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EVOLUTION OF HUMUS IN YOUNG SOILS OF MINING DUMPS (RUSSIAN NORTH WEST) AFTER FERTILIZATION BY ORGANIC AMENDMENTS.

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ABSTRACTS

The effect of amendment of spoilbanks substrata by organic amendments on soil formation and organic matter development were studied in chronosequences of soils, formed on different types of mining dumps on the territory of quarries of the Russian North-West. The reclaimed soils were located on lime-containing loams and glaciolacustrine sands. The first type of substrata was reclaimed by plugging of turf and further revegetation (series of 1-3-10-19-23-35 years old soils). The second type of parent materials are presented by two types of reclamation: surface amended 3-8-15 years-old soils and 1-2-15 years-old soils with plugged material of forest floor. Amendment of grounds by organic matter revealed as measure which assist to organic matter accumulation, intensification of soil formation and revegetation. Soils, amended by plugging of organic matter shows the tendencies of mineralization and humification of organic materials. The CHA:CFA ratio in these soils increases (0,20-0,66-0,74 for loams and 0,45-0,54-0,93 for sands), the free and mineral part connected humic acids accumulates in the age row, also the humus stability to oxidation were reveal as increases. Amendment of soils resulted in increasing of aggressive fulvic acids (FA) fraction content and increment of soils acidity. The last one changes from the prevailing of actual forms to potential, which is caused by soil sorption complex development. In case of the surface soil amendment by forest floor materials there wasn't the evident pedological effect, but just increasing of speed of revegetation. The general trend of organic matter evolution in all investigated soils is the increasing of deepness of humification, gradual decreasing of fuvlic acids content, relative accumulation of nitrogen and increment of humus stability to oxidation.

Keywords: Open-cast mining, Reclamation, Revegetation, Grounds amendment, Organic matter evolution

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INTRODUCTION

One of the main reasons of anthropogenic land degradation in the Russian North-West is the quarries and mines exploitation. This process leads to the various negative effects on the landscapes. Its can be divided into direct (formation of dumps, spoilbanks, new anthropogenic landscapes) and indirect (aeolian pollution of adjacent landscapes, changes in hydrology and so on) disturbances. Mines exploitation leads to formation of vast territories with destroyed soil and vegetation cover. The processes of natural revegetation and soil restoration are realizes on 90 % of quarries territory of the North-West of Russia economical region. Only about 10% of dumps and spoilbanks are reclaimed, remediated or restored by human. There are a many different grounds which are exposed on the surfaces of mining dumps: clays, loams, lime-containing loams, carbonate derivates of limestones, sands, sandy-textured granite crushing-siftings and many others. The wide spectrum of dump materials make the measures of quarries reclamation essentially complicated. Reclamation technologies for conditions of North-West are not perfect and characterizes as existing on the initial stages of development. That is why, investigation of different approaches for grounds reclamation, especially by natural organic matter amendment, became more and more urgent. Reclamation of grounds in Russia investigated for different climatic conditions: North part [2], North-West of Russia [2, 3, 4, 5], Central Russia [6], steppe zone [7, 8] and mountain regions [9]. In general, these investigations reveal the tendencies of soil restoration after artificial revegetation on non-amended mineral substrata with different particle-size distribution and coarse fraction content. The list of studies, connected with using of ground amendment by organic matter for the land reclamation is essentially less [10, 11]. Meanwhile, this amendment assists to intensification of revegetation and soil development. The speed of soil formation and differentiation of profile into horizons is higher on amended grounds in comparison with unfertilized soil, which were artificially revegetated [10]. The effects of soil amendment by organic matter were investigated only in terms of soil organic matter quality [11], but process of soil organic matter evolution in chronoseries, i.e. in time scale on the reclaimed territories were not revealed and discussed in Russian literature for Russian North-West. In opposite, destroyed grounds amendment by organic matter is an urgent topic in European and American Soil Science [12, 13, 14, 15, 16, 17, 18, 19]. Another branch of investigation in this context develops in frames of study the soils, reclaimed on the grounds which initially contents an organic matter which were mixed to the spoilbanks grounds during the formation of dumps [12, 18]. So, investigations of the speed of soil formation on the quarries dumps after the amendment by organic matter can be characterized as works on the initial stages of data accumulation and generalization, especially for the Russian North-West.

This work is aimed at monitoring of soils and soil organic matter evolution on grounds of dumps, amended by organic matter and reforested by human in two trends of soil formation: on lime-containing loams of phosphorite open-cast mines (loam-textured substrata) and on spoilbanks of sandy quarries in the Russian North-West. We studied (i) development of vegetation and morphology on initial soils, trends of profile differentiation, (ii) changes in humus profile of soils, development of organic matter system and humus composition, (iii) development of trends of soil organic matter changes in time scale.

MATERIALS AND METHODS

The first part of the study (“Phosphorite” plots) was carried out on reclaimed mining spoilbanks of Kingisepp phosphorite deposit, which was exploited during the 60’s-70’s of the 20th century. The open-cut layer consists of two sub layers: Quaternary deposits and Ordovician sediments. The surface ground of heaps is mixed sediments of these two categories of grounds. Lime-containing loams with high content of coarse fraction (about 60 %) were exposed initially on leveled surface of quarry, later, these surface overlaps by so-called “soft-textured” substrata with content of thin fraction about 70 %. The second stage of reclamation is so-called biological period, aimed to restore the plant cover by revegetation techniques. Norway spruce seedlings were seeded in rows into the “soft-textured” grounds. Soils (soil-like bodies) of 1, 3, 10, 19, 23 and 35 years old soils were studied. There was one monitoring plot, the data on 1 and 3 years old soils taken from article of E.I. Gagarina [11], also she give samples of these soils for further analyses. On the initial stages the space between row (0.7 - 2.0 m) were naturally revegetated by grosses, tree canopy on 19-years plot became more dense and replaces to 35 years to close-canopy spruce forest with developed forest floor horizons.

The second part of study (“Borovitchy” plots) was carried out on the sandy quarries in Borovitchy town, Novgorod region. Here, on the square about 100 ha, the big hills of glaciolacustrine sands were exploited, and destroyed surface were leveled to the inclination about 2-5^0 . Ground surface were covered, and by this way ameliorated by organic material of forest floor horizons of natural Podzolic (Spodosols) soils of pine forests. Later the pine seedlings were seeded on the surface of quarry with inter row distance about 1.0 m. Sufrace amendment of soil by forest floor assist to natural overgrowing (by mosses, grosses, brushes). It was an effect of seeds bank for revegetation. Organic matter of forest floor were covered on surface, but not plugged into soil. The chronoseries of 3, 8, 15 years old soils was studied.

The third object of investigation ("Shapki" plots) is located near Shapki settlement, Tosno district of Leningrad region. Here the glaciolacustrine sands were exploitated from deep quarries, which slopes were leveled to the inclination about 10-15^0, and later it was amended by organic compost which where plugged to the deep about 20 cm and revegetated by pine. Organic compost consists of two-year transformed material of forest-floor of natural Podzolic soils of pine forests. For this object we compare different age soils: 1-, 2- and 15-years plots.

So, we describe effects of grounds amendment by organic matter in case of lime-containing loams and acid sands. Sands were reclaimed by surface and plugging types of amendment.

The minimal square of different-age plots for investigation were 20 x 40 m. On this plots we collect the middle sample of higher layer (10 samples from one plot) and chose the one "typical" profile for further analyses, paying an attention for unhomogenity of soil and plant cover.

Soil samples were analyzed by routine chemical procedures [20]. The group and fractional composition of humus was determined according the method of Ponomarevea and Plotnikova (1980) with consequential extraction of all fractions from one sample and separate extraction of aggressive fulvic acids fraction (1-a) from additional sample. This method allows to extract following fractions of humic substances: 1st – HA and FA in free form of connected with labile forms of irons oxides; 2nd – HA and FA connected with Ca, 3rd – HA and FA connected with clay minerals and crystallized iron oxides. 1-a fraction is the part of fulvic acids, which is soluble in mineral acids and mostly aggressive to the soil mineral part. Extracted fractions were examined on organic carbon content by wet combustion-titrimetric Tyurin-Walkley-Blake method.

Powders of humic acids (HA) were extracted by traditional scheme by 0.1 M NaOH solution, soil-to-extragent ratio 1:10 [21, 22, 23], than an elemental composition of HA were determined with Packard CHN analyzer. Humus stability was investigated by original method of organic compounds chemodestruction by potassium dichromate, added to soil sample in mixture with different concentrations of sulfuric acid [25]. This method allows to estimate the content of labile (light-oxidated), stable (which can be destructed by concentrated chemicals) and medium stable humus content. The first fraction is one which oxidized by K2Cr2O7 in 30 % solution of sulfuric acid. The second and third are those which are oxidizable in potassium dichromate in 60 % and 100 % solutions.

RESULTS

Characterization of grounds materials

Data on chemical composition of initial, non amended parent materials of spoilbanks are presented in table 1. These data shows that amendment of coarse lime-containing loams by organic matter of turf leads to increasing of acidity (soil reverse from alkali to slightly acid), content of coarse fraction decreases because of disintegration and weathering of coarse fraction and due to relative accumulation of thin fraction of organic matter. Acid sands of both quarries shows a little content of exchangeable aluminum, relatively high acidity and characterizes by very low content of clay fraction. Level of available potassium and phosphorous content is low in all investigated grounds. Lime-containing loams and acid sands are different in preconditions for organic matter transformation. The Phosphorite grounds are favorable to humus accumulation and its reaction with thin fraction, development of humification process. In opposite, acid sand, with low content of clay fraction seems to be substrata which assist to organic matter mineralization, due to low water content, decreasing of its content, increasing of soil acidity.

Table 1: Characterization of spoilbanks grounds

pHH_2O	Exchangeable Al, mg/kg	Coarse fraction content, %	Clay fraction content, %,	available P, mg/kg	available K mg/kg
Phosphorite, coarse lime-containig loam before turf adding					
7.8	0.00	40	30-40	3.9	54.9
Phosphorite, coarse lime-containing loam mixed with turf, 3 years after amendment					
6.2	0.00	20	35-40	3.9	54.9
Sands of Shapki quarry					
5.2-5.7	0.60	5	5-7	8.7	11.0-22.0
Sands of Borovitchy quarry					
5.2-5.7	0.70	5	5-10	11.3	11.0-22.0

Development of Soil Horizons

Phosphorite plots. Amendment of carbonate loams by organic matter leads to formation of soil profile with soil horizons of AC and C horizons. AC horizon is mixture of organic matter and mineral substrata of dumps. During the first decade soil profile in space between rows are presented by Asod, AC and C horizons. Later, when the forest canopy became more close, the system of forest floor horizons start to develops. On the surface of 19-years there is only L horizon, further, in 35-years old soils F layer became more expressed, and below we can see Asod, A, AC and C layers. AC horizons of all investigated soils presented by organic material of turfs, mixed with mineral part of parent materials, Asod and A horizons is new formed layers, which contents both kind of organic matter: new formed and material of amendment.

Borovitchy plots. Profiles of amended soils consist of A, AC, C horizons. The thickness of A horizon increases from 6 to 7 to 10 cm in 3, 8 and 15 years old soils correspondingly. On the first, 3-years plot the forest floor cover is not regular, organic material were spontaneously scattered on the surface of dumps. There is not well expressed accumulation of forest floor on the surface of spoilbanks because the open canopy of the young pine plantations and overgrowing of space between rows by grosses. The accumulation forest floor starts actively only under the separate trees.

Shapki plots. Here the thickness of all horizons due to amendment is constant for Asod layer (0-8 cm), for A layer (8-15 cm) and for AC layer (15-25 cm) in 2 and 15 years old soils. As exception, we can observe 1-years soil, where the Asod horizon is weakly developed (about 4 cm).

Organic matter evolution in young soils

Phosphorite plots. The level of soil organic matter content in soils is closely connected with it percentage in initial ground after amendment. During the soil development the organic matter content decreases in Phosphorite plots due to mineralization and humification (Table 2).

Table 2: Contents of organic carbon and total nitrogen, pH values and lime percentages in different age soils of Phosphorite plots

Horizons	Organic carbon, g/kg	Ntotal, g/kg	C/N	pH_{H2O}	CO_2, carbonate content, g/kg
1-years not-amended soil					
C	3	0.3	11.7	6.8	34
Ground after amendment, 3 years after fertilization by compost					
AC	164.4	21.4	9.0	6.6	25
10-years old soil after amendment					

AC	104.4	13.5	9.0	6.5	20
19-years old soil after amendment					
Asod	71.8	6.9	12.2	6.4	12
A	73.6	5.5	15.6	6.4	13
AC	69.6	5.4	15.1	6.3	17
C	5.0	0.6	9.8	7.8	20
23-years old soil after amendment					
L	347.1	10.5	38.7	6.5	-
F	263.0	7.5	41.0	6.2	-
Asod	73.3	5.0	17.1	6.3	39
A	51.0	7.0	8.4	6.5	27
AC[1]	37.5	5.2	7.2	6.9	35
AC[2]	5.0	0.6	9.8	7.5	101
35-years old soil after amendment					
O	321	9.2	34.9	6	-
AY	62	7.2	8.6	6.5	20
AC	38.4	6.2	6.2	7	50

[1]with local admixture of turf
[2]without organic matter

It is evident form data of table 2, that organic matter contents in amended horizons decreases in age row. This amendment initially leads to increment of organic carbon stocks and percentages in soils, but this humus became exposed to the transformation process, therefore its portions decreases. We can observe decreasing of organic carbon content in AC horizons from 16.44, 10.44 to 6.75 and 3.75 in AC horizons of 3, 10, 19 and 23-years soils correspondingly (the deepness of sampling were the same, so we compare the layers where organic matter was admixtured to mineral part and wasn't influenced by accumulation on new-formed humus during the pedogensis). Level of humus richness by nitrogen content is the same in initially amended soil and in 10-years old soil, further, in 19 years old soils under the forest canopy C/N ratio decreases which are caused by big inflow of the fresh organic material of trees liter fall. Meanwhile, in 35-years old soil, organic matter shows the tendencies of increasing of humus richness by nitrogen, i.e. C/N ration decreasing due to stabilization of organic profile in developed forest ecosystem soil. Level of humus content in Asod horizon is the same in 19- and 23-years old soils, but the C/N ratio became wider due to accumulation of big amounts of plant residues in forest floor sub horizons (L and F) and its influence of humus of Asod horizons.

The data of table 2 also shows that amendment of grounds by organic matter assists to the leaching of carbonates and, respectively, to decreasing pH is in soils. The portion of carbonates and pH values decreases evidently in row of 1-3-10-19 years-old soils, but in 23-yeas soil the contents of carbonates increases, we suggest it due to intensification of weathering of coarse limestones fraction. This process leads to enriching of thin soil fraction by lime, and, therefore leads to increasing of pH. Meanwhile, in these 23-years old soil the influence of turf amendment also is good expressed, namely, in AC horizon which contents the amendment of turf the pH values and carbonate contents is essentially lower than in same material without the compost applying.

Results of humus acids fraction extraction (group and fractional analyses of humus) allows to reveal the trend in humus quality changes (table 3). Here we discuss the changes in humus composition for AC horizons, which are seems to be a minimum changed by the processes of new organic matter accumulation during the pedogenesis. There are three must important processes of organic matter development which were revealed by this analysis. The first one is an increasing of HA content, the second one is decreasing of fulvic FA content and the third one is a rapid increasing of CHA:CFA ratio in age row. In non-amended soils, also in 3- and 10-years amended soils the group of humic substances is presented by free-fraction (1st fraction). Later, in 19- and 23-years old soils portion of HA, which is connected with calcium and clay minerals (2nd and 3rd fractions correspondingly) increases due to development of the humification process and intensification of mineral part transformation (weathering). Content of all FA fraction decreases in contrary to the content of all HA fractions. The maximum content of FA revealed in soil just after amendment by turf. In this soil there are a big content of two FA fractions: free-fraction which is not connected with mineral part or connected with mobile iron oxides, and fraction of FA strongly connected with mineral part. In first case it is normal, because fresh organic matter in young soil is not essentially transformed, that is why it accumulates in low-molecular slightly humified forms, i.e. FA. The second fact can be explained by the reason of intensive influence of new formed FA on soil mineral part.

Table 3: Humus composition in AC horizons of different-age amended soils of Phosphorite plots (% of carbon to Ctotal content)

Horizon	Humic Acids				Fulvic Acids					NR	CHA/CFA
	1	2	3	HA total	1-a	1	2	3	FA total		
Soil before amendment											
AC	4.1	1.1	2.9	8.1	6.1	3.4	0.4	36.9	46.8	45.1	0.17
Ground after amendment, 3 years after fertilization by compost											
AC	4.9	3.5	2.7	11.1	1.0	31.6	3.4	17.6	53.6	35.3	0.20
10-years old soil after amendment											
AC	12.0	5.8	5.5	23.2	3.0	17.0	4.3	11.1	35.3	41.5	0.66
19-years old soil after amendment											
AC	9.2	11.5	6.6	27.3	1.3	20.5	5.5	9.5	36.8	35.9	0.74
23-years old soil after amendment											
AC	8.2	10.8	5.0	24.0	0.4	8.2	4.8	5.3	18.7	57.3	1.28

So, on the initial stage of soil formation, the humification process is not well expressed, in humus composition group of FA prevail. Further, in 19- and 23-years old soils we can see the increasing of HA fraction with simultaneous decreasing of fulvic substances. All these facts shows, that the process of humification of organic matter amended to soils develops slowly, but gradually from one stage to another.

Borovitchy plots. The surface amendment doesn't influence of the soil formation intensively, as it were revealed in Phosphorite plots. The data of table 4 shows that accumulation of organic carbon in mineral horizons is connected with soil formation but not with amendment of grounds by organic materials. The surface amendment only assists to the intensification of revegetation and by this, to intensification of soil formation through the processes of biological accumulation. The accumulation of organic carbon in soil series accompanies by absolute accumulation of total nitrogen, and therefore, by decreasing of C/N ratio. The tendency of pHH_2O values changes are not typical and not in strong tendency of decreasing. Firstly, pH decreases in comparison with initial surface ground (pHH_2O = 5,2-5,7), and then increases. But pH in KCl suspension decreases in row from youngest soils to older one evidently. The same tendencies revealed in soils of Shapki plots, where the suggested reasons of this appearance are discussed (table 5).

Table 4: Organic carbon and total nitrogen content, pH values in soils of Borovitchy plots

Horizon	Organic Carbon, g/kg	Ntotal, g/kg	C/N	pHH_2O	pHKCl
3-years old soil					
A	3.5	0.3	13.7	4.6	4.4
AC	1.5	Not det.		4.9	4.7
C	1.4			5.3	5.0
8-years old soil					

A	6.4	0.5	15.0	5.0	4.4
AC	7.0	0.6	13.7	5.0	4.4
C	1.3	Not det.		5.2	4.6
15 years old soil					
A	9.6	1.0	11.2	5.1	4.2
AC	7.4	0.7	12.4	5.0	4.3
C	1.0	Not det.		4.7	4.4

Table 5: Humus composition in AC horizons of different-age amended soils of Borovithy plots (% of carbon to Ctotal content)

Horizon	Humic acids				Fulvic acids					CHA/CFA	NR
	1	2	3	HA total	1-a	1	2	3	FA total		
2-years old soil											
A	5.7	0.0	8.6	14.3	8.6	2.9	0.0	20.0	31.5	0.45	54.2
8-years old soil											
A	10.9	4.7	12.5	28.1	9.4	21.9	3.1	17.2	51.6	0.54	20.3
15-years old soil											
A	14.6	0.0	14.6	29.2	7.3	17.7	0.0	6.3	31.3	0.93	39.5
AC	18.9	0.0	12.2	31.1	8.1	20.3	6.8	6.8	41.9	0.74	27.0

Data of group and fractional humus analyses shows that there is not evident influence of surface amendment on the humus formation process. In soil chronoseries we can see the accumulation of HA, especially of 1st and 3rd fractions, or free and connected with mineral part correspondingly. Due to the acidity of parent materials and absence of lime in it, there is not accumulation of humic substances, which are connected with Calcium. FA shows the accumulation of most aggressive to the mineral part fractions, i.e. 1-a (acid-extractable) and 1st fraction. Also there is accumulation of mineral-part connected acids in 3-years old soil; it seems due to the initial interaction of low-molecular acids with not weathered mineral matrix. Increasing of CHA:CFA ratio in chronoseries shows that humification process develops intensively in more older soils.

Shapki plots. During first and second years after amendment 0-20 cm layer contents a big portion of organic matter in all horizons, but this humus starts to be exposed to the mineralization process, that is why in 15 years old soil the percentages of humus decreases in all horizons (table 6). The transformation of organic matter leads to mineralization of nitrogen compounds, but the degree of humus riches by nitrogen increases. The pH values in water suspension in initial non-amended ground is about 5,2-5,7, but after amendment these values decreases and in contrary with the tendencies of acidity changes in soils of Phosphorite plots increases on 15-years old soils. But the potential soil acidity increases in time row. This unusual tendency can be explained by following arguments: firstly the actual soil acidity increases, and later, due to development of soil absorption complex the acidity, caused by absorbed hydrogen increases. In opposite, concentration of actually active protons in soil suspension decreases. So, it seems that the initial increasing of actual soil acidity is just a temporal, and results in intensification of weathering process, and therefore – to increasing of CEC with prevailing portion of exchangeable hydrogen.

Table 6: Organic carbon and total nitrogen content, pH values in soils of Shapki plots

Horizon	Organic Carbon, %	Ntotal, %	C/N	pHH_2O	pHKCL
1-years old soil					
AC	7.50	0.43	20.4	5.2	4.9
2-years old soil					

Asod	3.10	0.20	18.1	5.0	4.5
A	2.46	0.18	16.0	4.5	4.3
AC	3.01	0.17	20.7	4.5	4.3
C	0.14	Not det.		4.5	4.3
15-years old soil					
Asod	1.95	0.13	17.6	5.3	3.8
A	0.50	0.04	14.6	5.4	3.8
AC	0.60	0.04	17.6	5.4	4.1
C	0.15	Not det.		5.4	4.8

2- and 15-years old soils show essential differences in its humus composition (table 7). The first one is different portion of free fraction of humic and fulvic acids, which is show the tendency for increment of organic matter humification degree in 15 years old soil. The second important tendency is an increasing 3rd fraction (mineral-phase connected) of HA. The CHA:CFA ratio is essentially higher in 15-years old soil in comparison with 2-years old soil. The content of nonsoluble remainder (NR) in 2–years old soil is very high and it seem to be caused by big portion on undecomposed organic matter which were amended to soil. In 15-years old soils the portion of NR essentially decreases due to mineralization and intensive humification of organic matter.

Table 7: Humus composition in AC horizons of different-age amended soils of Shapki plots(% of carbon to Ctotal content)

horizon	Humic acids				Fulvic acids					CHA/CFA	NR
	1	2	3	HA total	1-a	1	2	3	FA total		
2-years old soil											
Asod	4.2	1.6	6.1	11.9	2.6	4.8	0.3	1.0	8.7	1.37	79.4
A	5.3	1.2	5.3	11.8	2.4	6.9	0.4	2.0	11.7	1.00	76.5
AC	7.8	0.0	3.3	11.1	2.7	3.0	0.7	1.0	7.4	1.50	81.5
15-years old soil											
AC	31.5	0.5	10.8	42.8	1.0	17.4	0.0	6.2	24.6	1.73	32.6

Table 8: The elemental composition of humic acids and content of acid functional groups in them

Plot	C	N	H	O	Functional groups, cM/1000 g of ashless material	
	Atomic %				-COOH	-OH phenol
Phosphorite, 19 years non-amended soil	38.2	2.9	45.0	13.9	410	440
Phosphrite, 19 years amended soil	38.1	1.9	43.6	16.4	670	440
Shapki, 15 years old	34.2	1.9	45.0	18.9	450	510

Assessment of humus stability by chemodestruction fractionation

The results of chemodestruction fractionation confirms the general tendency in increasing of organic matter degree of humificaion in age row. In different-age Phosphorite soils there is exactly expressed tendency of light-oxidizable fraction decreasing with age row, which accompanies by increment of portion o humus which is stable to oxidation. In a period from 19 to 23 years of soil development there is evident changes in portions of light and stable organic matter, this process coincide with increasing of CHA:CFA ratio (fig. 1).

In Borovitchy soils organic matter wasn't plugged into soil, that is why accumulation of humus is a result of pedogenesis. In these sandy textured soils there is high level of light fraction, the content of stable fraction gradually increases due to humification process (fig 2).

In soils of Shapki plots the same tendencies as in Phosphorite were revealed. The portion of labile humus decreases as result of mineralization, and content of stable fraction increases due to humification process (fig 3).

Fig 1: The results of chemodestruction fractionation of organicmatter of soils of Phosphorite plots

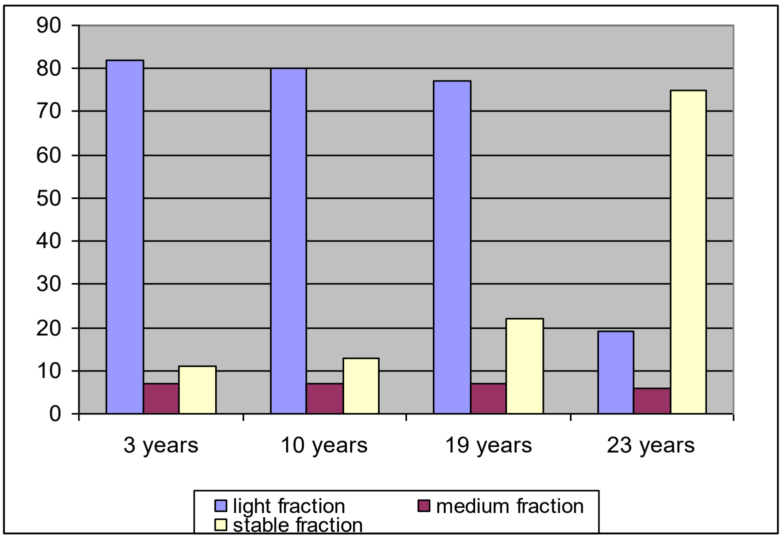


Fig 2: The results of chemodestruction fractionation of organicmatter of soils of Borovitchy plots

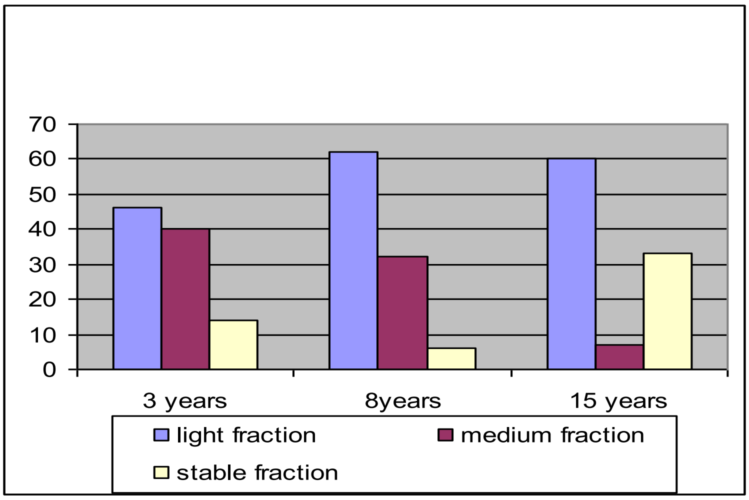
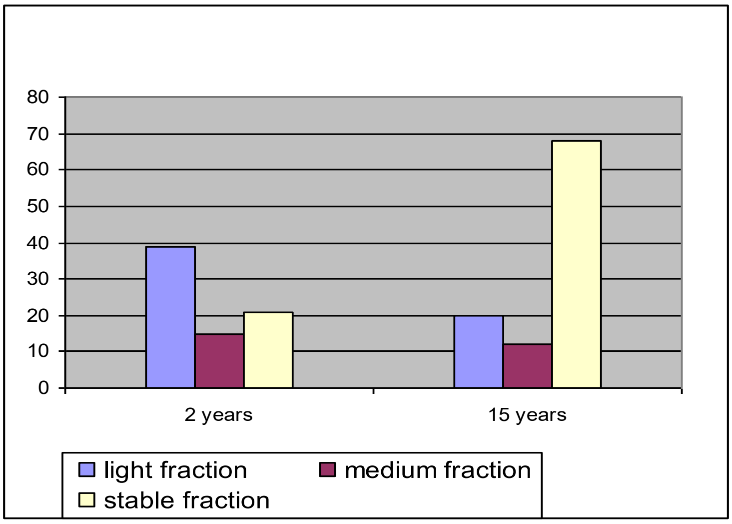


Fig 3: The results of chemodestruction fractionation of organic matter of soils of Shapki plots



Humic acids characteristics

Humic acids were extracted from three samples. Two samples we use to compare the effects of amendment on process of HA formation. It is Phosphorite non-amended soil and soil on the same parent material, which were amended. The age of soils is the same (19 years), also the deepness of sampling is the same (15-20 cm). The third sample is 15-years old soil of Shapki plot (A horizon).

The elemental composition of HA in non-amended and amended soils are different (table 8). HA in amended soil charachterizes by increased percentages of oxygen and decreased portion of nitrogen in contrary with HA of non-amended soil. By these characteristic HA of amended soil in Phosphorite plot can be classified as a substance, which is close to the fulvic acids class. Additionally the increased content of acid functional groups shows the same result. In non-amended soil due to the lesser content of organic carbon the intensity of humification is increased, that is why we can see the fewer portions of acid functional groups and lower content of oxygen and increased reaches of HA by nitrogen.

The preparatus of HA, extracted from Shapki 15-years old soil can be classified as intermediate between HA and FA type of substances. There is a low content of nitrogen and increased content of oxygen which is characteristic for FA. But the functional groups contents are the same as in usual humic acids.

So, the humic substances of amended soil is not well developed deeply humified material, it characterizes by low nitrogen content and increasing of percentages of oxygen, and also with big content of acid functional groups.

DISCUSSION

The turfs and forest floor application for grounds amendment is a specific, regional way for destroyed land reclamation. The must popular ways of grounds amendments in Russia is plugging of manure, crop plants organic residues and scrapped soil materials. But this procedures use to be applied in a basic mining complexes of Russia – Kuzbass, Donbass and others, which not belongs to the territory of taiga zone. In North-West economical region the natural sources of organic matter start to be used for soil amendment about 20 years ago. That is why our results have not analogies for North-West region and cannot be compared with some published works in regional scale.

Amendment of soils by organic wastes leads to the intensification of natural overgrowing, and plant growing seeded during revegetation. Two types of amendment – plugging of organic matter into soil layers and scattering of it's on the soil surface are very different in sense of these measures influence on soil formation process. In first case amendment leads to increasing of soil acidity, leaching of lime and development of soil sorption complex. The thickness of soil profile and separate horizons also increases, as the changes in soil morphology are evident. In second case the amendment influence actively on the revegetation, due to dispersing of seedlings on the soil surface. By this indirect way the surface amendment influence on soil formation, resulting in slowly humus accumulation and soil profile development.

The general chemical properties changes in soils with ploughed organic matter are evident. On the lime-containing loams of Phosphorites there are expressed tendencies of pH decreasing and carbonate leaching. The same was revealed buy Gagarina et al [5] and Sourkova et al [19]. In soils on the sands the actual acidity (in water suspension) initially increases, and then decreases in older soils. The potential acidity as measured by pH in KCl suspension in opposite shows the strong row of increasing in age row. Therefore we can conclude that amendment firstly influences on the actual acidity increment, by this – to intensification of weathering and therefore to development of soil sorption complex, which is responsible for the potential acidity of soil.

Soils of Phosphorite plots consists of two parts: new formed Asod and A horizons and black-colored AC horizons formed due to amendment. The separation of humus fractions to groups of new formed and hereditated from amendment is complicated problem [15], and it can be solved only by the way of assumption that in AC horizon organic mater not contain a big portion of new formed fractions. Asod and A horizons also contents the organic matter which were plugged to soil, but evolutional tendencies of initial organic matter quality changes can be described only for AC horizons, which seems to be changed by new-humus formation, i.e. pedogenesis in lesser proportion then Asod and A horizons. During the soil formation the contents of initially amended humus decreases due to mineralization and intensive humification. In youngest of amended lime-containing soil there is very essential portion of fulvic acids fraction, which leads to weathering of mineral part. Further, humification of organic matter leads to accumulation of free fraction of HA and FA connected with mineral part. The stability of humus, assessed by chemodestruction increases within the age row due to the mineralization of light oxidazible fractions and accumulation of stable one. The system of organic matter became relatively stable in age stage of 23 years, both, the new formed horizons and residual AC shows the stabilization of C/N ratios, increasing of CHA:CFA ratios and increasing o humus stability. The process of organic matter formation on lime-containing spoilbanks which were amended by composts we can divide on the stages: 1. initial influence of FA on mineral part, 2. starting of intensive mineralization and slow humification, 3. starting of intensive humification with following stabilization of organic soil profile. The changes of FA accumulation on young stages of soil formation by intensifying of humification process seems to be typical for all lime-containing grounds, which were amended by organic matter [11].

In case of plugging of organic matter into sandy grounds humus were exposed to the intensive transformation, especially during the initial 1-2 years after soil amendment. The sandy type of grounds characterizes by low water-retention capacity, little content of clay and colloids, the great rate of the aeration porosity which assist to mineralization. All these properties are favorable to the intensive organic matter transformation, especially for mineralization. The time trends in OM properties changes are close to the same in Phosphorite plots, in exception of the speed of organic matter mineralization, which is more intensive on the sands.

The surface amendment of sandy soils leads only to intensification of revegetaion and by this way to accumulation of humus. The percentages of humus and degree of it humification increases within the age row.

Amendment of soil by organic matter assist to formation of humic substances which is intermediate on the properties between humic and fulvic acids. The most important property of it is high content of acid functional groups, increased oxygen and low nitrogen portions in comparison with HA of mature zonal soils [5, 6]. That is why we can conclude that humification leads to formation of not developed humic substances in conditions of big content of fresh organic matter amended to soils.

In general in all investigated soils we can see the tendency on increasing of humus stability, which can be assessed both by CHA:CFA ratios and content of humus stable fraction. This facts shows that, transformation of humus in any cases must realize by the way of increasing of its products stability [2, 12].

CONCLUSIONS

Amendment of different spoilbanks grounds by organic matter leads to the intensification of soil formation and revegetation, but the organic matter development trends are different as results of the different grounds types and way of amendment. Lime-containing loams under the plugging of composted turfs show the increasing of soil acidity and leaching of carbonates. Sandy grounds under the forest floor plugging became more acid too. In both types of amended grounds the losses of organic matter due to minerilisation, further humification, increases of CHA/CFA ratio and the portion of stabile humus were revealed. In opposite to grounds which were amended by plugging, the surface amendment doesn't show the evident pedological effect and not leads to organic matter accumulation. Meanwhile, humus in this surface amended chronoseries show the tendencies to accumulation, increasing of the degree of humification and portion of stable fraction, but this tendencies caused by intensification of revegetation and biological productivity increment, but not the direct influence of amendment on soil.

So, is it necessary to use the organic amendments for grounds reclamation or not? Results of this study shows that amendment leads to intensification of soils formation and revegetation. But its also leads to essential emission of carbon dioxide to atmosphere which need to be assessed more precise. In any case organic amendments can be effective only in case of plugging, i.e. intensive contact of organic matter with mineral solum. Humification and deep transformation of organic matter possible only in this case. In opposite, surface amendment is not effective both in ecological and economical sense. Concluding this article it is needed to emphasize that, organic matter is main agent of soil formation, main instrument of ecosystem influence of soil substrata. Therefore, soil formation can be essentially intensified only by organic matter amendment. This method is quite effective for both loamy and sandy textured technogenous grounds of spoil heaps of Russian North West quarries.

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