SOIL BIODIVERSITY UNDER ANTHROPIC INFLUENCE

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Abstract

For the study of the anthropic influence (land use change respectively) on soil biodiversity, two Chernozem profiles have been chosen: under the forest (P1-forest) and on the arable land (P2-arable), located near the forest edge. The general background of the two soils is loamy, both profile being formed in loess like deposits. The presence of soil fauna were studied by their traces in the soils (biological pedofeatures). In P1-forest, the pH is relatively high for a forest profile, but the appearance of very small $CaCO_3$ concretions brought by soil fauna from the deeper calcic horizon, and observed by the aim of micromorphology, explains the high values in the upper part of the soil profile. The change of the land use (from forest to arable land) influenced soil biodiversity and furthers the biochemical and physical characteristics of the two profiles. In P1-forest mezofauna and big earthworms are more active, while in P2-arable, big earthworm traces have a relict character. The soil fauna have an important influence on the main pedogenetic processes developed in the studied Chernozems: as bioturbation and plasma leaching. The depleted areas (suggesting plasma leaching and residual enrichment in mineral grains) located within the old lumbric coprolites and the illuvial coating fragments embedded in mezofauna coprolites, pointing out that soil fauna contribute both to the genesis and to the collapse of the coatings.

Key words: micromorphology, biodiversity, Chernozems, pedofeatures, hypo-eluviation.

INTRODUCTION

The study of soil biodiversity is difficult to accomplish even through the interdisciplinary research. However, micromorphology can detect the presence in the soil of different species of soil fauna and flora, the intensity of their activity, as well as their influence on soil pedogenesis end evolution, due to the specific methodology: the study on thin sections made from undisturbed soil samples.

The biological activity generates neoformations in the soils, which are known as „biological pedofeatures", recognizable by their shape and color and represented by coprolites and pedotubuls. In the international literature they are called „excrement pedofeatures" (Brewer et al., 1985; Fitzpatrick, 1993). Aguilar et al. (1995) showed that excrement pedofeatures are important micromorphological features for two reasons: they reflect environmental activity and a specific animal activity; they often form an essential part of the soil structure.

The paper emphasized the micromorphological study of soil biodiversity under the anthropic influence (the land use change) and soil fauna impact on the main pedogenetic processes of two Chernozem profiles.

MATERIAL AND METHOD

The studied area is located in the Eastern part of Romania, in Bârlad Tableland, Fălciu Hills, Viisoara region, on a plateau, faces W - SW.

For a complete image of soil biodiversity characteristics and evolution under the anthropic influence (land use changes respectively), two soil profiles were made, at small distance from each other: 1) in the Idrici forest (P1-forest) and 2) on arable land (P2-arable), near the Idrici forest edge. The parent material of both soil profiles is loess like deposits, with a loamy texture. The water table is at > 10 m and the global drainage is good. The bioclimatic zone is forest-steppe, with *Quercus* forests and natural meadows. The vegetation in P1-forest is *Quercus robur, Fraxinus excelsior* (planted), *Carpinus betulus, Tilia tomentosa*; with shrubs of*: Cornus sanguinea, Cornus mas*; and herbaceous species as*: Agrostis sp., Bromus sp., Polygonum convolvulus, Urtica dioica.* While in P2-arable the vegetation is composed of crops with *Echinocloa crus-gali, Setaria glauca, Amaranthus retroflexus, Polygonum convolvulus, Convolvulus arvensis, Matricaria chamomilla, Solanum nigrum, Cynodon dactylon, Agropyron repens, Cirsium arvense.*

The climate is temperate continental, with a mean annual temperature of 9.7^{o}C and a mean annual precipitation of 518.8 mm.

Both profiles are Chernozems: Cambic Greic Chernozem in P1-forest and Cambic Eroded Chernozem, in P2-arable, according to SRTS-2012 (while according to WRB-SR-2006, the soils are: Calcic Chernozem in P1-forest and Haplic Chernozem in P2-arable).

The profiles were described in the field and sampled (from each pedogenetic horizon), after the removal of forest litter, for particle size distribution, pH, CEC, $V_{8.3}$% (disturbed samples) and micromorphological (undisturbed samples) analyses, conforming to RISSA Methodology-1987.

For micromorphological study, oriented thin sections (25-30 μm) for each pedogenetic horizon of both soil profiles were made, after impregnating with epoxidic resin and hardening of the undisturbed samples. The thin sections were studied with the Documator (20 X) and the optical microscope (50 - 100 X) in PPL and XPL and described according to Bullock et al. (1985) and Fitzpatrick (1984) terminology.

RESULTS AND DISCUSSION

Physical and chemical characteristics of P1-forest and P2-arable

The two soil profiles (P1-forest and P2-arable) inherited the textural characteristics from the parent material, the particle size distribution of both profiles being loamy.

The colloidal clay (< 0.002 mm) of **P1-forest** is relatively low (19.6 to 28.5 %), increasing from the surface towards the AB horizon, where it reaches the maximum value and gradually decreased to the bottom of soil profile.

The pH values are relatively high (6.68 – 6.32), mainly in the upper horizons, for a forest profile, and closely correlated with the clay values (Fig. 1).

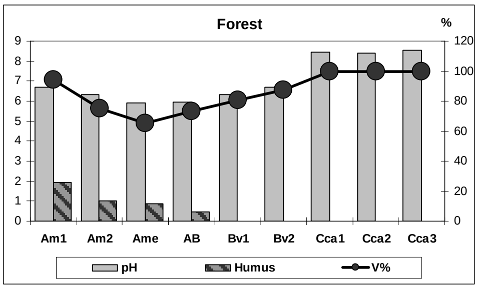

Fig. 1. Chemical characteristics of P1-forest.

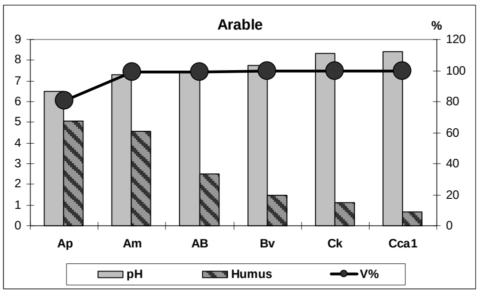

Fig. 2. Chemical characteristics of P2-arable.

The base saturation degree ($V_{8.3}$ %) follows a downward curve (Fig. 1) from the eubasic (in Am) to the mezobasic values (in Ame horizon), after which the values progressively increased throughout the highest value (100%) in the deeper Cca horizons.

The litter of P1-forest is discontinuous and represented mainly by Ol horizon. The organic matter content (Fig. 1) in the horizon under the litter is higher (2.93 %) and drastically decreases in the lower horizons.

Regarding to the soil fertility, the N, P, K values reveal that the soil under the forest is slightly supply in nutrients. In the surface horizon the total N content of the soil is medium and the mobile P content is very low, while under the surface horizon, the total N content is very low and the mobile P content is extremely low. The content of mobile K is medium in all analyzed horizons.

In **P2-arable** the relatively small amount (18.7 to 30.9%) of clay (< 0,002 mm) reached the maximum value in Am horizon and decreasing gradually through the deeper horizons.

Soil reaction is slightly alkaline (Fig. 2), except the surface horizon (which is slightly acid). The base saturation ($V_{8.3}$ %) values (Fig. 2) placed the profile into the eubazic soil group, and achieve maximum value of 100 % in the Cca horizon.

The organic matter content (Fig. 2) is relatively low and ranged between 2% in the surface and 0.5% in the Bv horizon, leading to the formation of mull calcic humus type.

The N, P, K contents of the arable soil reveal a lower supply in nutrients, comparing to the P1-forest. The content of total N is low - very low, while the P content is present in lowest concentration (very low in the upper and extremely low in the lower horizons). The values of the mobile K are low in the upper and middle in the deeper horizons.

Micromorphological characteristics of P1-forest and P2-arable

The micromorphological study on oriented soil thin sections showed that on the general background of a loamy Cambic Greic Chernozem (**P1-forest**) the bioaccumulation is relatively low. At the soil surface, a thin discontinuous litter, composed of the fresh vegetal fragments partially consumed by phytophagous mezofauna (vegetal tissues being replaced by small reddish brown coprolite) was formed. The litter of P1-forest (Ol horizon) is discontinuous, due to the quickly transformation of plant detritus, by soil fauna. It is well known that soil fauna represent multiple trophic roles, i.e. earthworms, enchytraeid worms and millipedes are detritivores while collembola act as fungivores (Lavelle, Spain, 2001; Xiaodong, Chen, 2009).

Among the vegetal residues of the litter, coprolite with different sizes and compositions frequently occur, pointing out the biodiversity of the forest soil.

The organic matter in this profile is represented mainly by humic constituents, plant debris being rare. This emphasizes the intense biological activities which largely control the decomposition process through breaking down the litter, digestion of vegetal remains and its integration in soil matrix. As a result, tissue and cell residues were observed either in biological pedofeatures (coprolites and pedotubuls) or in soil matrix.

The intensity of faunal activity is also showed by the high number of biological pedofeatures (which represent over 80 % of the thin sections surface).

The fragments of mycelium and sclerotia, located on the vegetal remains or in their proximity, certify the microfaunal activity in the soil.

It should be noted that earthworms have an important influence on the main soil processes as bioturbation and plasma leaching.

The bioturbation is very high in P1-forest, as a result of faunal activity by soil reworking, burrowing, and ingestion etc., followed by the removal and transport of soil material from one horizon to another.

Very small carbonate concretions ($\leq$ 0,5 mm Ø) in the surface horizon, brought by soil fauna from the deeper Cca horizons, very rich in $CaCO_3$, explains the high level of the pH values in the upper soil under the forest. Thus, the micromorphological study on soil thin sections, explains the analytical data (the pH values respectively).

The channels (of 4.0 - 4.5 cm Ø) with walls (of 0.5 cm wide) composed of dens, compacted plasma, with fine semicircular cracks, parallel to the channel walls (Fig. 3), give a special image to the Ame horizon (27-42 cm). These channels contain lumbric coprolites and pedotubuls, partially consumed by coprophagous mezofauna and replaced by small coprolites (Fig. 3). Very fine tissue fragments and reddish vegetal cell groups were also observed in these coprolites.

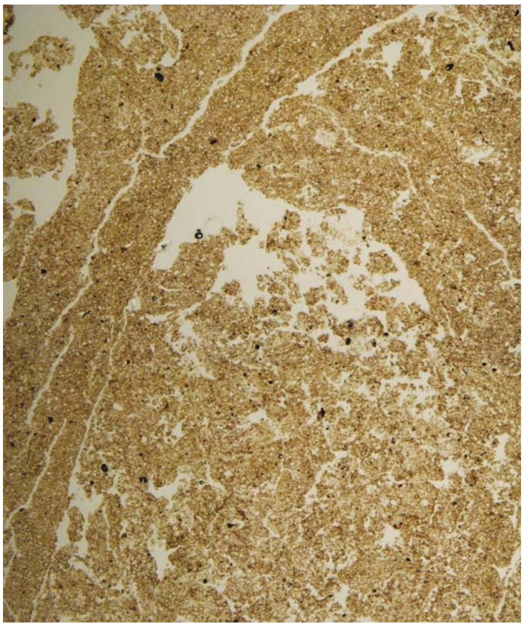

Fig. 3. P1-forest: A channel, framed by a wall composed of dens plasma and fissured (with fine semicircular cracks), filled with macrofauna coprolites, partially consumed by coprofagus mezofauna.

An important characteristics of this profile is the „greic character□ or (hypo) eluviation process, defined as „the presence of the Ame horizon (located in the lower part of Am), powdered with grains of quartz without colloidal coatings□.

Many such „powdered with uncoated quartz grains□ zones, or „depleted□ areas, are frequent in P1-forest, not only into the Ame (27-42 cm), but also in all the soil horizons: from the upper to the bottom Cca horizon. These depleted areas, suggesting plasma leaching and residual enrichment in mineral grains, are located within the old coprolites.

The illuvial clayey-Fe(±humic) fine coatings, generated by plasma leaching and deposition, were observed in many horizons of P1-forest. Fragments of the illuvial coatings appear embedded in the coprolites (Fig 4), as a result of their ingestion by soil mezofauna.

The depleted areas located within the old macrofauna coprolites and the coatings fragments embedded in mezofauna coprolites, pointing out that soil fauna contribute both to the genesis and to the collapse of the illuvial coatings.

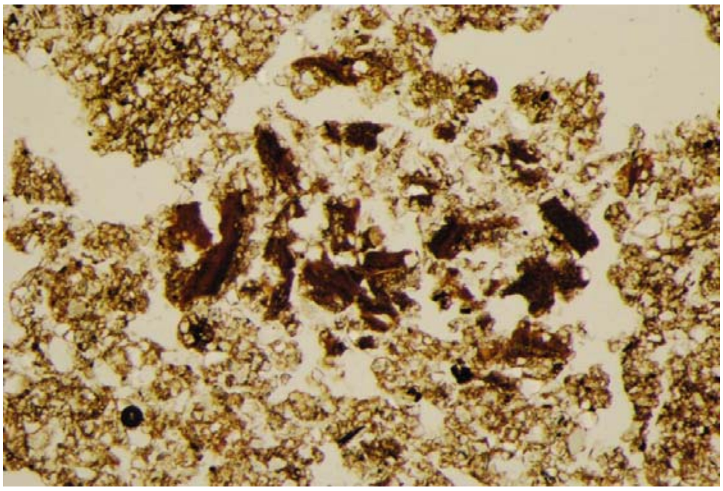

Fig. 4. P1-forest (AB horizon 42-62cm): fragments of an illuvial clayey-Fe(±humic) coating embedded in a mezofauna coprolite.

The term illuvial coating is unsuitable for P1-forest, because the pores are very rare in all the pedogenetic horizons, and the coatings are mainly integrated into the soil matrix or biological pedofeatures.

In **P2-arable** (Cambic Eroded Chernozem), as in P1-forest, no structural aggregates are present, soil matrix continuity being interrupted by the rare voids, generated mainly by mezofaunal activity, as well as by the rare cracks. The voids originated into chambers (burrows) or into loose continuous and/or discontinuous coprolites which collapsed in time to packing irregular pores (or vughs) less interconnected (Raducu et al., 2002).

The bioaccumulation process is relatively low, as under the forest, the organic matter being present in small quantities, mostly in the form of humic plasma. The small amount of the organic matter could be explained, by the field history (the previous land use being forest) and by the agricultural management of crop residues after harvest.

The soil fauna activity is high but poorly preserved in the tilled surface horizons.

In Bv horizon (48-80 cm) large coprolite (2 cm Ø) similar to the P1-forest, emphasized by the darker color, contrasting to the matrix, is a relict feature, characteristic to the soils under the forest.

The bioturbation process is also emphasized by the appearance, in Ck horizon (80-110 cm), of the more humic biological pedofeatures (Fig. 5) brought by soil fauna from the surface mollic horizons (Am).

Fig. 5. P2-arable (Ck horizon): humic coprolites brought by fauna from the upper horizons.

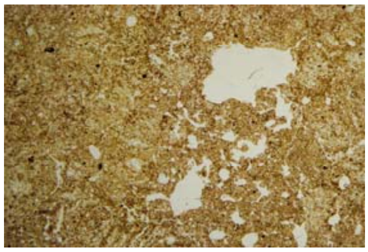

Fig. 6. P2-arable (Bv horizon): interlaced silty intercalations in a collapsed channel.

Interlaced silty intercalations (Fig. 6), generated by soil fauna, with many depleted areas, pointed out that in the P2-arable, as in the P1-forest, the (hypo)eluviation occurred in all horizons: sporadic in the surface, relatively numerous (but extended in surface) in Am and very frequent in AB, Bv (Fig. 6) and C horizons. The abundance of the depleted areas („powdered with uncoated quartz grains) could raise the questions concerning the P1-arable classification (according to SRTS-2012).

In P2-arable, the clay illuviation process had a polyphasic character: near the inherited illuvial clayey-Fe(±humic) coatings (formed under the forest conditions), actual impure clay coatings (clayey-humic±Fe) were also observed.

CONCLUSIONS

Soil micromorphology proved to be a powerful tool for the study and identification of biological activity in the two studied Chernozems, clarifying some aspects difficult to be explained by analytical data.

The very small carbonate concretions, brought by soil fauna from the deeper Cca horizons, explains the high level of pH values, in the surface horizons of P1-forest.

The change of the land use (from forest to arable land) influenced soil biodiversity and furthers the biochemical and physical characteristics of the two soil profiles.

The biodiversity is very high in both studied profiles, each species being very active and prevailing in the two profiles; depending on their specialization and adaptability (i.e. mezofauna and big earthworms are more active in P1-forest); in P2-arable big earthworms traces having relict character.

The soil fauna have an important influence on the main pedogenetic processes developed in the studied Chernozems: as bioturbation and plasma leaching.

The presence of the small carbonate concretions (originate in Cca horizon) in Am horizons, as well as of the more humic biological pedofeatures in Ck horizon (brought from the Am), emphasized a very active bioturbation process in both profiles.

Many depleted areas, suggesting plasma leaching and residual enrichment in mineral grains and emphasizing the (hypo)eluviation or „greic character, are located within the old coprolites of all horizons of both profiles, and raise the questions concerning the both soils classification.

The depleted areas located within the old macrofauna coprolites and the coating fragments embedded in mezofauna coprolites, pointing out that soil fauna contribute both to the genesis and to the collapse of the illuvial coatings.

The faunal activity strongly marked both soil profiles, generating or influencing the specific physical, biochemical, pedogenetic processes: structure, plasma mobilization and leaching, as well as the texture at micromorphological scale.

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