Organic Matter Content and Composition of Soils with Stagnic Properties from Bulgaria

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Abstract

This paper deals with the contents and composition of organic matter in soils with stagnic properties. Study on the content and composition of soil organic matter, shows that these soils have low content of organic carbon. Soil formation proceeds under influence of acid plant residues from forest and seasonal waterlogging caused by the surface stagnating waters. The total carbon content decreases sharply in subsurface horizons. The amount of fulvic acids (C_f) prevail over humic acids (C_h) and type of humus is humic-fulvic and fulvic.

Key words: Soil organic matter (SOM), humus, fulvic acids, humic acids, Stagnosols, Planosols

Introduction

Soils with stagnic properties are spread mainly in Central Bulgaria close to the *Stara Planina* (Balkan mountain) and Sredna Gora. According to the Bulgarian soil classification these soils are considered as Pseudopodzolic soils (Koinov et al., 1964; Penkov et al., 1992). They occupy about 9.75 % of the territory of Bulgaria (Shishkov et al. 2014). According to Ninov and Teoharov (1990), the area of Pseudopodzolic soils with surface waterlogged in Bulgaria is 180 000 ha. The World reference base for soil recourses - WRB (IUSS Working Group WRB, 2014) classify these soils as Planosols and Stagnosols. These two soil types are spread over secondary-sediments, highly eroded granite, andesite, sandstones and metamorphic rocks, mainly acidic (Koinov et al., 1998). They occur on flat to gently sloping lands with a cool and temperate humid climate. Soil formation proceeds under the influence of acid plant residues from forests (mainly oaks) and seasonal waterlogging caused by the surface stagnating waters. Soil formation consisted of some pseudo-clay formation processes as, waterlogging, leaching, and clay formation.

Studied Stangosols and Planosols have stagnic properties in depth. They are low productive due to the unfavorable soil properties. These soils have one of the lowest content of organic matter in the country. Average humus content is about 1 - 1.5 % cultivated soils, up to 2% under forest. The organic matter stocks in the one-meter layer do not exceeds 2 t per hectare in uncultivated lands and 1-1.5 t/ha in agricultural areas (Koinov et al. 1998). Conditions of humus formation and humus accumulation of Stagnosols and Planosols are unfavorable (Artinova, 1977; Gushevilov and Filcheva, 1988; Ilieva, 1986; Ilieva and Grishina, 1986; Kolchakov, 1978; Moshev, 1989; Filcheva, 1976; Filcheva et al., 1994; Filcheva, 2007; 2015, Petkova, 2014). The soil organic matter determination as a diagnostic

feature of the soil and data on organic matter composition of this soil group were published earlier (Boyadgiev et al, 1994b, 1994c, Filcheva and Boyadgiev, 1997). The organic matter composition is characterized by the low content of humic acids (C_h) compared with some soils in Bulgaria. However, fulvic acids (C_f) are presented in significant quantities, which determine the very low C_h/C_f ratio. The humus type is fulvic along the soil profile depth (C_h:C_f <0.5). The content of humic acids is low and sharply decreased along the profile's depth (Artinova, 1977). In the middle part of the soil profile humic acids are missing and at the bottom the amount is increasing. Morphologically established dark color in this part of the profile is explained with increasing of humus content, probably as a result of movement of mobile humic acids in this horizon and bind with calcium in less mobile compounds (Filcheva, 2015). Due to the low pH and seasonal surface waterlogging, the degree of humification in these soils, especially in the area of waterlogging is low, with the exception of the upper part of eluvial horizon. Humic acids in the surface horizons are represented as "free" and bind with the mobile forms of R_2O_3. The content of aggressive fulvic acids fraction in the SOM composition is high (12-20 %), mainly in the areas with intensive periodic of gleyic processes (Filcheva, 2015). These soils are very poor in organic matter and nutrients the biological activity is also low.

The aim of this paper is to examine the present state of soil organic matter (SOM) of soils with stagnic properties and their humus quality, quantity and composition.

Materials and Methods

Three soil profiles were studied in central part of Bulgaria.

Profile 1, is located at N 42˚39.373'; E 027˚48.046', (240 m elevation) near to village of Banya (Varna district). Soil moisture and temperature regimes are mesic and udic. The land use is agricultural with crop rotation. According to WRB 2014 soil type is classified as Luvic Gleyic Stagnosol (Aric, Chromic, Clayic).

Profile 2, is located at N 42˚36.31.6'; E 023˚37.069', (638 m elevation) near to village of Novi Han (Sofia district). Soil moisture and temperature regimes are mesic and udic. The vegetation is forest (Oaks). According to WRB 2014 soil type is classified as Dystric Luvic Umbric Planosol (Chromic, Epiclayic). Data are taken from Boyadjiev et. al. (1994a).

Profile 3, is located at N 42˚24.751'; E 025˚01.220', (312 m elevation) near to village of Zlatosel (Plovdiv district), Soil moisture and temperature regimes are mesic and xeric. The vegetation is forest (Oaks). According to WRB 2014 soil type is Epidystric Luvic Albic Planosol (Chromic, Epiclayic, Bathycalcaric). Data are taken form Hadjiyanakiev et. al. (1981).

Content and composition of SOM in the studied profiles are determined with the modified Tjurin's method [oxidation with a solution $K_2Cr_2O_7/H_2SO_4$ in a thermostat at 125^oC for 45 min, in the presence of a catalyst Ag_2SO_4 and titration with $(NH_4)_2SO_4$. $FeSO_4.6H_2O$ and the Kononova – Belchikova's method (Kononova, 1966; Filcheva and Tsadilas, 2002)].

Results and Discussion

The study on the content and composition of SOM confirm previous results that a soil with stagnic properties has low content of organic carbon (Filcheva, 2015). Data show the

following: content ranges between 0.7 and 1.7 % in the surface horizons although these profiles (2 and 3) are under forest (Table 1).

Total carbon content decreases sharply in subsurface horizons. This is typical for soil such as Planosols (Figure 2 and 3). In profile 1, organic carbon is also low but decrease in depth is more gradual (Fig. 1).

Table 1. *Content and composition of soil organic matter. Designations: a - % of the sample mass, b - % of the total carbon mass, c - % of the total humic acids.*

Horizon depth, cm	Total carbon Corg %	Organic carbon (%) extracted with 0.1M $Na_4P_2O_7$+0.1M NaOH			C_h/C_f	Organic carbon , (%) humic acid fractions		Unextracted Organic carbon (%) (C res.)	Extra. with 0.1N H_2SO_4 (%)	Extracted Corg with 0.1N NaOH %	Soil pH (H_2O)
		total	Humic acids C_h	Fulvic acids C_f		free and bind with R_2O_3	Bind with Ca				
Profile 1. Luvic Gleyic Stagnosol (Aric, Chromic, Clayic)											
Ap 0-26	1.04	0.26[a] 25.00[b]	0.12 11.54	0.14 13.46	0.86	0.00	100.00	0.78 75.00	0.04 3.85	0.20 19.23	4.9
A1 26 - 48	0.90	0.23 25.56	0.09 10.00	0.14 15.56	0.64	0.00	100.00	0.67 74.44	0.04 4.44	0.15 16.17	4.9
Btg1 40-62	0.33	0.08 24.24	0.00	0.08 24.24	-	0.00	0.00	0.25 75.76	0.03 9.09	0.06 18.18	5.0
Btg2 62 – 82	0.27	0.08 29.63	0.00	0.08 29.63	-	0.00	0.00	0.19 70.37	0.02 7.41	0.06 22.22	4.6
Bt gr3 82–108	-	-	-	-	-	-	-	-	-	-	4.7
Profile 2. Dystric Luvic Umbric Planosol (Chromic, Epiclayic)											
AE 0 - 20	1.71	0.74 43.27	0.30 17.54	0.44 25.37	0.68	100.00	0.00	0.97 56.73	0.06 3.51	-	4.4
E 20 – 42	0.45	0.12 46.15	0.08 30.77	0.04 15.38	2.00	100.00	0.00	0.14 53.85	0.04 15.30	--	4.4
Btg1 42-60	0.69	0.17 42.24	0.00	0.17 42.50	-	0.00	0.00	0.23 57.50	0.07 17.5	-	4.6
Btg2 60 – 125	0.45	0.08 30.77	0.04 15.38	0.04 15.38	1.00	0.00	100.00	0.18 69.32	0.04 15.38	-	4.5
BCk 125–150	-	-	-	-	-	-	-	-	-	-	7.4
Profile 3. Epidystric Luvic Albic Planosol (Chromic, Epiclayic, Bathycalcaric)											
AE 0 – 10	0.7	0.34 48.39	0.15 20.77	0.19 27.65	0.75	83.08[c]	16.95	0.36 51.61	0.06 8.33	-	4.5
E1 10 – 28	0.28	0.15 52.20	0.05 18.62	0.09 03.92	0.56	100.00	0.00	0.13 47.80	0.10 37.1	-	4.5
E2 28 - 40	0.18	0.10 53.46	0.04 21.76	0.06 33.70	0.68	13.59	84.41	0.08 46.54	0.09 48.00	-	4.7
Btg1 40-55	0.18	0.09 52.22	0.01 5.00	0.08 44.22	0.1	0.00	100	0.09 47.78	0.08 44.44	-	4.6
Btg2 55 – 73	0.2	0.09 46.76	0.01 4.83	0.08 41.92	0.12	0.00	100	0.11 53.24	0.08 41.63	-	4.8
Btg3 73–96	0.24	0.08 34.92	0.02 9.76	0.06 25.16	0.4	0.00	100	0.18 75.05	0.08 31.96	-	6.6
Ck 96-125	0.15	0.05 33.65	0.03 18.62	0.02 15.03	1.24	0.00	100	0.11 76.35	0.06 37.05	-	8.4

Figure 1. *Organic matter content (% / cm depth) - Profile 1 Picture BG051PO0001-3.3.06-044 project .*

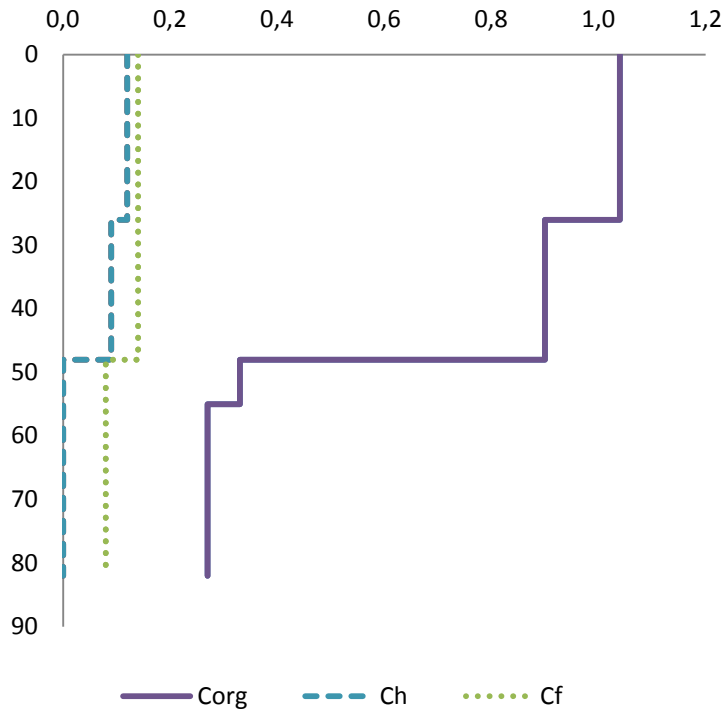
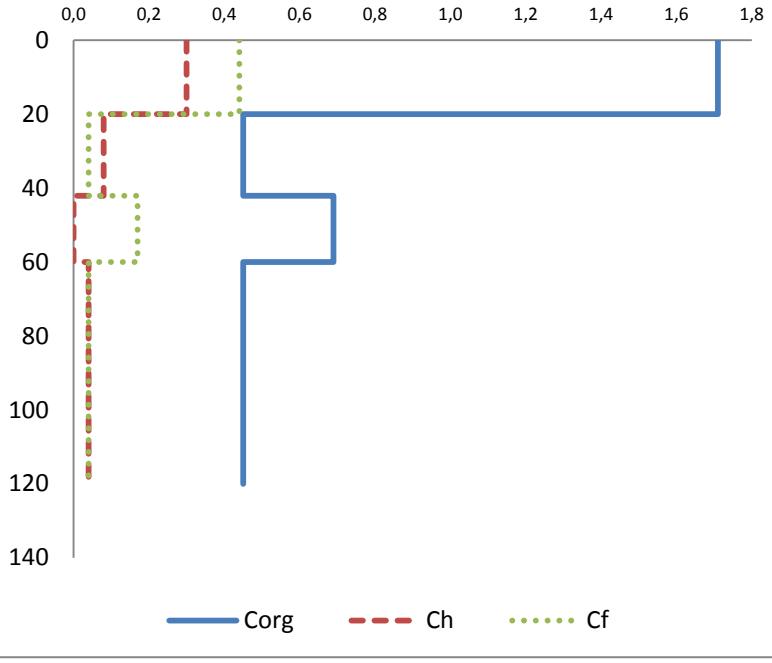
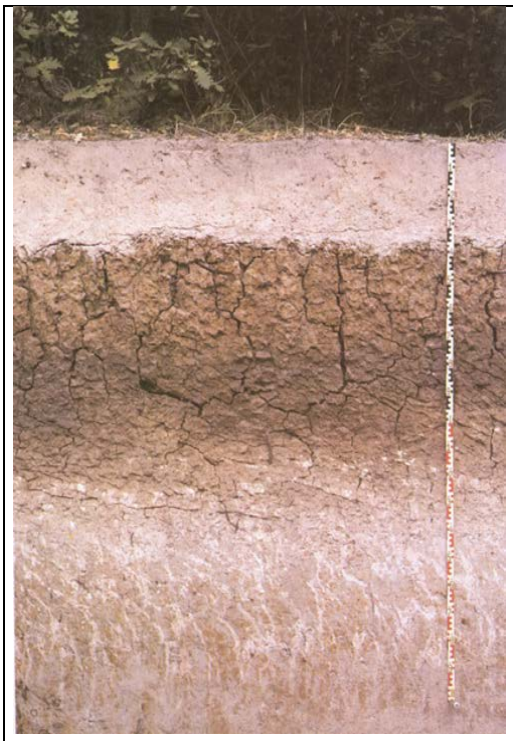


Figure 2. *Organic matter content (% / cm depth) - Profile 2*





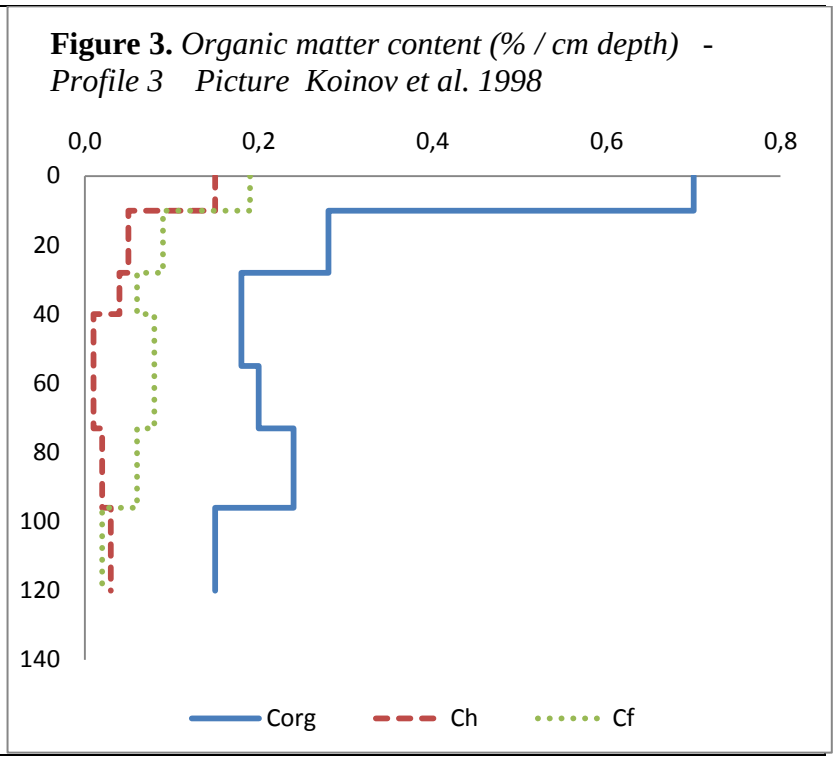


Figure 3. *Organic matter content (% / cm depth) - Profile 3 Picture Koinov et al. 1998*

According to Filcheva (2015), the degree of waterlogging and type of land use (cultivated, uncultivated, forest), indicators of humus state for Planosols are changed. Fulvic acids (C_f) prevail in soil horizons especially in soil surface, because of forest vegetation.

Humic acids (C_h) content is low. They exceed fulvic acids (Ch>Cf) in only three soil horizons in the deeper layers of the profile, where the pH activity is higher. Therefore the type of humus is humic-fulvic (Ch/Cf ratio 0.5 – 1) in surface horizons. In E horizon of profile 2 the type of humus is fulvic - humic (Ch/Cf ratio 1-2) which is not typical for Planoslos. The reason for that could be the influence of clay minerals as smectite and vermiculite which dissociate alkaline calcium and magnesium and humic acids are more stable. In Btg layers of profile 3 the type of SOM is fulvic (Ch/Cf < 0.5), which is typical composition for these stagnic horizons. The degree of humification (Ch/Corg) *100) % in studied soils ranges from average (10-25%) to poor (under 10 %).

Previous studies on soils with stagnic properties show that free humic acids present in surface horizons (Boyadjiev et al. 1994b, 1994c). In profile 1 humic acids are 100 % bound with calcium (Ca-complex), possible reason for that is liming in recent years. In Planosols's surface horizons (AE and E) humic acids are almost free and R_2O_3 complexed. In deeper layers with stagnic properties (Btg) humic acids are 100 % bound with calcium. Consequently humic acids are stable in subsurface horizons. Lack of "free" and bind with mobile forms of R_2O_3 humic acids in Btg horizons may be is due to the influence of acidic vegetation and the possibility to formation of iron-humus complex compound, which could not be extracted with 0.1 N NaOH (Filcheva, 2015).

The unextracted organic carbon in profiles 2 and 3 is averagely about 50 % and it is not so stable. On the other hand unextracted organic carbon in profile 1 is about 75 %, as well

as in the deepest horizons in profiles 2 and 3. Therefore the SOM is strongly bound and more stable.

Conclusion

Soils with stagnic properties have low content of organic carbon. Total carbon content decreases sharply in subsurface horizons (Btg). Fulvic acids (C_f) prevail over Humic acids (C_h) in soil profile. The type of humus is humic-fulvic (1-0.5) and fulvic (<0.5). In Planosols's surface horizons (AE and E) the humic acids are almost free and R_2O_3 complexed. In deeper layers with stagnic properties (Btg) humic acids are in minimal quantity and they are totally bound with calcium in profile 1 and 2. The degree of humification in studied soils ranges from average to poor.

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