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Characteristics of Alluvial Soils from Aydemir and Vetren Islands of Lower Danube

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Abstract. Soil characteristic is an important factor for conducting sustainable management of the territories. In the present work a general characteristic of the soils (texture, pH, humus%, total N and humus composition) of Aydemir and Vetren Islands from the Lower Danube is done. The results show a distinction between two soil types, characterized by different duration of soil formation processes: those from the periphery of the islands and those from the interior of the islands. The peripheral soils, which are newer formations with shorter soil-forming process, are lighter in texture and have a smaller part of the clay fraction. The soils from the inside have a texture from slightly to heavy sandy-clay and slightly clay. Soil acidity from both islands is slightly alkaline. In Aydemir Island the pH in the range of 7.2 ± 0.9 and in Vetren Island it is respectively 7.3 ± 0.6. The humus content varies greatly from (0.9 - 2%) in the sandy soils from the periphery of the islands, to 2.8 - 4.3% for the interior of the islands. Particularly high humus content has the soils under old *Salix* spp. forest of Vetren Island, where the quantity of total carbon is up to 8%. Humus composition of soils from both islands shows higher share of fulvic acids compared to the more stable humic acids. The soils from the periphery of the islands show fulvic type of humus, while those from the interior humic-fulvic type of humus.

Key words: soils, texture, soil organic matter, humus composition.

Introduction

The islands of the Lower Danube, which spans the course of the river from Turnu Magurele Town to the Danube delta, are very rich in ecosystems and provide unique conditions for the development of flora and fauna. Their favorable climatic and ecological characteristics, as well as the pronounced recreational and sanitary-hygienic functions make them a good basis for the development of eco-tourism, fishing, forestry, etc. The natural functions and significance of the islands for the economy have been a prerequisite for their study and description since the beginning of forestry science in Bulgaria (Minchev, 1936; Stoyanov, 1948). Such studies were made until the 80s of the last century, but there are no newer ones, as well as studies related to the humus formation process, which led us to conduct the current study.

The islands are complex element of the landscape, mobile and non-permanent formations, which are formed over the time and sometime destroyed by the waters of the Danube River. Currently, the Bulgarian territory includes 75 islands with unique biodiversity and on which 14 habitat types,

which are protected. Largely, the natural forest vegetation has been destroyed by man and in many places it has been replaced by successfully growing plantations of Euro-American poplar *Populus euroamericana* (Dode) *Guinier cv. regenerate* (Marinov & Fakirov, 1977). The natural vegetation, where it occurs is represented by well-developed and viable populations of the typical native species of *Salix* spp. and *Populus* spp. where occurs natural vegetation is presented. On the higher elevations of the Danube islands, the native species *Ulmus* spp., *Fraxinus* spp, and *Quercus* spp. are well represented, and in some places almost pure associations are preserved (Green Balkans, WWF - Greece, 2001). These natural phytocenoses have high conservation value and ecological functions. The policies are aimed at identifying activities to protect existing natural floodplain forests and create forests of local species that are more adaptable and sustainable. There is a Strategy and Action Plan (2000), which outlines the measures to no-allowed further replacement of natural forests and restoration of existing ones, as well as to comply with Bulgaria's commitments to establish a green corridor along the Lower Danube. The preservation of the rich biodiversity of vegetation and habitats in the Danube Islands, as well as the sustainable management of natural resources is also related to good knowledge of the components of natural environment, including soils. Soils are this important factor on which depends the good development of vegetation cover (Bogdanov, 2014), also its productivity and normal functioning (Ilinkin et al., 2018).

Soils from Danube river islands are classified as *Fluvisols,* with weak or no profile differentiation (IUSS Working Group WRB, 2014). The main factor of their formation is the river deposits. According the Basic Classification of Soils in Bulgaria (Penkov et al., 1992) the studied soils are classified as *Alluvial,* which are part of Class *Fluvisols*. Thus, these soils are specified as *Alluvial Fluvisols* in the soil description. They are complex, dynamic systems with no genetic connection between different layers (Donov, 1993; Pavlović et al., 2015). Their properties depends on alluvial river materials that form them (West et al., 2017; Ilinkin, 2019). In the Lower Danube, the *Alluvial Fluvisols* are usually deep, fine-grained, surface humified, formed on alluvial soil-forming materials of sand, loess and clays (Naumov, 1959). The soil-forming process takes place on these sediments and these processes are under the influence of moisture-loving woody, shrubby and grassy vegetation (Tsanov, 1992). As the soils are formed from alluvial materials accumulated by river during periodic seasonal floods, the soil formatting process is irregular. These soils do not have a clear morphological differentiation and genetic horizons with exception of top humus horizon (Ah), and they are composed of separate layers - Ah, I, II, III etc. (Donov, 1979; 1993; Galić, 2010; Koynov et al., 1998). The Danube collects waters from 19 countries, and carries different compounds from urban, industrial and agricultural sites (Liška et al., 2008). Thus, elements and nutrient contents, as well as physicochemical properties of these soils are varied. Humus content ranges from 0.1 to 4% and in some sites up to 6% (Biolchev et al., 1963; Donov, 1993). Regarding the humus composition there is no research in the literature. Nitrogen contents is varied too, commonly in the range from 0.1 to 0.4% (Biolchev et al., 1963; Donov, 1979) and its mobile forms from 66 up to 126 mg/100g soil (Donov, 1979). Soil pH values is mainly from moderately acid to alkaline (Donov, 1993; Illinkin, 2019). Soil texture depends on the duration of periodic floods and commonly varies from sandy to loamy, with predomination of sand fraction (Naumov, 1959; Ilinkin et al., 2018; Illinkin, 2019). In the periphery of the island these soils are poor in fertility, sometimes presented only from no fertile sands and gravel (Donov, 1993). However the studied soils show very good and high fertility (Stoyanov, 1948; Tsanov,

1974) and are favorable for fertilization (Denev, 1974; Shishkov & Kolev, 2014).

The aim of this study is to characterize some main properties of *Alluvial Soils* from Lower Danube with a case study from the islands Aydemir and Vetren.

Thus will give a clear view on the features of soil formation processes, especially on humus formation and humus composition from the surface layers of the island soils.

Material and Methods

Aydemir (Chayka) and Vetren (Ciocăneşti) islands are situated in the Danube River nearly the towns of Silistra and Călăraşi. The island of Aydemir is divided between Bulgaria and Romania, and the island of Vetren (Ciocăneşti) is claimed by both countries at the same time, but factually is controlled by Romania. Both islands are included in NATURA 2000 protected areas. The island of Aydemir has an area of 77 ha, while Vetren (Ciocăneşti) Island covers 280 ha. Both islands are located in the Mizian Forest-plant Zone. According to vertical zoning they are in hilly and pre-mountain belt of oak forests and more precisely in its sub-belt of floodplain and riparian forests (Zahariev et al., 1979). Climate is typical continental, with high temperatures in summer and low in winter. The average annual temperature is 11.7 ^{o}C, and the amount of precipitation is the lowest in the Country (518 - 579 mm) (Tsanov, 1992). Climate, along with the nature of alluvial materials, moisture-loving vegetation and periodic flooding are those important factors that determine the formation of these intrazonal alluvial soils.

Five sample plots (Sps) under typical woody vegetation are set on the Aydemir and Vetren Islands. The description of SPs is presented in Table 1.

Three soil samples were taken from each sample plot at depths: 0-20 cm, 20-40 cm. An average sample was formed for each SPs and a total of 20 samples were given in the laboratory for analysis. It was determined: pH – potentiometrically by pH-meter "Placitronic, MV 88" according ISO 10390, 2002; Soil texture: titration method, with HCl treatment; Bulk density: by the method of Kaczynski; Total carbon (C%) and humus (%): by the Thurin method; Total nitrogen (N%): by the method of Kjeldal– all above mantioned methods are included in Donov et al. (1974). We studied also the composition of humus in soils by the method of Kononova-Belchikova (1961): total content of humic and fulvic acids with a mixed solution of 0.1N $Na_4P_2O_7$ and 0.1M NaOH; free acids and bound to the sesquioxides (R_2O_3) with 0.1M NaOH; aggressive fulvic acids with 0.05M H_2SO_4.

Result and Discussion

The characteristics of soil texture which is the relative contents of different in size mineral elements in solid phase of soils is important in relation with consideration of issues about soil fertility. The soils with more clay content are more fertile due to the presence of mineral colloids that retain a significant amount of nutrient elements because of adsorption/desorption processes. Certainly, these soils are more prone to adsorption of contaminants too.

The results of soil texture analysis from the SPs are presented in Table 2.

The studied soils of the islands differ in texture. In practice, the texture is in the range from clayey-sandy to medium-clayey according to Kachinski's scale (Donov, 1993). However, the soils fall mainly in the range from light-sandy-clay to heavy-sandy-clay and light-clay, which corresponds to the studies of Tsanov (1992) and Biolchev et al. (1963) for the Danube River basin and islands.

The *Alluvial Fluvisols* of SP1 has the lightest texture (clay-sandy). Morphologically it is represented by a large amount of sand fraction. The interesting thing about this area is that it is located in the eastern periphery of Aydemir Island, on newly formed sand embankments.

Table 1. Characteristics of the studied sample plots (SPs).

SPs	Coordinates	Altitude m	Description
		Aydemir Island	
SP1	N44°08'033" / E27°09'269"	13.5	*Populus hybrid* forest; canopy closure 35%; flooding up to 1.30m; area 200m^2.
SP2	N44°08'069" / E27°09'339"	10	*Populus* hybrid, *Tamarix ramosisima*, *Amorfa Fruticosa*, canopy closure 60%; flooding up to 1.20m; area 200m^2.
SP3	N44°07'561" / E27°10'368"	27	*Populus Nigra* (P.h.), *Fraxinus pensilvanica*, *Ulmus; Amorfa Fruticosa* mixed forest, natural origin; the populous tree have a poor vegetation status; canopy closure 70%; no flooding; area 500m^2.
SP4	N44°07'691" / E27°10'268"	10	*Salix* forest, natural habitat, hybrid species; *Amorfa Fruticosa*; canopy closure 55%; flooding up to 0.4m; area 500m^2.
SP5	N44°07'922" / E27°09'766"	22	*Salix Alba* hybrid forest. Poor vegetation status; canopy closure 50%; flooding up to 1m; area 500m^2.
		Vetren Island	
SP6	N44°08'270" / E27°03'247"	12	*Salix Alba* hybrid forest; *Amorfa Fruticosa*; canopy closure 60%; flooding up to 1.4m; area 500m^2.
SP7	N44°08'433" / E27°03'286"	13	*Fraxinus*; *Negundo*; *Morus*; *Ulmus* mixed forest, natural origin; canopy closure 65%; flooding up to 0.4m; area 500m^2.
SP8	N44°08'320" / E27°03'925"	17	*Salix*; *Fraxinus*; *Morus*; *Ulmus* mixed old forest, natural origin; canopy closure 55%; flooding up to 0.9m; area 500m^2.
SP9	N44°08'551" / E27°04'551"	12	*Populus* hybrid forest with *Negundo*; *Fraxinus*; *Ulmus*; canopy closure 60%; flooding up to 1.3m; area 500m^2.
SP10	N44°08'708" / E27°03'966"	12	*Salix Alba* forest - many trees are doubled. The stems were cut at the level of water - to be regenerated as sprouts; canopy closure 55%; flooding up to 1.4m; area 500m^2.

Table 2. Characteristics of the soil texture in the studied SPs.

SPs	Depth cm	Particle density	Fractions, %						Mechanical composition, %		Waste from HCl, %
			Sand		Ash			Clay	Physical clay < 0.01	Physical sand 1 – 0.05	
			Coarse and middle size	Small	Coarse	Middle	Small				
			1-0.25	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001			
						Aydemir Island					
SP1	0-20	2.8	17.19	44.54	17.14	no	4.07	4.06	19.37	80.63	11.00
	20-40	2.7	15.23	46.23	18.12	1.25	5.08	3.02	19.35	80.65	10.00
SP2	0-20	2.7	23.13	30.28	16.34	2.37	6.09	8.47	27.13	72.87	10.20
	20-40	2.7	14.37	33.23	15.37	4.82	9.27	5.38	29.87	64.13	10.40
SP3	0-20	2.7	1.79	9.14	21.06	21.05	14.32	22.00	68.01	31.99	10.64
	20-40	2.6	12.37	15.18	14.38	22.15	8.23	17.47	60.15	43.85	12.30
SP4	0-20	2.3	1.66	8.43	47.67	4.14	12.42	12.43	42.24	57.76	13.25
	20-40	2.4	6.12	18.47	28.29	12.87	13.72	15.38	44.72	54.28	12.75
SP5	0-20	2.5	1.68	24.22	no	11.7	21	29.42	74.10	25.90	11.98
	20-40	2.4	9.36	18.12	7.28	15.3	16.18	18.32	61.98	38.02	12.18
						Vetren Island					
SP6	0-20	2.7	2.53	39.46	36.13	4.36	no	4.05	21.88	78.12	13.47
	20-40	2.6	4.32	32.78	30.18	5.80	6.25	6.38	29.59	68.41	11.16
SP7	0-20	2.8	2.04	10.74	42.23	3.37	12.44	16.58	44.95	55.05	12.56
	20-40	2.8	2.70	20.72	34.28	9.18	10.28	8.45	40.95	59.05	13.04
SP8	0-20	2.0	2.09	10.53	41.75	4.18	16.10	12.53	45.63	54.37	12.22
	20-40	2.3	3.06	8.06	11.71	27.87	13.18	20.04	72.79	27.21	11.70
SP9	0-20	2.4	2.77	13.16	no	25.51	21.25	25.51	84.07	15.93	11.80
	20-40	2.5	4.32	8.18	12.17	17.15	24.07	20.34	73.59	26.41	12.03
SP10	0-20	2.3	3.62	25.55	21.30	4.26	8.52	25.56	49.53	50.47	11.19
	20-40	2.6	2.18	24.50	22.21	8.12	10.45	20.78	50.15	49.85	10.80

It should be noted that SPs, which are located in the peripheral parts of the islands (SP2 and SP6), in greater proximity to the flowing waters of the Danube, also have a lighter texture (lightly sandy-clay) in comparison with other SPs. On the other hand, SPs from the interior of the islands show heavier texture, with content of physical clay fraction from 42.24% (SP4) to 84.07 (SP9). The most clayey (slightly to average clay) is the soil from SP9, which inwards to the central part of Vetren Island (150 m from the shore). This area is under a mixed forest dominated by *Populus* spp. hybrid. The soil from SP8 also has heavier soil texture (heavy sandy-clay to slightly clay). It is located in the interior of the island too (80 m towards the cost) and, at the same time has the highest altitude (17m). This trend is also confirmed by the soils of Aydemir Island. Here, the most clayey (slightly clay) is also the soil from the interior of the island (130 m towards the cost), with the highest altitude (27m) and no traces of flooding - SP3. In this case the alluvial materials are the oldest and the soil formation process took the longest time. In addition, the SP3 is under mixed forest with domination of *Populus Nigra* and *Fraxinus pensilvsnica*. *Salix* spp. Which develops on slightly to heavy sandy-clay soils.

In general, it can be concluded that the soils from the periphery of the islands have lighter texture, and those from the interior of the islands, where the floods are shorter and less and the soil formation process lasts longer, have heavier composition.

In terms of particle density, the whole range of 2.8 to 2 is covered.

The distribution of mineral particles by size in vertical duration is much diverse which confirm the research of Galić (2010) about soils in the islands of the Middle Danube. Ilinkin (2019) finds an increase in silt and cay fraction into depth in *Fluvusols* from the countryside (Sofia district), but here such regularity is not observed. There is no such tendency in the distribution of clay fraction in soil depth, too. Obviously, the texture of the considered soils was formed by different in structure alluvial materials during periodic flooding.

The most important chemical properties and characteristics of studied soils are presented in Table 3.

The chemical characteristics of studied soils vary, which is reported by other authors (Illinkin et al., 2018; Ilinkin, 2019; Galić, 2010), as well.

The acidity is neutral to slightly alkaline, varying in the range of 6.95 ÷ 7.50. This is normal for the soils that are formed from the periodic waters of the Danube River. Similar are the studies of Naumov (1959) for carbonate-free soils from the Danube Islands and of Fakirov & Tsanov (1967) for the islands near Oryahova and Tutrakan. Biolchev et al. (1963) obtained slightly higher pH values of 7.6 ÷ 9.1 for the floodplains of the Belene and Vardim islands, probably due to high Ca content in soils. Illinkin (2019) also observed variations without a trend in pH changes in soil depth.

The organic carbon content in studied soils varies from very low to very high 0.96 ÷ 8.16%. The published data are also contradictory: from poor 0.55 ÷ 1.90% (Naumov, 1959; Fakirov & Tsanov, 1967) to medium-humus (≤ 3.83%) (Biolchev et al., 1963; Tsanov, 1992) and very high to the river soils named "talog", which are extremely rich in organic matter, and where turbulent vegetation develops (Styanov, 1948). Largely, the content of organic matter is determined by the composition of sediments deposited on the river (Pavlović et al., 2015), as well as by periodic floods, which can either enrich the soil with organic matter (Stoyanov, 1948) or wash away organic forest litter (Mikelsen & Vesho, 2000).

The analysis of the results shows two tendencies: reduction of the carbon content in soil depth and lower content in the soils from the periphery of the islands (SP1; SP2 and SP6) compared to the other soils from the

Table 3. Chemical characteristics of the soils in the studied SPs.

SP	Depth, cm	pH	C %	N %	C / N
		Aydemir Island			
SP1	0-20	6.96	0.96	0.15	6.4
	20-40	7.20	0.95	0.14	6.7
SP2	0-20	6.90	2.5	0.17	14.7
	20-40	7.10	1.17	0.14	8.3
SP3	0-20	7.26	4.56	0.20	22.8
	20-40	7.30	3.12	0.19	16.4
SP4	0-20	7.37	2.88	0.17	16.9
	20-40	7.50	2.75	0.16	17.2
SP5	0-20	7.24	3.48	0.20	17.4
	20-40	7.38	3.20	0.18	17.8
		Vetren Island			
SP6	0-20	7.36	1.96	0.05	39.2
	20-40	7.45	0.98	0.02	49.0
SP7	0-20	7.27	3.36	0.18	18.3
	20-40	7.50	2.23	0.17	13.1
SP8	0-20	7.29	4.32	0.21	20.6
	20-40	7.05	3.45	0.21	16.4
SP9	0-20	7.31	4.50	0.30	15.0
	20-40	7.28	3.76	0.29	12.9
SP10	0-20	7.32	8.16	0.41	19.9
	20-40	7.48	7.23	0.33	21.9

Table 4. Composition of soil organic matter in the studied SPs. Columns 2, 3, 4, 5, 7, 9, 10. are given as a percentage to the weight of soil sample.

SPs	Depth, cm	Organic C% Extracted with 0.1 M $Na_2P_4O_7$ + 0.1MNaOH			Cx / Cf	Organic C% Fractions of humic acids		Non extracted organic C % (humin)	"Aggressive" fulvic acids
		Extracted totally	Humic acids Cx	Fulvic acids Cf		Free or bounded with R_2O_3	Bounded with Ca		
1	2	3	4	5	6	7	8	9	10
				Aydemir Island					
SP1	0-20	0.05	0.01	0.03	0.30	100	0	1.56	0.01
	20-40	0.04	0.00	0.01	0.00	100	0	1.48	0.03
SP2	0-20	0.97	0.23	0.65	0.35	100	0	1.45	0.06
	20-40	0.68	0.17	0.43	0.40	100	0	1.63	0.07
SP3	0-20	1.10	0.40	0.52	0.77	100	0	1.56	0.08
	20-40	0.98	0.47	0.53	0.88	100	0	1.20	0.07
SP4	0-20	0.82	0.38	0.40	0.95	100	0	0.46	0.06
	20-40	0.75	0.25	0.42	0.60	100	0	1.15	0.08
SP5	0-20	0.90	0.40	0.42	0.95	100	0	2.06	0.08
	20-40	1.03	0.34	0.63	0.54	100	0	1.23	0.06
				Vetren Island					
SP6	0-20	0.42	0.03	0.35	0.08	100	0	2.58	0.02
	20-40	0.74	0.15	0.54	0.28	100	0	1.17	0.04
SP7	0-20	1.28	0.48	0.72	0.67	100	0	0.54	0.08
	20-40	1.12	0.52	0.54	0.96	100	0	0.95	0.06
SP8	0-20	1.58	0.58	0.97	0.59	100	0	2.08	0.09
	20-40	1.35	0.54	0.73	0.74	100	0	1.27	0.09
SP9	0-20	1.82	0.68	0.81	0.83	100	0	2.74	0.13
	20-40	1.53	0.73	0.85	0.85	100	0	1.35	0.10
SP10	0-20	2.54	1.02	1.32	0.77	100	0	2.68	0.19
	20-40	2.04	0.98	1.18	0.83	100	0	1.75	0.20

interior. Soils from peripheral sites SP1; SP2 and SP6 are poor of humus (≤ 2% C). The soil of SP4 on Aydemir Island has the highest content (C% in the top layer 4.56). This soil has the highest altitude (27m) and is not flooded by the river. High content of organic carbon have the soil of SP10 on Vetren Island as well as SP8 and SP9, which are internal to the island and have high content of clay soil colloids. The stock of soils with total N also varies. Slightly (N% 0.1 ÷ 0.15) are supplied with nitrogen sandy soils of SP1 and SP6. Sandy fraction is vary inert material and does not hold nutrients (Ilinkin, 2018). Well-stocked (N% 0.2 ÷ 0.25) are soils rich in organic matter from SP3 and SP8, and very well-stoked (N% ≤ 0.25) are those of SP9 and SP10.

Important for he processes of mineralization and humification of organic residues in the soil is the C/N ratio. The smaller value ratio leads to faster mineralization processes of soil organic matter, and more mature is the humus, and vise versa. At C/N ˂ 14 the humus system is defined as Mull, between 14 ÷ 25 as Moder, and > 25 as More. For most of the soils in the area the ratio is low (C/N 17 ÷ 24), which indicates relatively fast mineralization process and formation of Mull and Moder type of humus. The mineralization processes in the soil of SP1, SP2 and SP9 (C/N <16) are very fast, and very slow in the soils of SP6.

An analysis of the humus composition in studied soils from both islands was made. It represents the content of humic and fulvic acids, as well as their ratio in the soils. The results are presented in Table 4.

Humic acids are the stable part of organic matter, insoluble in strong acids, which gives stability and "maturity" to the humus in the soil. On the contrary, fulvic acids are more mobile and short-chain and their participation in the composition of humus gives it higher lability and instability. The results show that in all cases, the amount of fulvic acids is higher than that of humic acids in the soils of both islands. The quantity of "aggressive" fulvic acids, which are the most unstable part of the soil humus is also high. This is expected result, due to the short-term soil-formation process, interrupted by periodic flooding from the Danube. The participation of fulvic acids in SP10 is the highest under old natural forest from *Salix* spp., but here is also the high participation of humic acids, due to the highest percentage of organic C% extracted with 0.1 M $Na_2P_4O_7$ + 0.1 M NaOH (2.54%). Another trend is observed - in the sample areas from the peripheral parts of the islands (SP1; SP2; SP6), which have the lowest percentage of organic C% extracted with 0.1 M $Na_2P_4O_7$ + 0.1 M NaOH, and also the lowest amount of both humic and fulvic acids. This tendency for differences in the composition of humus for peripheral soils, compared to those of the internal parts of the islands is confirmed by considering the Ch/Cf ratio which shows soil humus type (Zhyianski et al., 2012). For the soils from the peripheral parts (SP1; SP2; SP6) the type of humus is fulvate (Ch/Cf <0.5), as soils which are the latest formations of the islands, with the lowest degree of humus-formation processes. For all other areas falling within the islands, the Ch/Cf ratio is > 0.5p, which defines the humus as humic-fulvic. Kirillov et al. (2015) also find a fulvic-humic and humic type of humus system in soils from the Danube lowlands. Another feature showing the "immaturity" of humus in the soils of the islands is that the humic acids in all Sps are 100% free or bound to R_2O_3 sesquioxides and do not form stable complexes with Ca ions. This shows the mobility of organic matter in soil profile depth and its low degree of retention in the surface soil layers.

Conclusions

The characteristic of *Alluvial Fluvisols* from Aydemir and Vetren Islands of the Danube River distinguish two groups of soils. The newly formed soils from the periphery of the islands, which are closest to the river waters, are characterized by a

lighter texture (clay sandy) and a lower participation of the clay fraction in the soil texture, as well as a lower content. of organic carbon, with fulvic type of humus, and the largest predominance of fulvic acids over the humic acids. The soils from the interior of the islands, where the soil formation processes are more advanced, have heavier texture, between heavy sandy-clay to slightly clay, with a larger amount of humus, which is of humic-fulvic type. Fulvic acids predominate over humic acids in the composition of humus. This shows the instability of organic matter in soils and its greater lability in the soil profile depth and potential to release larger amounts of carbon gases into the atmosphere. In this respect, forest vegetation would contribute for stabiliztion of carbon in these soils.

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