: Bryansk State University.
34. Prosyannikov, E.V., & Torikov, V.E. (2017?). Regularities in Changes in Some Agrochemical Properties of the Opolje Arable Soils of the Bryansk Region [Zakonomernosti izmeneniya nekotorykh agrokhimicheskikh svoystv pakhotnykh pochv opoliy Bryanskoy oblasti]. A*grochemical Herald* (Agrokhimicheskiy vestnik), 3, 11–14.
35. Tyuryukanov, A.N., Bystritskaya, T.L. (1971). *Opolye Areas in Central Russia and Their Soils* [Opol'ya Tsentral'noy Rossii i ikh pochvy]. Moscow: Nauka.
36. Ivanov, A.L., Shoba, S.A. (Eds.). (2014). Unified State Register of Russian Soil Resources. Version 1.0. Collective Monograph [Edinyy gosudarstvennyy reyestr pochvennykh resursov Rossii. Versiya 1.0. / Kollektivnaya monografiya]. Moscow: Dokuchaev Soil Science Institute, Russian Academy of Agricultural Sciences.
37. Prosyannikov, E.V., Torikov, V.E. (2019). Soil Improvement As Basics for Sustainable Land Management in Eastern Polesye [Okul'turivaniye pochv – os-nova ustoychivogo zemlepol'zovaniya v Vostochnom Poles'ye]. *Polesye Areas in the Southwest of Russia* [Poles'ya Yugo-Zapadnoy Rossii], vol. 1, book 4.Ryazan: Meshchera branch of All-Russian Research Institute of Hydraulic Engineering and Melioration named after A.N. Kostyakov. pp. 141–172.
38. Gorbunov, N.I. (1971). Technique of Preparing Soils for Mineralogical Analyses [Metodika podgotovki pochv k mineralogicheskim analizam]. In *Techniques of Mineralogical and Microscale Morphological Pedogenic Study* [Metody mineralogicheskogo i mikromorfologicheskogo izucheniya pochv]. Moscow: Nauka. pp. 5–15.
39. Biscaye, P.E. (1965). Mineralogy and sedimentation of recent deep-sea clay in the Atlantic *Ocean. Geol. Soc. Amer. Bull*, 76, 803–832.