Organic matter in low weathered soils from Pantanal region, Brazil

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Abstract

The organic matter (SOM) from five representative soil profiles from Pantanal region, Brazil, was investigated aiming to evaluate the relationship between SOM composition with the soil class and the environmental conditions. The observed low C soil contents are probably related to the flood pulse and some aspects of climate (high temperatures in dry season), soils (predominance of light textures in the upper horizons) and spontaneous and frequent fire in this region. The N content was comparatively high, resulting low C/N ratios. In comparison to other tropical soils, the proportion of aromatic structures is high and the O-alkyl tends to be low. Considering that the vegetation shows little influence on the SOM composition, these results are most probably related to the annual fires. The increase of both aromatic C and carboxylic C with depth may indicate that aromatic organic acids are migrating along the profile as result of the flood pulse. The input of vegetation residues with high contents of C-O alkyl, on the upper horizons may dilute the recalcitrant groups.

Introduction

The Pantanal region is a complex tropical wetland with geomorphic surfaces originated by landscape evolution processes inherited from successive Plistocene and Holocene climate changes, creating small areas of gently sloping relief, which most probably are former river levees and lowlands, which are seasonally flooded. In the gently sloping surfaces Planosols and Plinthosols occur, while in the lowlands mainly Gleissols are found. These soils are developed from non consolidated alluvial deposits. In the last 20 years, this region underwent environmental disturbances such as deforestation due to the expansion of the agricultural frontiers and cattle raising areas have contributed to modify the soil attributes of A horizon, mainly the organic matter content. In this context, the present study aimed to evaluate the soil organic matter composition in low weathered soils from Pantanal region and to establish the relationship between soil class and environmental conditions. The results obtained in this study will contribute to the stablishment of strategies for preservation and sustainable development of the Pantanal.

Materials and methods

Samples from different horizons of five representative soil profiles under native grassland from Pantanal region, Brazil, were morphologically described and collected. Particle-size distribution was determined gravimetrically by the pipette and sieving methods. The pedogenic iron oxides (Fed) and the poorly crystaline Fe-oxides were determined by DCB and by Oxalate extractions, respectively. The contents of C and N were determined by dry combustion. The soil samples were demineralized with 10% (m/m) HF. The water extracted SOM and the HF treated samples were analyzed by solid-state 13C NMR spectroscopy on a Bruker DSX 200 spectrometer and the SOM composition was determined relating the ^{13}C chemical shifts to tetramethylsilane (0 p.p.m.). The NMR spectra were divided into four main regions, assigned to different C groups, which were quantified employing the equipment software. From these data, an aromaticity index (Dalmolin et al, 2006) was calculated: aromatic C/ O–alkyl C (Arom/O-A).

Results and Discussion

The two Planosols and the Plinthosol presented the lowest clay contents in upper horizons, which is related to the fine fraction loss due to the the ferrolysis (hydromorphic soil forming process). In the Gleysols the clay content varied between 36 and 66% (Table 1). Concerning the Fed content, the samples also differed according to the soil class. The Planosols showed the smallest Fed contents (≤ 19 g kg-1), while values between 11 and 41 g kg-1 were observed in the Gleysols, indicating that the in the latter the pedogenic proccess were comparatively more effective. The high Fed content in the Btf1 horizon of the Plinthosol is due to the occurrence of Fe(III)-oxides nodules, which precipitated in the oxygen-trapped containing pores. With exception of Gleysol (P3), the Feo/Fed ratio, which shows the proportion of poorly crystalline Fe-oxides, was relatively high in the upper horizons, reflecting the hydromorphic conditions caused by the annual flooding of the area. The observed low C soil contents are probably related to the flood pulse as mentioned by Nogueira et al. (2002) and some aspects of climate (high temperatures in dry season), soils (predominance of light textures in the upper horizons) and spontaneous and frequent fire in this region. The N content was comparatively high, resulting low C/N ratios (Table 1), when compared to well drained oxisols (Dick et al. 2005). The relative enrichment of N in the SOM may be related to the periodic anaerobic conditions. The water extracted SOM, which represents a more labil SOM, was composed mainly by O-alkyl structures and probably is a result from the microbial activity. The chemical composition of the A horizon showd high variability among the soils: 19 to 25 % of Alkyl C; 31 to 42 %O-alkyl C; 19 to 29 % of aromatic C and 13 to 16% of carbonylic C. In comparison to other tropical oxisols, the proportions of aromatic structures are higher and those of O-alkyl tend to be lower (Dalmolin et al. 2006). Considering that the vegetation shows little influence on the SOM composition, these results are most probably related to the annual fires. The increase of both aromatic C and carboxylic C with depth may indicate that aromatic organic acids are migrating along the profile as result of the flood pulse. The input of vegetation residues with high contents of C-O alkyl, on the upper horizons may dilute the recalcitrant groups

Table 1. Content of clay fraction, of pedogenic iron oxides (Fed), of organic carbon and of nitrogen, C/N ratio, proportions of C functional groups determined by ^{13}C NMR CPMAS and NMR index Arom/O-A in diferent horizons of five soils of Pantanal, Brazil.

Soil	Hor.	Clay (g kg^{-1})	Fed (g kg^{-1})	Feo/Fed	C (g kg^{-1})	N (g kg^{-1})	C/N	Alkyl C 45-0	O-alkyl C 110-45	Aromatic C 160-110	CarbonilC 245-160	Arom/ O-A
Gleysol	A	222	12	0.77	23	3.8	6.1	24.3	30.7	28.6	16.4	0.9
	AB	355	14	0.71	21	3.2	6.6	19.7	29.0	34.3	16.8	1.2
P1	Btg1	360	19	0.07	4	0.8	5.0	14.7	36.6	34.0	14.6	0.9
	Btg2	495	27	0.03	4	0.7	5.7	16.2	31.3	38.9	13.8	1.2
	Btg3	550	41	0.02	2	0.6	3.3	15.8	35.5	34.0	14.6	1.0
Planosol	A	90	2	0.70	9	1.2	7.5	19.3	42.1	24.3	14.2	0.6
	E	55	4	0.25	1	0.3	3.3	12.2	38.6	36.9	12.4	1.0
P2	EBt	120	7	0.23	2	0.5	4.0	14.3	32.2	39.5	14.1	1.2
	Bt1	122	9	0.22	2	0.5	4.0	13.7	31.6	37.8	16.9	1.2
	BC	522	19	0.09	2	0.6	3.3	11.6	28.5	44.5	15.4	1.6
Gleysol	A	430	11	0.27	13	1.7	7.6	24.9	38.8	23.2	13.1	0.6
	Btg1	471	20	0.14	8	1.2	6.7	17.8	35.8	28.8	17.6	0.8
P3	Btg2	664	32	0.03	7	1	7	14.8	38.8	32.1	14.4	0.8
	BC	645	23	0.03	6	0.9	67	12.8	32.7	34.5	20.0	1.1
Planosol	A	180	4	0.63	15	1.6	9.4	21.8	40.4	22.6	15.1	0.6
	Bt1	390	11	0.12	3	06	5.0	15.1	38.0	31.2	15.6	0.8
P4	Bt2	330	11	0.10	2	0.4	5.0	15.1	36.5	30.0	18.5	0.8
Plinthosol	A1	182	1	0.80	10	1.3	7.7	25.2	40.0	19.1	15.6	0.5
	E	200	8	0.04	3	0.6	5.0	19.4	43.4	21.7	15.6	0.5
P5	Btf1	270	50	0.01	1	0.4	2.5	17.4	42.8	25.7	14.0	0.6

Conclusions

The chemical composition of the SOM of low-weathered soils from pantanal region seems to be strongly affected by the annual fires in the soil surface. Due to the relatively high amount of recalcitrant structures, the contribution of SOM to the soil fertility may be limited.

References

Dalmolin, R.S.D.; Gonçalves, C.N.; Dick, D.P.; Knicker, H.; Klamt, E.; Kögel-Knabner, I., 2006. European Journal of Soil Science, **57**:644-654.

Dick, D.P.; Gonçalves, C.N.; Dalmolin, R.S.D.; Knicker, H.; Klamt, E.; Kögel-Knabner, I.; Simoes, M.L.; Martin-Neto, L.M. 2005. Geoderma, **124**:319-333.

Nogueira, F.; Couto, E.G.; Bernardi, C.J. 2002. Brazilian Journal of Biology **62**:1-10.