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DETRITUS PARTICIPATION IN WATER-RESISTANT UNITS FORMATION OF CHERNOZEM TYPICAL IN DIFFERENT ECOSYSTEMS[1]

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It was found that particular components of organic part of soil play different roles in formation of soil-structure aggregates, depending on kind of typical chernozem use.
Major role, in formation of water-stable <1-mm sized structural aggregates in all test-soil samples, is played by humic substances proper (HSP).
HSP-portion of humic substances is the biggest one in the content of >1mm aggregates of ploughed and fallow soil, while in formation of aggregates in soils of virgin steppe and tree belts, the leading role is played by detritus.
Ratio of humic substances proper vs detritus [i.e., HSP / D], for all ecosystems studied, has revealed a predicted prevalence of the detritus role in formation of large aggregates.

Key words: *typical chernozem, organic part of soil, structural aggregate, humic substances proper, detritus*
([1] Prof. V.V. Degtyarev is the Scientific Curator of this work)

Introduction. The organic part of soil takes a direct part in processes of structure formation, determining the structural aggregates quality. As stated by M.I. Laktionov [1], the organic part of soil comprises at least four major components, including detritus, i.e., semi-decayed plant residue having lost their shape and anatomic structure. Scientific bibliography avails but very little data on detritus contents and role in organic part of soils, as well as conditions of accumulation and features of further transformations in the course of soil-formation process. Hence, a question of the detritus role in structural soil aggregates' formation is of a certain interest, being nowadays quite an actual issue.

Review of topical publications. The most interesting and important problematic aspect of humus participation in structure formation refers to the role of organic part of soils in genesis of water-stable structural aggregates. Specific humic substances proper (HSP) and detritus (D) are typically the most important components of the organic part of soil.

I.V. Tyurin [2] suggested that in virgin soils, processes of grass vegetation bulk transformation by microorganisms flow somewhat slow due to its excessive amount. Residues of semi-decomposed died-off plants having lost their anatomic structure, undergo natural conservation in form of ligno-humates or detritus [2].

V.V. Medvedev et al [3] note an enhanced status of typical chernozem physical properties owing to long-term application of organic fertilizers (e.g., manure). This fact is caused by many factors, including upgrowth of detritus content.

M.I. Laktionov [4] found that virgin soils contain most of the detritus ever, nearly 40 % of the total content of humus in the top-soil. Author has proven experimentally that particles of virgin soil detritus adsorb HSP on their surfaces, whereas ploughed soil detritus is almost incapable of it. Difference between detritus properties is predictable. The virgin soil detritus is a product of age-long decay of organic residues. Its conservation there results from consequent deterioration of aeration conditions (in the course of 'steppe felt' formation) for microorganism groups capable of transforming

organic residues at latest stages of their decomposition. Hence, detritus in virgin soil is mainly represented by actively HSP- adsorbing cellulose.

Treating humic substances as agents of structural formation in chernozems traditionally fertilized with manure, T. M. Laktionova [5] notes that detritus, together with HSP adsorbed on its surface, are directly involved in processes of aggregating the solid phase of soil or, in other words, detritus performs a role of binding material during structural macro-aggregates' formation.

A brief review of relevant bibliography shows that function of detritus, as a factor of structural formation in chernozems, is viewed by various scholars from different points, but this issue is still far from its logic end as yet.

Purpose of the work: to investigate the role of detritus as a special component of organic part of soil in formation of typical chernozem structural aggregates in different ecosystems.

Materials and methods. Chernozem typical loamy on terrain of Ukrainian "Myhailivska Cìlina" (Michael's virgin) natural steppe reservation in Sumy region (N. Ukraine) enlisting such test-sites as: virgin land; fallow land (this plot was under ploughed cultivation before 1956); shelterbelt forest (this plot was founded 1956 over virgin soil strip encompassing the Reservation territory); arable land 77 years (this plot has been under ploughed cultivation since 1933).

Research method. Soil samples were taken from surface down to 50 cm deep, from three walls of vertical profiles through every 10 cm. The structural-aggregate composition was determined at unbroken soil-samples by method of M.I. Savvìnov (ДСТУ 4744: 2007).

Medium mixed samples (ДСТУ 4149: 2004) were prepared from individual samples, and further used to define the content of humus substances.

Total content of humus was defined by method of I.V. Tyurina in modification by S.M. Simakova (ДСТУ 4289: 2004); while the contents of HSP and detritus were defined in water-stable structural aggregates by modified method of Yu. Springer [6].

Results and discussion. The major amount of optimum size (0.25-10 mm) aggregates was found in structural composition of soil in virgin land (Table 1), whereas this index in ploughed soil was considerably lower. Changeover to the fallow land regime helps improving soil structure, and this fact is especially noticeable in the upper soil layer studied. Planting a woody vegetation brings to a decrease in amount of optimum size aggregates, as compared to that in virgin soil.

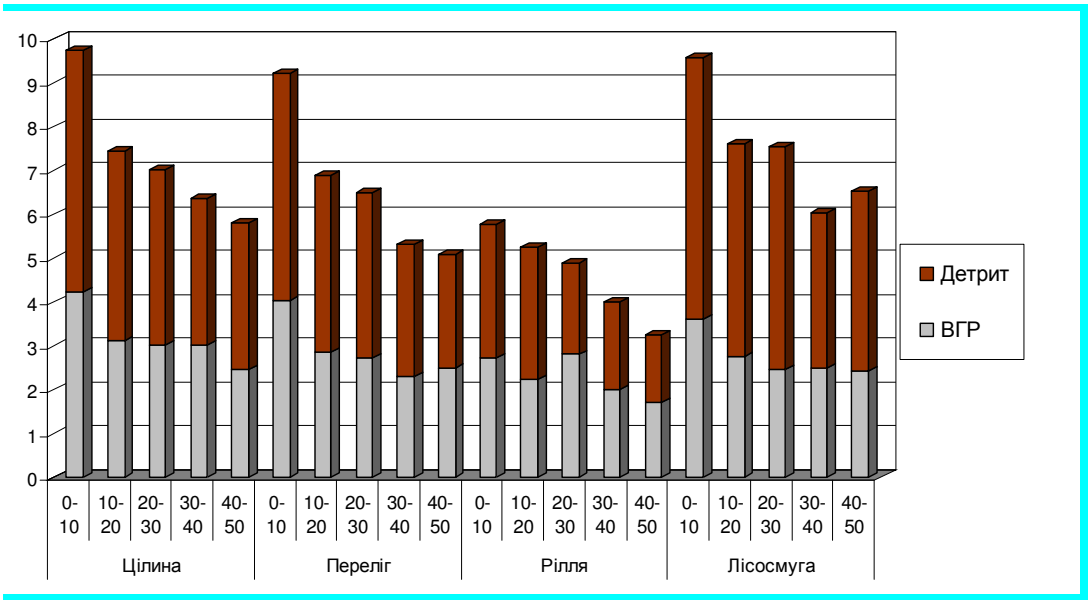
It was found that highest water-stability indices are inherent to chernozem structure under absolute virgin cover and in fallow land, thus exceeding significantly those of ploughed soil. Chernozem structure below tree belt is more water-stable than in ploughed soil, but less stable than in chernozem of natural and post-agrogenous ecosystems.

Humus content evaluation in water-stable virgin chernozem structural aggregates (Figure 1) has shown that D- percentage in > 3 mm sized aggregates of 0-10 cm layer makes up 5.50 %, gradually decreasing with depth and coming down to 3.35 % in a 40-50 cm deep layer. The HSP content somewhat lower that of detritus. In ploughed soil, content of detritus in similar aggregates is considerably lower as compared with all other options.

Table 1. Structural and aggregate composition of typical chernozem in different ecosystems of "Mihaylovsky Test-Site" virgin soils

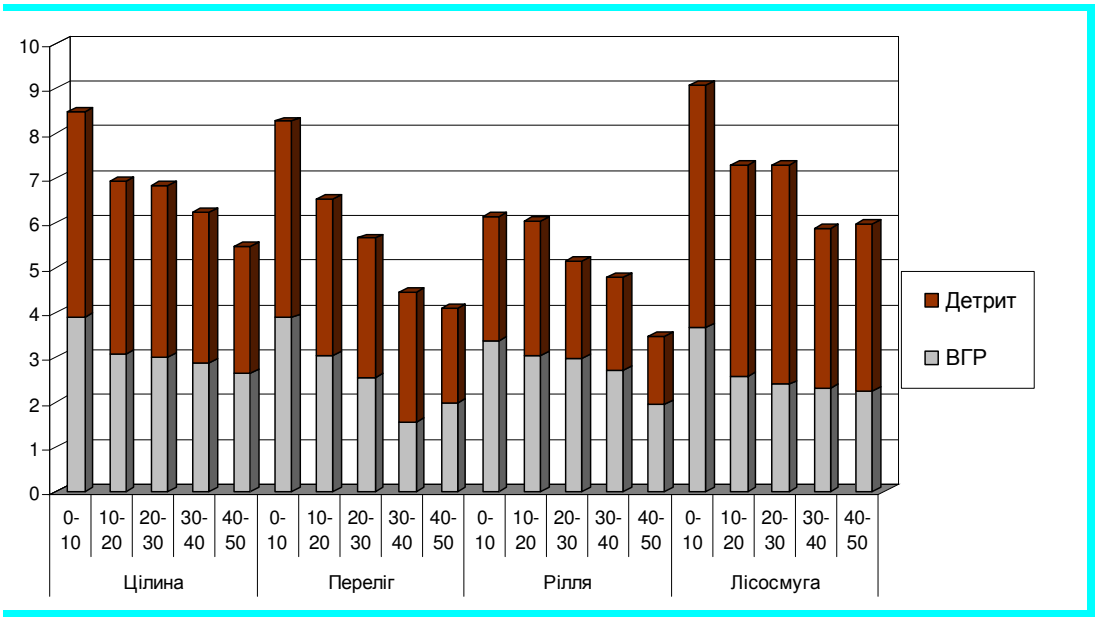
Layer, cm	Content of aggregates (%) per size, mm									Structure index	Water-stability index
	>10	10-7	7-5	5-3	3-2	2-1	1-0.5	0.5-0.25	<0.25		
Virgin land											
0-20	1.8	3.8	10.1	21.7 22.0	20.6 12.1	20.8 23.4	5.6 7.8	7.7 10.4	7.9 24.5	9.3	0.82
20-50	4.7	6.6	10.6	21.6 29.8	13.3 10.2	15.4 13.1	5.2 7.4	6.4 10.5	16.1 28.1	2.9	0.85
Fallow land											
0-20	2.0	7.4	11.3	20.6 23.8	13.5 11.9	19.9 23.0	6.0 11.5	7.3 8.85	8.6 21.4	8.4	0.86
20-50	7.6	8.2	12.4	15.7 27.8	15.6 11.4	13.1 15.0	4.3 8.7	6.2 8.7	16.4 28.5	3.1	0.85
Shelterbelt forest											
0-20	2.2	3.4	5.6	11.8 13.3	8.7 9.7	18.2 16.7	20.9 11.1	8.7 13.6	20.5 35.8	3.0	0.82
20-50	2.7	4.1	6.9	13.6 11.4	13.2 9.5	19.3 14.4	4.4 11.1	11.4 12.9	24.3 40.6	2.7	0.78
Arable land											
0-20	7.3	8.3	9.1	14.3 0.9	7.8 1.9	15.9 6.4	7.4 10.8	12.3 25.6	17.6 54.5	3.1	0.55
20-50	10.0	8.3	9.2	16.6 3.6	10.4 5.3	17.0 11.9	7.0 13.8	8.3 20.1	13.1 45.2	3.3	0.63
NOTE: Digits above the line denote dry separation Digits below the line: separation in water											

Somewhat different dependence was found for detritus content in fallow land chernozem. The HSP (4.04 %) index, being lower than detritus contents in the upper layer, is sharply decreasing with depth. This fact indicates that if arable land were left to fallow with natural vegetation, D percentage in macro-aggregates increases, which is clearly seen in a 0-30 cm layer. Water-stable > 3 mm sized aggregates possess highest D content (5.96 %) in 0-10 cm layer of soil under tree vegetation, which index changes with depth unevenly.



Legend: Left to right: Virgin land, Fallow land, Arable land, Shelterbelt forest;
Brown: Detritus; Grey: HSP

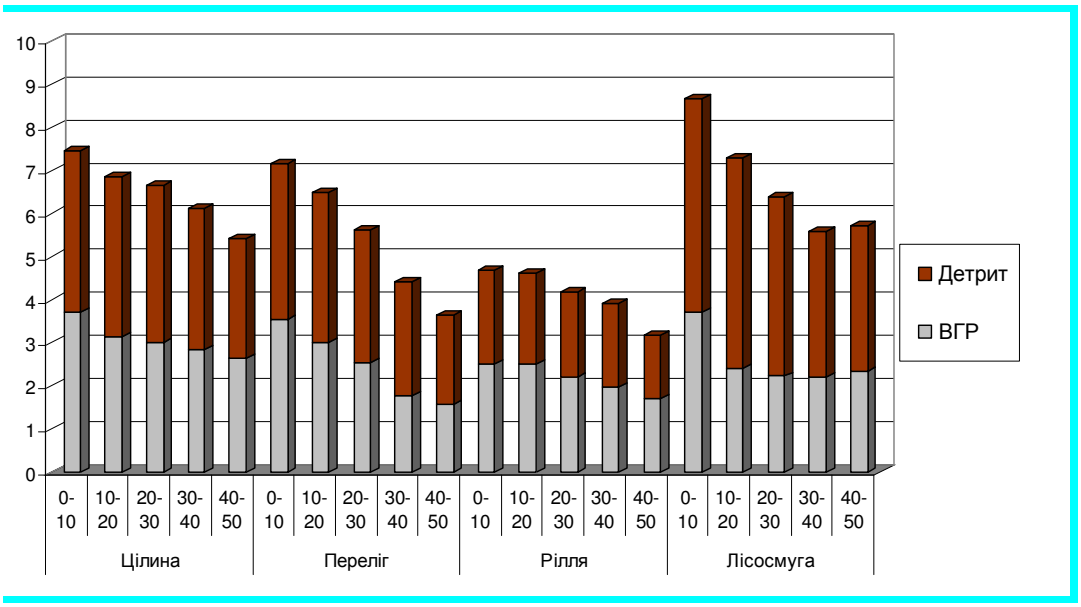
Figure 1. Contents (%) of humic substances proper and detritus in water-stable > 3 mm sized structural aggregates, in soil layers from 0 to 50 cm



Legend: Left to right: Virgin land, Fallow land, Arable land, Shelterbelt forest;
Brown: Detritus; Grey: HSP

Figure 2. Contents (%) of humic substances proper and detritus in water-stable 3-1 mm sized structural aggregates, in soil layers from 0 to 50 cm

Detritus content in 0-10 cm layer of 3-1 mm virgin chernozem aggregates (Figure 2) makes up 4.57 %, yet with depth, it is markedly decreasing similarly with HSP contents. Detritus content in ploughed soil aggregates of above-said size is the least among every other option studied, yet slightly increasing in 10-20 cm layer, which fact we presume by significant amount of plant residues buried at this depth in every ploughing session. Concerning HSP content index, it exceeds that of detritus. Contents of HSP and detritus in fallow land chernozem aggregates sized as much as 1-3 mm and over, exceed those of structural aggregates in arable soil. Planting the woody vegetation affects, to a certain extent, the contents of detritus in structural aggregates of humus-accumulative horizon. In particular, detritus content in 0-10 cm layer exceeds that even in virgin soil aggregates. Detritus content in 1-0.25 mm virgin chernozem aggregates does not almost change with depth. HSP contents is also high, yet reducing with depth (Figure 3).

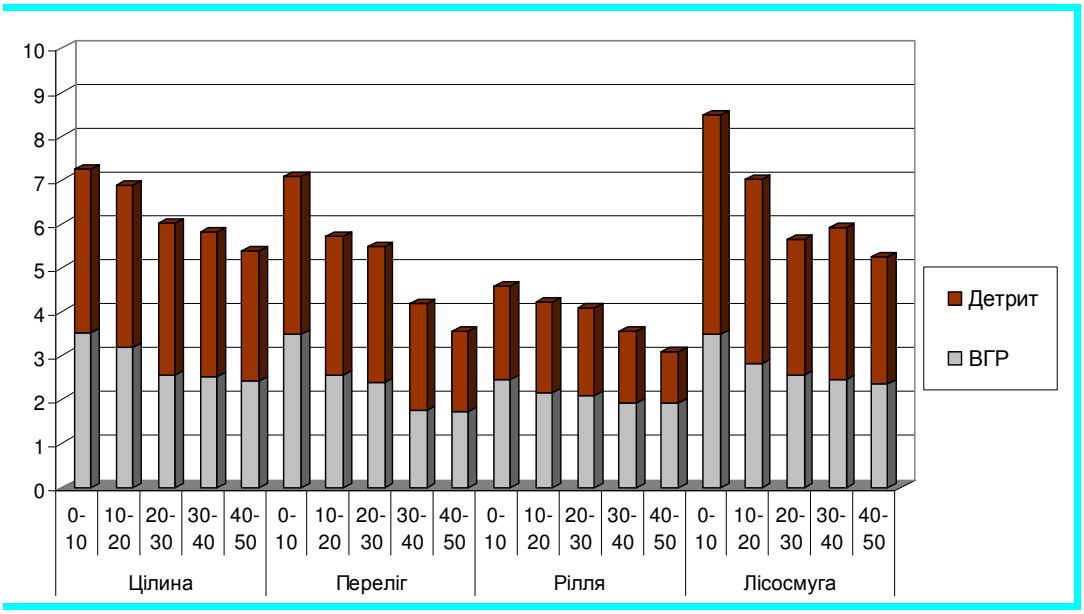


Legend: Left to right: Virgin land, Fallow land, Arable land, Shelterbelt forest;
Brown: Detritus; Grey: HSP

Figure 3. Contents (%) of humic substances proper and detritus in water-stable 1–0.25 mm sized structural aggregates, in soil layers from 0 to 50 cm

Contents of HSP and detritus in 0-10 cm layer in fallow land make up 3.53 and 3.62 % (correspondingly), and with depth, both indices are decreasing. Ploughed upturning of typical chernozem reduces HSP and D content in these aggregates, whereas plantings of woody species makes it notably vice versa. This law applies to the entire thickness of soil studied.

The minor (< 0.25 mm) structural aggregates are generally characterized by the least contents of HSP and detritus, as compared with larger aggregates (Figure 4). Contrast to plow land, fallow land soil use regime promotes an increase of D content even in the lowest layers. Ploughed soil possesses much less detritus content in < 0.25 mm water-stable aggregates, versus that in > 0.25 mm ones, in inverse proportion to HSP index herein. In our opinion, this fact may be referred to changes of soil- and bio-regimes, in microbial species' composition and in their amount, - as a result of virgin chernozems' upturning. Detritus and HSP contents were the largest in <0.25 mm aggregates of soil under woody vegetation.



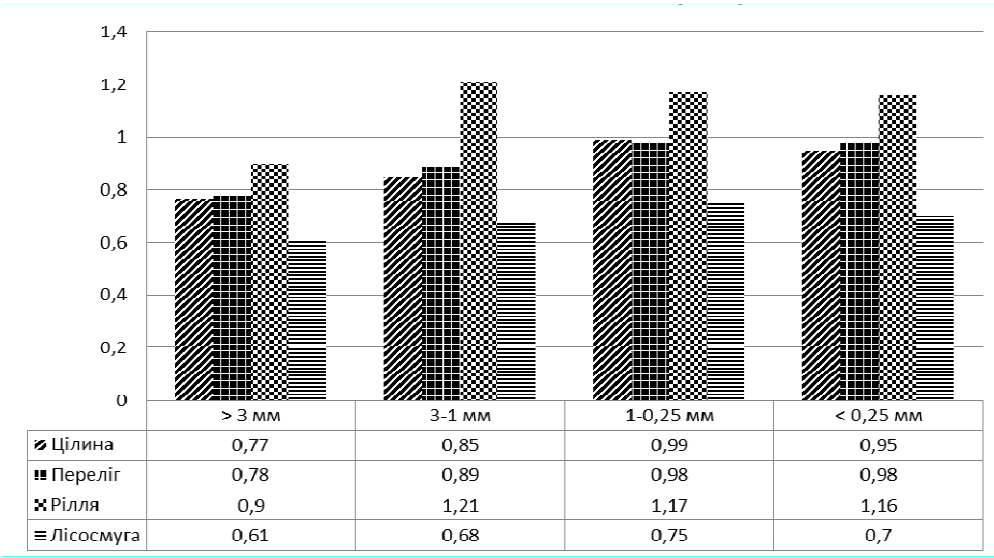
Legend: Left to right: Virgin land, Fallow land, Arable land, Shelterbelt forest;
Brown: Detritus; Grey: HSP

Figure 4. Contents (%) of humic substances proper and detritus in water-stable < 0.25 mm sized structural aggregates, in soil layers from 0 to 50 cm

M.I.Laktionov and V.V.Degtyarev were the first to render the organic part of soil as a qualitative index, now known as [HSP / detritus] ratio. Authors found that plow upturning of typical chernozems is accompanied with a slight decrease of HSP index simultaneously with a sharp decrease of D content, i.e., ploughing up modifies the spread of [HSP / detritus] ratio [7].

Ratio of [HSP/D] contents calculated for typical virgin chernozem at 'Mihaylovsky Test-Site' showed that in 0-10 cm deep layer of virgin soil in water-stable aggregates, it makes up 0.77 and 0.95 for > 3 and <0.25 mm sized structural aggregates, and 0.99 in > 1 and <0.25 mm aggregates (Figure 5).

Plow upturning of virgin chernozems and their subsequent ploughing within 77 years has led to a notable rise of [HSP/ D] ratio in > 3 mm sized aggregates and still more notable in < 3 mm ones. Fallow land regime of soil use brings to decrease in [HSP/ D] ratio as compared to ploughed soil, which is most expressly seen in < 3 mm aggregates. In soil under shelterbelt, [HSP/ D] ratio for all structural aggregates is the lowest versus all other options, making up almost identical index (0.61 and 0.70), irrespectively of aggregates' sizes.



	> 3 мм	3-1 мм	1-0,25 мм	< 0,25 мм
Цілина	0,77	0,85	0,99	0,95
Переліг	0,78	0,89	0,98	0,98
Рілля	0,9	1,21	1,17	1,16
Лісосмуга	0,61	0,68	0,75	0,7

Legend: Left to right: Virgin land, Fallow land, Arable land, Shelterbelt forest

Figure 5. [HSP / D] ratio in structural aggregates of 0-10 cm deep layer of typical chernozem

Conclusions

1. In genesis of structural < 1 mm sized water-stable aggregates of typical chernozem, major role belongs to humic substances proper and to detritus – in > 1 mm aggregates. It was found that in virgin soil and in soil under tree belt, detritus prevails in organic part of structural aggregates, however with their decrease in size, D-proportion is considerably reducing and becomes equal to HSP amount.In large structural aggregates of ploughed chernozem, detritus content is notably reducing, while HSP-index is growing up. In genesis of >1 mm – water-stable aggregates of chernozem under plow and fallow land, HSP-index somewhat prevails, while in soils of a virgin plot and under tree belt area, the leading role undeniably belongs to detritus.

2. The typical features, for all the site studied, is a changeover of [HSP/ D] ratio with increase in size of structural aggregates, which fact testifies to significant role of detritus in genesis of large water-stable aggregates.

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