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SOIL BIODIVERSITY MODELLING ITS HABITAT AND CREATING PEDOFEATURES FOR SOIL CLASSIFICATION

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Abstract

Soils "are alive" due to the high activity of their biota. But, when named soils in different classifications the biological activity is more or less ignore. This paper brings biodiversity in the centre of the soil genesis and evolution, and emphasized its activity that modelling the habitat and consequently generating pedofeatures specific to each soil. The researches had been performed on two Greyzemic Phaeozems. Their main morphological characteristic is the presence of the „uncoated silt and sand grains on structural faces in the lower half of a mollic horizon" (WRB-SR-2014). The micromorphological observation located the areas with the uncoated silt and sand grains in the old macrofauna coprolites, integrated into the soil groundmass. The macrofauna also brings from the deeper horizons, soil material (more clayey and less humic) compensating in this way plasma eluviation. On the general background of pedolandscape characteristics (relatively mobile soil plasma containing fulvic acids - in Ame horizon exclusively; clayey loamy texture; and climatic conditions) the soil biodiversity modelling its habitat and created specific pedofeatures helpful for soil classification.

Key words: *biodiversity habitat, micromorphology, Greyzemic Phaeozem, macrofauna.*

INTRODUCTION

Soil is the critical and dynamic regulatory centre for the majority of processes occurring in both natural and managed terrestrial ecosystems (Barrios, 2007). At the scale of plant roots and macrofauna (centimeters to millimeters), soil is best described as a highly complex assemblage of pore spaces (more or less water saturated) and soil aggregates (Tecon & Or., 2017).

Many species of invertebrates are important in soil fertility and play a vital role in the production and maintenance of healthy soils (Chiriac & Murariu, 2021).

The variety of aggregate sizes, of pore spaces and of chemical gradients results in highly diversified microhabitats (Tecon & Or., 2017).

Soil functions as a favorable habitat for many invertebrate species, and invertebrate communities are involved in geochemical cycles (Lemanceau et al., 2014).

Several biotic and abiotic processes act to redistribute organic C and mineral constituents as bioturbation by soil macrofauna or transport by water flow in soil pores (Lavelle, 2012; Tecon & Or., 2017).

The trophic structure of soil fauna can be influenced by changes in soil properties, therefore, different trophic groups respond in various ways to changes in the plant community and soil properties (Xue et al., 2021).

In what concerning the properties of the Greyzemic Phaeozems, as a result of an irrational land use, the present tendencies in their evolution of highly dispersive silicate part (of the Greyzemic Phaeozems from the Pre-Carpathian region) indicate the degradation of their clay profile and loss of very important ecological functions (Franco, 2018).

The microscopic study of Greyzemic Luvic Phaeozems showed, near the greyzemic features, as uncoated sand and silt grains on pores and ped surfaces, also the presence of abundant clay cutans in the argic horizon, as well as abundant secondary carbonates in the subsoil presented by carbonate impregnation of plasma, pseudomicellia and soft and hard nodules (Puzanova et al., 2017).

Soil is the critical and dynamic regulatory centre for the majority of processes occurring in both natural and managed terrestrial ecosystems (Barrios, 2007).

Land-use intensification strongly influences biodiversity by altering habitat heterogeneity, the distribution of habitat types and their extent (Eggleton et al., 2005).

The soil environment is likely the most complex biological community and soil organisms are extremely diverse and contribute to a wide range of ecosystem services that are essential to the sustainable function of natural and managed ecosystems (Barrios, 2007).

This paper emphasized the biological activity that modelling the soil, its habitat, and generating pedofeatures, specific to each soil type, and used for soils classifications.

MATERIALS AND METHODS

Two Greyzemic Phaeozems (WRB-SR–2014) located in different pedolandscapes and climatic conditions had been studied: P_1 - in upper Jijia Plain, and P_2 - in Western Romanian Plain.

P_1 was formed on a slightly sloping surface to the northeast (2-5%) of interfluves, at the absolute altitude of 265 m, in marly clay parent material. Thus the global natural drainage is good. The soil humidity regime is ustic-udic, whilst the soil temperature regime is mesic. The bioclimatic zone is forest-steppe with *Quercus petraea* forest, *Carpinus betulus*, *Acer campestris, Cornus sanguinea*; the grassy vegetation is dominated by *Poa nemoralis* and *Galium schultesi*.

The climate is temperate continental, with the average annual temperature of 8.3ºC, and the average annual precipitations of 563.3 mm.

The second soil profile, P_2, was formed on flat surface, at an absolute altitude of 86 m. The parent material is composed of loessoid deposits. The global natural drainage is good and the groundwater is at 5-10 m depth. The soil humidity is ustic (humid tempustic), whilst the soil temperature regime is mesic. Bioclimatic zone is of oak forest (*Quercus cerris* and *Quercus frainetto*). In the grassy cover, the main edifying species were: *Lithospermum purpureocoeruleum, Festuca valesiaca, Potentilla recta, Verbascum phoeniceum*, *Lathyrus niger, Crepis praemorsa, Ranunculus polyanthemos*, *Polygonatum latifolium,* and *Euphorbia amygdaloides*.

The climate is temperate continental, with an average annual temperature of 10.7ºC, and the average annual precipitations of 545 mm.

Disturbed (for physical and chemical analysis) and undisturbed (for micromorphological study) soil were sampled from each pedological horizon and determined by the standard methods of ICPA-Bucharest (ICPA Methodology, 1987).

From the undisturbed soil blocks (air dried and impregnated with epoxy-resins), oriented thin sections (of 25-30 μm) have been made for the micromorphological investigation. The thin sections had been studied with Documator (20X) and the optical microscope (50-500 X) in plane polarized (PPL) and crossed polarized (XPL) light. The terminology used for micromorphological description was according to Bullock et al. (1985).

RESULTS AND DISCUSSIONS

The main morphological characteristic of the Greyzemic Phaeozems is the presence of the "uncoated silt and sand grains on structural faces in the lower half of a mollic horizon" (WRB-SR–2014), the Ame horizon respectively. This horizon is defined (according to SRTS - 2012) as an A mollic-greyzemic (Ame) horizon located at the base of the Am horizon and has residual accumulations of quartz or other weather-resistant minerals, stripped of colloidal coatings, as spots frequently enough to give the faces of dry structural elements colors with values of 3 and higher, and chrome below 2. This horizon is between an Am and a Bt horizon. It is also called A hypoluvic and showed a "powdering" with quartz; representing the initial stage of an E horizon formation.

The granulometry data of the two Greyzemic Phaeozems emphasized that clay content (Figure 1) ranging between 32.8% into the Am horizon, and 34.5% into the Ame horizon of the P1, while in P2 the clay content (Figure 2) ranging between 28.0% in Am and 33.5% in Ame.

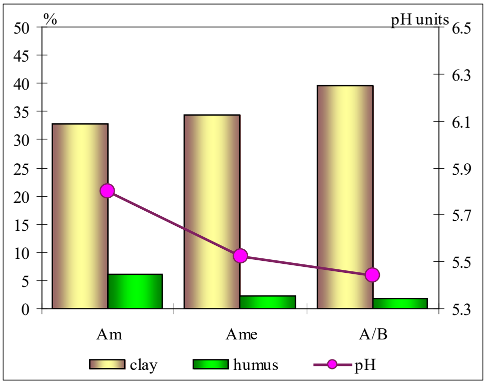

Figure 1. The clay and humus content of P_1 and the soil acidity

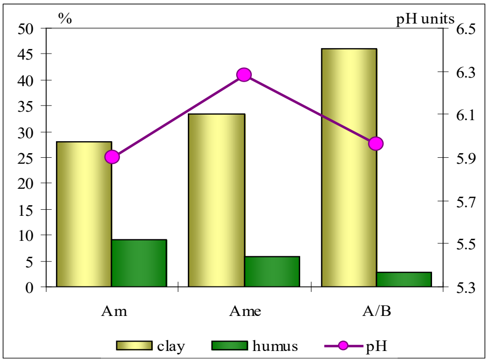

Figure 2. The clay and humus content of P_2 and the soil acidity

Both Greyzemic Phaeozems are moderately acid, the pH values ranging between 5.52-5.90. Into the Ame horizon of P_2, the pH is higher (6.28). According to the values of the base saturation degree (56-68%), the P1 is mezobasic in the mollic epipedon, while Ame horizon is oligo-mezobasic, due to a lower value (42%). The P_2 profile is saturated in bases, the values being very high (92-94%), as well as in Ame horizon (93%).
The analytical data showed high content of humus (Figure 1) both in Am upper horizon (6.12-9.12 %) and in Ame (2.34-5.57%).
In what concerning the analysis of the fractional organic carbon, on the background of a pH 6.1-6.5, the fulvic acids (CAFT) had been detected into the Ame horizon of P_2 (13.1% from the total carbon). Along with this, the presence of the aggressive fractions of the total fulvic acids (CAF_{1a}) had been identified (0.2% from soil).

The mineralogical composition of clay (< 0,002 mm) in both soil profiles showed that illite is dominant (50-53% - Figure 3), while the smectite, the most mobile clay fraction, is lower (42-45%) in Ame.

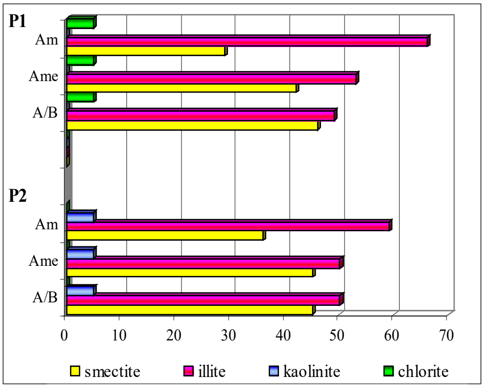

Figure 3. The mineralogical composition of clay (< 0,002 mm) in both soil profiles.

The dominance of the inactive illite clay in the whole humus horizon (0-70 cm) of all Greyzemic Phaeozems (studied by Franco in the Pre-Carpathian region), as well as the high content of kaolinite reduce the role of the clay plasma as the major stabilizer of the organic matter and further of the soil microstructure, along with the accelerated humus mineralization (Franco, 2018).
The exclusive presence of the fulvic acids in Ame horizon and specially their aggressive fraction, showed a great mobility of the organo-mineral plasma at this level and also its local reorganization giving the groundmass an uneven appearance.
What keeps the Ame at the level of an A mollic horizon is the high amount of organic matter (4.38-5.76%) and especially the large amount of stable fractions: humic acids (ranging between 25.8-34.8% from the total C) and humines (varying from 52.0 to 64.8% from the total C). These stable organic components are intimately linked (by means of the binding Ca^{++} and Fe^{++} cations) to the colloidal edaphic substrate which they stabilize, thus, the dominant image of this horizon is that of a mollic one.
At micromorphological level this horizon (Ame - 22-34 cm) appears having a complex structure: subangular blocky and locally

spongy. The porosity is relatively high (20-30%) and is represented by a network of fine cracks, interconnected voids and also biogenic channels (2-6 mm ∅).

The related distribution pattern (the spatial arrangement between the coarse and fine material, skeleton grains and plasma respectively) is complex: chitonic, and locally gefuric (in the areas depleted in plasmic constituents), and monic (in the areas where the skeleton grains appear concentrated and uncoated).

Plasma is clayey-humico-ferric with un-differentiated b-fabric (the spatial arrangement of plasmic, fine material).

The colloidal edaphic substrate is dominated by illite (Figure 3) in the mollic epipedon, and as a result the related distribution pattern is chitonic (*the best type of related distribution pattern, from the agricultural point of view*) in which the shape and size of illite particles make the spatial organization of matrix components more lax.

The soil skeleton is frequent and consisting of quartz, feldspars plagioclase, mica flaks (muscovite), glauconite. Phytolites integrated in the soil groundmass also appear.

Plant debris, still remains numerous at Ame depth (22-34 cm), and are fresh (with birefringent cellulose) located into the bio-channels, and in different degrees of decomposition (located either in the deformed channels or integrated into the soil groundmass).

Particles of charcoal (in longitudinal section) having < 1 mm, appear frequently.

Fungal spores (black, spherical, strongly ornamented and yellowish-brown, ellipsoidal) had been observed on vegetal remains or in their vicinity. Also, brown fragments of mycelium appear sporadically in the voids.

The pedofeatures (generated by different pedo-genetically processes) that appear in this horizon are: textural, depleted and amorphous.

Many type of textural pedofeatures formed into the Ame horizons, as:

- impure clay coatings (illuvial coatings composed of plasmic material identical to that of the horizon groundmass - clay + organic matter ± Fe) without optical orientation, appear located on the surfaces of the structural elements;
- dark brownish yellow coatings (more reddish in N+) with diffuse-sharp extinction; some of them appear integrated in the groundmass and are slightly deformed; also identical material clogs some pores; this type of coatings appears located inside the structural elements, in the intrapedal pores; also the groundmass in their vicinity is very rich in organic matter and Fe;
- yellow to yellowish brown clay coatings free of impurities, with good optical orientation and sharp extinction.

Depleted pedofeatures are groundmass microzones depleted of plasma and residually enriched in skeleton grains.

Amorphous pedofeatures are represented by small blackish-brown nodules.

The micromorphological image of the Ame horizon reveals a mosaic of microzones with different colors, appearance and compositions:

- in some microzones of the groundmass, the constituents are densely packed, which generated chitonic related distribution pattern (Figure 4);

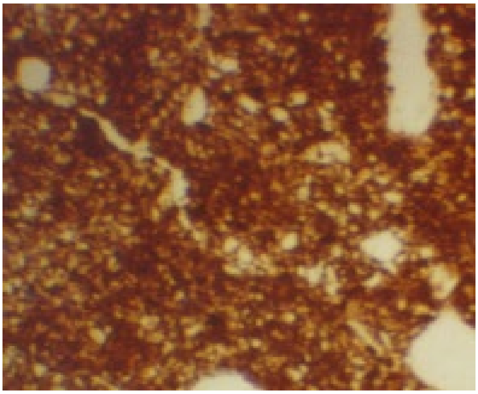

Figure 4. Ame horizon: the horizon groundmass rich in clayey-humico-ferric plasma

- microzones, relatively wide and very frequent, enriched residually in skeleton grains (Figure 5), due to the plasma migration, where the constituents are loosely packed, the related distribution pattern being gefuric; in these areas the clay-humic-ferric plasma remained only as discontinuous coatings or formed locally bridges between the skeleton grains; their presence highlighted a very intense process of plasma leaching;

- microzones with monic related distribution pattern were also observed, in which uncoated skeleton grains appear concentrated (Figure 5).

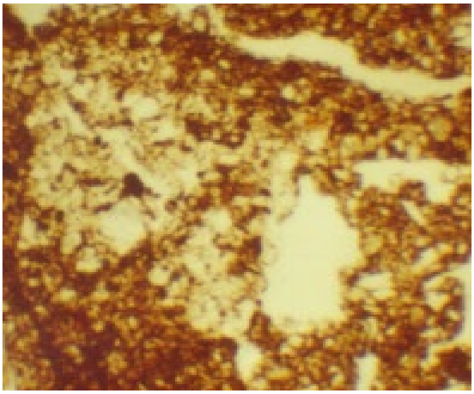

Figure 5. Ame horizon area with uncoated silt and sand grains (depleted in plasmic material and enriched residual in skeleton grains)

The soil macrofauna activity is very high, emphasized by the biological pedofeatures that occupied ≥ 70% of the horizon groundmass. Modelling their habitat, they repeatedly process the soil material. Thus, fresh coprolites (created by the earthworms) appear into the channels and old coprolites and pedotubuls had been integrated in the horizon groundmass.
The microzones with uncoated skeleton grains appear concentrated into the old coprolites, integrated into the groundmass (Figure 6).

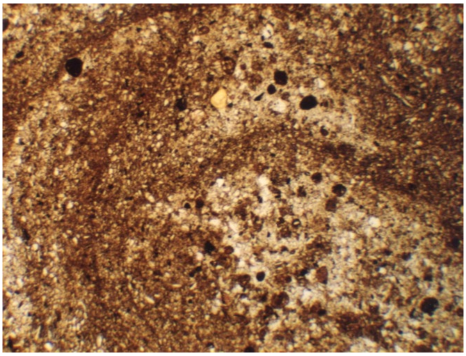

Figure 6. Mezofauna coprolites with bowlike distribution pattern and extended microzones with uncoated skeleton grains.

In these areas the skeleton grains are partially or totally uncoated, and from their more or less lax spatial distribution, results a porous micro-space which further favors the soil solution circulation, and consequently creates furthermore leaching conditions for plasma).
In this respect, it is noteworthy that the main characteristic of the Ame horizon and consequently of the Greyzemic Phaeozems "uncoated silt and sand grains" are located in the old coprolites and pedotubuls created by the earthworms and integrated, in time, into the horizon groundmass. Therefore, the main classifying characteristic of the Greyzemic Phaeozems had been generated by the soil macrofauna.

CONCLUSIONS

The defining feature of the Ame horizon is the presence of areas residual enriched in the skeleton grains due to plasma leaching, consequently a specific spatial redistribution of plasma and skeleton grains (of silt and fine sand sizes) generated during pedogenesis.
The genesis of the Ame horizon cannot be attributed exclusively to plasma leaching, but mainly to biological activity, because these specific areas appear in the old macrofauna coprolites (integrated in the groundmass).
The biological activity also compensates the plasma eluviation by bringing, from the deeper horizons, soil material (more clayey and less humic).
On the general background of the pedolandscape characteristics (relatively mobile soil plasma containing also fulvic acids - in Ame horizon exclusively; a clayey loamy texture and climatic conditions) the soil biodiversity modelling its habitat creates specific pedofeatures helpful for soil classification.

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