

Soil Organic Matter in Clayey Soils from Intermountain Valley of Sofia City

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Abstract

Two clayey soils Eutric Fluvisol and Chromi-vertic Luvisol (FAO) under the virgin grass conditions situated at the outwash valley of Sofia city have been selected to present the state of organic matter in relation with soil formation. Soil samples from the genetic horizons are analyzed to determine total and organic carbon extracted and non-extracted fractions.

Organic matter is strongly bonded with the clay minerals. The quantity of unextractable organic carbon is high – 70-80% and it is bound strongly as organic-clay compounds. 70% of humic acids are “free” or R_2O_3 complexed for the surface horizon of the first profile and deeper are 100% Ca complexed. Humic acids are Ca complexed for the second profile. The optical characteristics E_4/E_6 show low weight molecular, low condensed humic acids with later fragment in the surface horizon of the second profile.

Key words: humic acids, fulvicacids, unextractable organic carbon, clayey soils

Soil organic carbon along with clay and carbonate content are key parameters that affect the global cycling of elements and response of soils to global warming and land use change. The stable fractions of organic matter are considered resistant to change and correspond in general to humus fractions. The labile organic matter is rapidly degraded and is an important source of nutrients; being usually about 10 to 20% of the total soil organic carbon. The stable organic matter, or humus, plays important role in formation of soil structure, stability, and ability of soil aggregates to resist in changes from external impact. The adsorption of organic compounds on the soil particles protects most of the organic matter from decomposition. Organic carbon is positively correlated with clay content and cation exchange capacity (Filcheva, 2004). The large surface area per gram of humus enables adsorption of water many times exceeded its weight.

Total organic carbon (C) is commonly used as component of soil quality, while composition of organic matter is rarely used as a reflection of the local soil forming features. This paper discusses interpretation of the variables of humus system in clayey

soils from Sofia city's valley at different location on the landscape. The aim of this paper is to clarify the effect of organic matter status and the formation of studied soils characterized with clayey texture.

Material and Methods

Two clayey soils under virgin grassland conditions situated at the outwash valley of Sofia city have been selected to present the state of organic matter in relation to soil formation. Soil samples from the genetic horizons are analyzed to determine total and organic carbon extractable and non-extractable fractions.

Soil organic carbon content was determined by modified Turin's method (dichromate digestion at 125 °C, 45 min, in presence of Ag_2SO_4 and $(NH_4)_2SO_4 \cdot FeSO_4 \cdot 6H_2O$ titration, phenyl anthranilic acid as indicator). Soil organic matter composition was determined by the method of Kononova-Belchikova (Kononova, 1966; Filcheva & Tsadilas, 2002).

The first soil Profile 1 characterized area of the terminal stratiform cone of Lozenska mountain influence, while the second soil Profile 2 performs undulated well drained plain. Parent materials for both soils are Quaternary deluvial and proluvial (coluvial and alluvial) deposits. The climate is moderate continental sub humid, mean annual temperature is 10 °C; mean January temperature is 1.9 °C; mean July temperature 20.5 °C; mean annual precipitation is 566 mm. Soil moisture and temperature regimes is mesic-udic.

Deluvial-meadow soil (Profile 1) classified as Eutric Fluvisol (FAO Legend, 1990) or Haplic Fluvisol Eutric (WRB, 2006) or Vertic Eutrudept (Soil Taxonomy, 2010), is located on the northern sloping coluvial cone, Elin Pelin district, village Gorni Lozen (with location N 42°37'30.0" and E 23°27'32.0"). Five kilometers away Iskar River forms an alluvial valley formed on the old topography. The relief of studied area is plain with low gradient and altitude of 585 meter. This area is characterized by the former existed extensive network of ditches and drainage channels, which help run-off of excess water. The biggest part of the area is occupied with stratified sediments of different origin. The level of ground water table is

Ah 0 - 9 cm 7.5YR 3/2 (dry) dark brown and 10YR 3/4 (moist) dark yellowish-brown, compacted sod with abundant of fine roots with size <0.5 mm as well larger 0.5-1.0 mm, clayey, strong fine crumb structure, friable when dry, with smooth gradual boundary;

A1 9 - 27 cm 7.5YR 3/2 (dry) dark brown and 10YR 3/4 (moist) dark yellowish-brown, loose, abundant of fine roots with size <0.5 mm as well larger 0.5-1.0 mm, clayey, strong large crumb structure with size 5-10 cm, many worm casts and worm channels, with smooth gradual boundary;

A2 27 - 56 cm 5YR 3/2 (dry) dark reddish-brown and 5YR 2/2 (moist) dark reddish-brown, slightly compacted, clayey, common large roots with size 0.5-1.0 mm, strong fine subangular blocky structure with size 5-10 cm, large aggregates under gentle pressure crushed into the smaller one, many worm casts and worm channels, with clear boundary;

ABt 56 - 82 cm 5YR 3/3 (dry) dark reddish-brown and 5YR 3/2 (moist) dark reddish-brown, compacted, heavy clayey, single roots, strong fine subangular blocky structure with size 5-10 mm, large aggregates under gentle pressure crushed into the smaller one, few slickenside on ped oblique faces, few worm channels, clear boundary;

Bt 82 - 106 cm 2.5YR 3/6 (dry) dark red and 2.5YR 3/4 (moist) dark reddish-brown, compacted, heavy clayey, strong medium subangular blocky structure with size 10-20 cm, at the oblique ped faces occurs slickenside, few cutance at the channels walls and large pores, sharp boundary;

Btk 106 - 124 cm strong effervescence of 10% HCl, color 2.5YR 3/6 (dry) dark red and 2.5YR 3/4 (moist) dark reddish-brown, compacted, heavy clayey, fine subangular blocky structure with size 1-5 cm and 5-10 cm, segregation of carbonates as single large concretions with size 1 cm to 3-5 cm, large pores filled with dark soil material incorporated from the upper horizons, at the oblique ped faces occurs slickenside, few worm channels, roots of plants penetrated to the depth of 98 cm, single plant roots occur at the depth 140 cm, clear boundary;

Bck 124 - 144 cm strong effervescence of 10 % HCl, color 5YR 4/8 (dry) yellowish-red and 5YR 4/6 (moist) yellowish-red, compacted, clayey, large subangular blocky to massive structure, very hard when dry, soft powdery carbonate nodules up to 2 cm size with color 7.5YR 7/4 (dry) reddish-yellow и 7.5YR 7/6 (moist) reddish-yellow, few gravel, internal part of the aggregates is with color 5YR 6/3.

Results and Discussion

Discussing the soils formation where soils with heavy clayey texture dominate, it is obvious that this soil group is very broad influenced by the local envi-

ronment. Variation of soil organic matter parameters is significant and genetically defined.

Historically, soil organic carbon concentrations were estimated through dry combustion, from heating soil for 180 min at 550 °C (Soil Survey Staff, 1996; Method 6A2a). This method may lead to false results in mineral soils, because clay minerals lose adsorbed and crystal lattice water upon heating. In addition, carbonate may interfere due to partial decay of carbonates (Petrova, Shishkov, 2001).

The surface horizon (0-3 cm) of the Profile 1 is characterized by the high (3.0%) amount of total carbon which sharply decreases at the depth (3-8 cm) to (1.56%) which is about one and a half times less as compared to that at the top of the soil (Figure 1). Downward decrease of total carbon content is followed and is of low (0.93%) to very low (0.53%) amount downward the soil. The trend of distribution of total carbon in the Profile 1 is not typical for the grasslands in Bulgaria where meadow stage took place in soil development. Such mode of carbon distribution is more likely to the forest soils or some soils from group of Fluviosols. The results of microbial population study to the depth 25 cm shows that amount of microorganisms defined for some groups as well as the respiration rates are lower in the virgin grassland compared to the cultivated Deluvial-meadow soil (Nedyalkova et al., 2011).

The total carbon content can be also characterized as high (2.22%) at the surface horizon (0-9 cm) in the Profile 2. The trend of gradual decrease at the horizon beneath (9-27 cm) is obvious and is of medium (1.44%) amount. Downward the depth the decrease of total carbon is gradual and is of medium (1.33%) at the depth 27-56 cm to low (0.78%) amount at the depth 56-82 cm. Morphological humus horizon is well pronounced to a considerable depth of 80 cm liken to the Smolnitza soil. The gradual distribution of total carbon downward defines the soil as with advanced stage of humification.

The amount of the extractable organic carbon (extracted with 0.1M $\text{Na}_4\text{P}_2\text{O}_7$ + 0.1M NaOH) in the surface horizons varies between 29% (Profile 1) and 33% (Profile 2) from the total organic carbon to the depth of 0-9 cm, while in the subsurface horizons this amount is 31% to 33% from depth 8-19 cm (Profile 1) and 9-24 cm (Profile 2) respectively. The distribution of organic carbon with soil depth to 56 cm in Profile 1 shows the amount of 25% and in Profile 2 it is 20%. This shows that the organic matter in both studied soils is stronger bounded to the soil mineral phase.

Humic acids amount is 8-12% at the surface horizons (0-8 cm) against 11-17% of fulvic acids in Profile 1, determining it as such with of very low de-

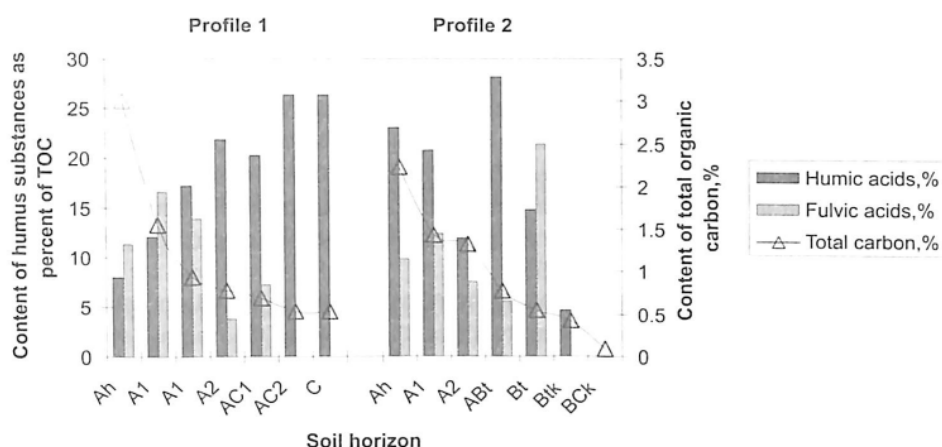


Fig. 1. Content and distribution of total organic carbon and organic matter fractions
* Humic and fulvic acids are presented as percentage of total organic carbon.

gree of humification. It is established the prevailing of fulvic over the humic acids from 11% to 17% at the depth of 19 cm. The obtained data can attributed to the stratification of surface layers. Downward the soil the amount of humic acids sharply increased to 17-22% to the depth of 1 meter, and the degree of humification is low i.e. 17 or medium 22%.

Humic acids amount is 21-23% to the depth of 24 cm against 10-12% of fulvic acids in Profile 2, characterizing it as of medium degree of humification. At higher depths the amount of humic acids varies from 12 % to 28% determining it as such as low and medium degree of humification.

Ratio Cha/Cfa varies in Profile 1 from 0.7 to 1.2 to the depth of 19 cm indicating humus to be respectively of humic-fulvic and fulvic-humic type, according to the classification of Grishina and Orlov (Orlov, 1985). There is sharp change of the ratio Cha/Cfa (3 to 5.5) beneath the 19 cm depth, which means that humus downward the Profile 1 is of humic type. Such sharp change of humus type at the depth is evidence of historical change of pedomorphism (Petrova, 1994).

In soil Profile 2 the humus type is stable through the profile. The ratio Cha/Cfa is 1.6-2.3 determining humus as humic type, which is an evidence of relatively stable ambient environment during the soil formation.

The soil (Profile 1) contains 68% free or R_2O_3 complexed humic acids in the surface horizon (0-8 cm) and 100% of humic acids Ca-complexed in the deeper horizons. In the soil (Profile 2) predominating humic acids are 100% bound with calcium, forming insoluble microstructure fragments.

The unextractable organic carbon of 70-80% is bound strongly to clay forming organic-clay compounds in soils Kononova (1966).

Data obtained from optical characteristic E_4/E_6 shows that optical density of humic acid in Profile 1

in the surface 0-8 cm horizon are of low weight molecule with specific configuration of long lateral fragments and less compacted structure.

Conclusions

The organic matter in both studied soils is stronger bounded to the soil mineral phase. The amount of unextractable organic carbon is high (70-80%) forming strongly organic-clay compounds. The conditions of soil formation determine the mode of carbon amount and distribution. The

first soil is characterized with low degree of humification, low content and sharp reduction of total carbon at the depth. The second soil is with medium degree of humification, higher content and gradual distribution of total carbon. At the surface of the Deluvial-meadow soil, Eutric Fluvisol (FAO Legend, 1990); Haplic Fluvisol Eutric (WRB) fulvic acids prevailed over humic acids consequently humus type is humic-fulvic. Humus is of humic type in the first soil below 19 centimeters and throughout in the second soil. Sharp change of humus type in the first soil is an evidence of change of pedomorphism or external impact. The historical record about vast flood throughout the area of the first soil took place in 2005. The fact is that the upper part of soil was affected by newly floated sediments from Iskar River. It is assumed that occasional event did not enable to change the soil humus status entirely; however in case that past events took place this could affect soil with weak resistance of humus system.

In the first soil 70% of humic acids are free or complexed with sesquioxides in the surface horizon, deeper are 100% Ca-complexed. Humic acids are bound with calcium throughout in the second soil. The optical characteristic E_4/E_6 shows that humic acids in the surface horizon of the first soil are of low weight molecule configuration and with lateral fragment.

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