Change of distribution of soil phenolic matter along profiles of soils with different use

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1. Abstract

Soil phenolic matter (SPM) constitutes an important compartment of the soil organic matter (SOM). However, a very few studies on their different forms and on their distribution in soil is available. The present paper deals with an investigation of experimental pedology aimed at evaluating the distribution of phenolic matter as a possible indicator of soil use impact.

The investigation was carried out on 7 soil profiles (Andosols, Calcisols, Cambisols, Fluvisols, Lixisols, Podzols) with different land use: mountain pasture, grass, cereal, oak, chestnut, pine and eucalyptus wood. Three main SPM fractions were categorized: 1) the "total" (SPMt, extracted by 0.1M NaOH), 2) the "soluble" (SPMs, extracted by deionized water) and 3) that with "high" (SPMh, as SPMt-SPMs) affinity with soil body.

The content of all SPM fractions, as well as the phenolic parameters values, are usually larger in surface A horizons than in the deep B and C ones. Both SPM fractions and phenolic parameters appear to vary along soil profiles according to the different pedoclimatic environments and soil use. Our data suggest that the amount and the distribution of soil phenolic matter could be regarded as indicators of anthropic impact as well as of peculiar pedogenetic processes.

2. Introduction

Soil phenolic matter (SPM) represents an important component of the soil organic matter (McKeague *et al.*, 1986; Stevenson, 1982; Stevenson *et al.*, 1986). It is ubiquitous and characterized by high values of acidity, mobility, chemical reactivity and complexing activity (Oess *et al.*, 1999). Soil phenols are produced by micro organisms (microbiota, algae, fungi, lichens, mosses) and higher plants (root exudates, galls, ect.), as well as by organic matter decomposition (Frimmel *et al.*, 1988; Hartley *et al.*, 1985; Haslam, 1988). Furthermore they are believed to play a crucial role in humification pathways (*polyphenols theory*) (Flaig, 1966, 1988; Swaby *et al.*, 1966). A very few studies on their different forms and on their distribution in soil is available.

This work aims at evaluating the distribution of phenolic matter as a possible indicator of soil use impact and analyzing and interpreting the relationships among SPM, soil organic matter (SOM) and humic substances (HM) in these soils.

A survey was carried out on 7 soil profiles, as Andosols, Calcisols, Cambisols, Fluvisols, Lixisols, Podzols (FAO-ISRIC-IUSS, 2006), representative of various land uses: mountain pasture, grass, cereal, oak, chestnut, pine and eucalyptus wood. Table 1 reports selected characteristics of the investigated soil profiles. Surface (A) and deep (B and C) soil horizons have been sampled. Three main SPM fractions were categorized: 1) the "total" (SPMt), 2) the "soluble" (SPMs) and 3) that with "high" affinity with soil body (SPMh).

3. Methods

Soil analysis were carried out according to Italian Standard Methods of Soil Analysis (Mi.P.A.F., 2000). The SPMs has been extracted by deionized water (Lowe, 1993). The total SPM has been extracted by a 0.1 M NaOH solution, according to the same procedure described for the SPMs. The net amount of SPMh has been calculated as: SPMh = SPMt – SPMs. The SMP content in the extracts was determined by UV-VIS spectrophotometry at a wavelength of 750 nm, and expressed as vanillic acid equivalent. The content of SOM, HM and total extractable organic matter (TEOM) was determined, and phenolic parameters, as SPMt/SOM%, SPMt/TEOM%, SPMt/HM% and SPMh/SPMs, were also calculated.

4. Results

Table 2 shows the content of SOM, TEOM, HM and SPM (g kg^{-1}) in the investigated samples. The results highlight that SOM, TEOM and HM contents greatly vary according to land use, pedoclimatic environment, and horizonation. The SPMt content dramatically vary from 0.012 to 13.136 g kg^{-1}, averaging out at 2.164. The SPMh content, ranging from 0.001 to 13.080, and averaging out at 2.134 g kg^{-1}, largely contributes to the total SPM amount, whereas the SPMs content is very low, ranging from 0.005 to 0.161 g kg^{-1}, and averaging out at 0.030. The content of all SPM fractions, as well as the phenolic parameters values, are usually larger in surface A horizons than in the deep B and C ones (Tab. 3); besides, the ratios SPMt/SOM %, SPMt/TEOM % and SPMt/HM % show small differences between A and B horizons, whereas the SPMh/SPMs ratio in surface horizons is up to three times, and up to eighteen times larger than the respective observed in A and B horizons.

In surface A horizons the values of SPMh/SPMs ratio vary with pedoclimatic environment and vegetal cover (Fig. 1), decreasing as: chestnut on Dystric Andosol > oak on Haplic Cambisol > mountain pasture on Hyperskeletic-Entic Podzol > eucalyptus on Arenic Lixisol > grassland on Calcic Fluvisol > mixed wood (pine and eucalyptus) on Petric Calcisol > cereals on Haplic Fluvisol. A similar order can be observed for the SPMt/SOM % ratio, albeit it shows the larger values in Haplic Cambisol with oak and Arenic Lixisol with eucalyptus.

Figures 2 and 3 show the distribution of SPMt *vs* depth for all the profiles. It is evident that also the amount of SPMt along soil profiles varies according to the different pedoclimatic environment and, above all, the different soil use. Indeed, the amount of SPMt (g kg^{-1}) in surface A horizons shows two different trends: it is quite large for Haplic Cambisol with oak (13.136) > Dystric Andosol with chestnut (5.925) > Arenic Lixisol with eucalyptus (4.909) > Hyperskeletic-Entic Podzol with mountain pasture (3.585), whereas it is very low for Calcic Fluvisol with grassland (0.108) > Petric Calcisol with mixed pine and eucalyptus wood (0.084) > Haplic Fluvisol with cereals (0.068). A similar trend is observed for SPMh and SPMs. In most of cases, the values of the SPM content and of the phenolic parameters decrease along the soil profiles but with different patterns, with special reference to pedoclimatic features and horizonation. However, it is noteworthy the relevant exception of the Hyperskeletic-Entic Podzol with mountain pasture, whose Spodic horizon Bhs shows SPMt content much larger than that of the overlaying A horizon.

On the whole, our results show that soils with high anthropic impact as cultivated soil, grassland and reforested wood pine-eucalyptus are characterized by the lowest values of both SPM fractions content and phenolic parameters. Furthermore, both SPM fractions and phenolic parameters appear to vary along soil profiles according to the different pedoclimatic environments and soil use. As a concluding remark, our data suggest that the amount and the distribution of soil phenolic matter could be regarded as indicators of anthropic impact as well as of peculiar pedogenetic processes.

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Table 1 Selected characteristics of the investigated soil profiles

Profile	Substratum	Land use	WRBSR Classification	Horizonation
ALP 4	Glacial drift	mountain pasture	Hyperskeletic-Entic Podzol	A-Bhs-Bs-BC-C
VHM 14	Greyish basalt weathered	Oak	Haplic Cambisol	A1-A2-Bw-C
MSP 9	Clay-sand alluvium	Grassland	Calcic Fluvisol	Ap-Bw-2Bk1-2Bk2
MSP 10	Mixed alluvial	Cereals	Haplic Fluvisol	Ap-AC-C1-C2-C3
VHM18	Latite	chestnut	Dystric Andosol	Ap-B
SHM 11	Sand	pine and eucalyptus wood	Petric Calcisol	A1-Bk
SHM 12	Sand	eucalyptus wood	Arenic Lixisol	Ah-Bt

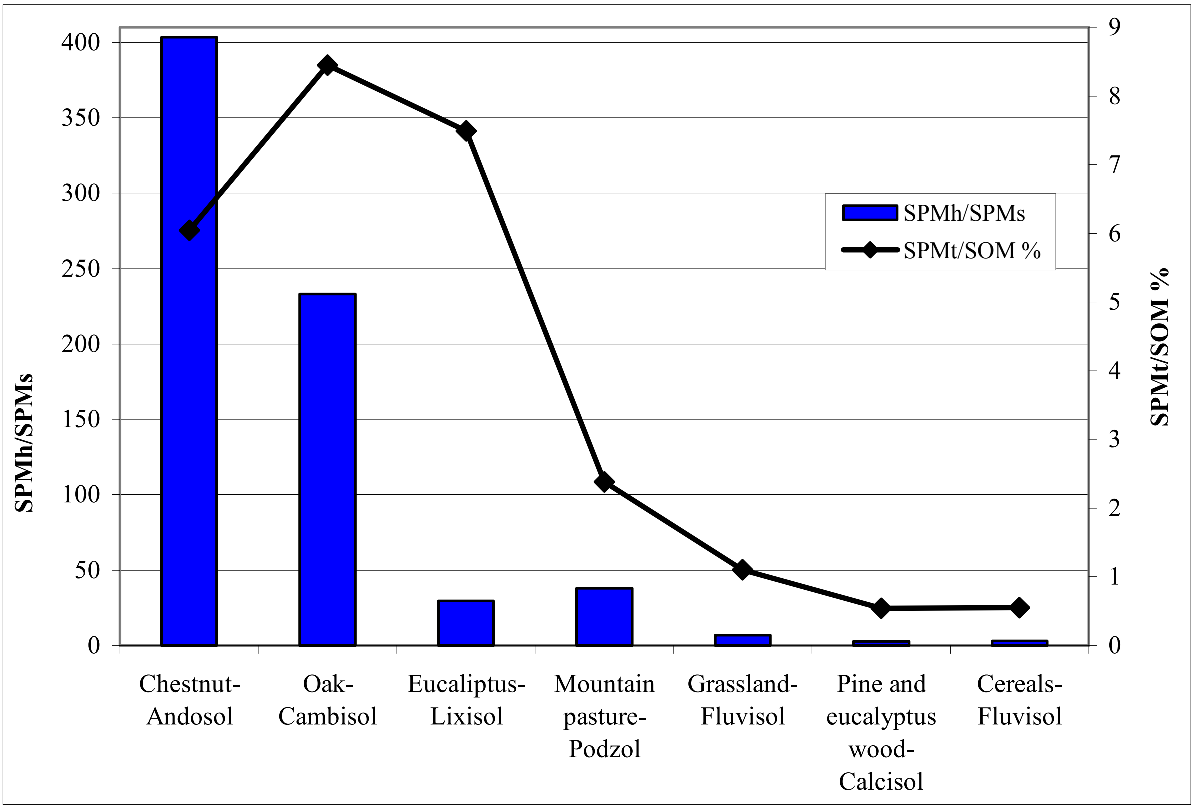

Figure 1 Variability of SPMh/SPMs and SPMt/SOM% in surface horizons under different vegetal cover

Table 2 Content of Soil Organic Matter, Humic Matter, and Soil Phenolic Matter in soils

	SOM (g/kg)	TEOM (g/kg)	HM (g/kg)	SPMt (g/kg)	SPMs (g/kg)	SPMh (g/kg)
min	3.500	0.304	0.000	0.012	0.005	0.001
Mean	40.652	16.149	8.764	1.843	0.030	2.134
MAX	155.544	115.508	61.168	13.136	0.161	13.080
Std. error	47.23	29.03	15.10	3.16	0.04	3.45

Table 3 Soil phenolic matter and phenolic parameters in A, B and C horizons

Horizon	N	SPMt (g/kg)	SPMs (g/kg)	SPMh (g/kg)	SPMt/SOM%	SPMh/SPMs	SPMt/TEOM%	SPMt/HM %
A	9	4.045	0.046	4.000	4.09	128.32	22.15	31.79

B	10	1.274	0.023	1.252	3.75	39.22	21.99	30.33
C	5	0.599	0.013	0.142	1.15	7.10	10.83	14.12

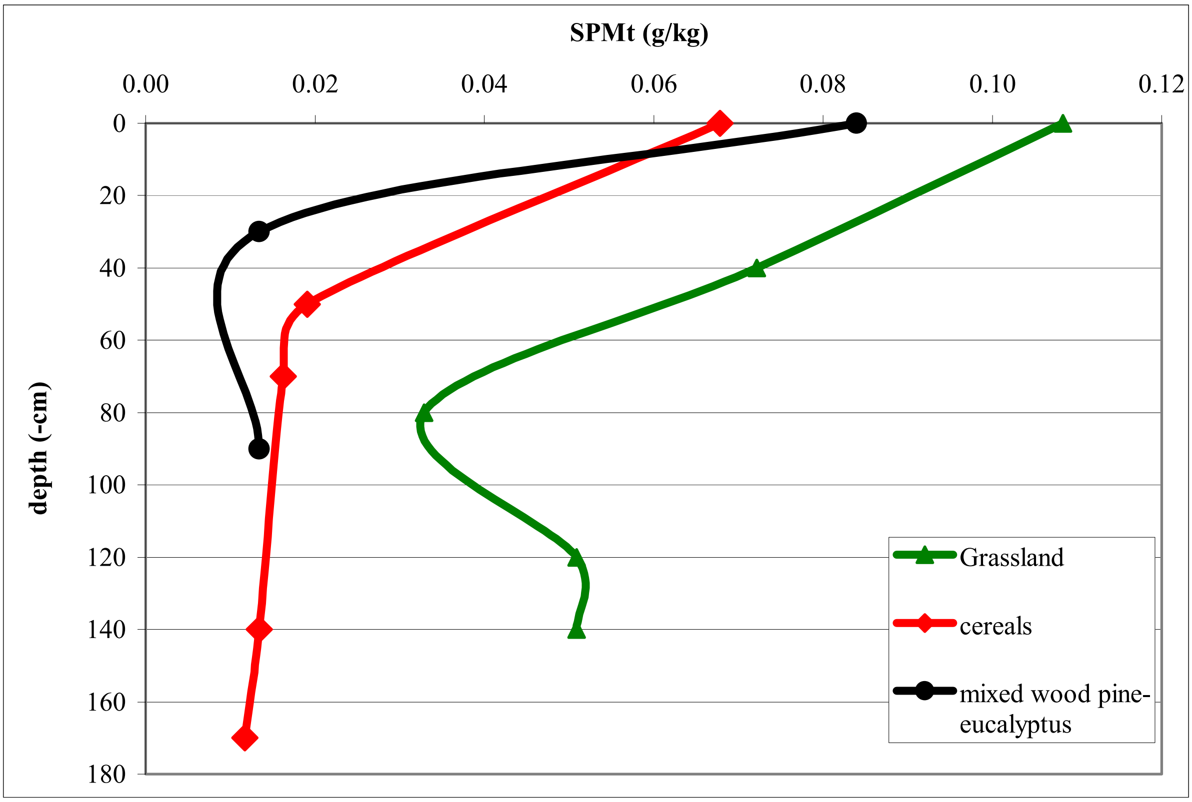

Figure 2 Soil phenolic matter distribution along profiles under grassland, cereals and mixed wood pine-eucalyptus

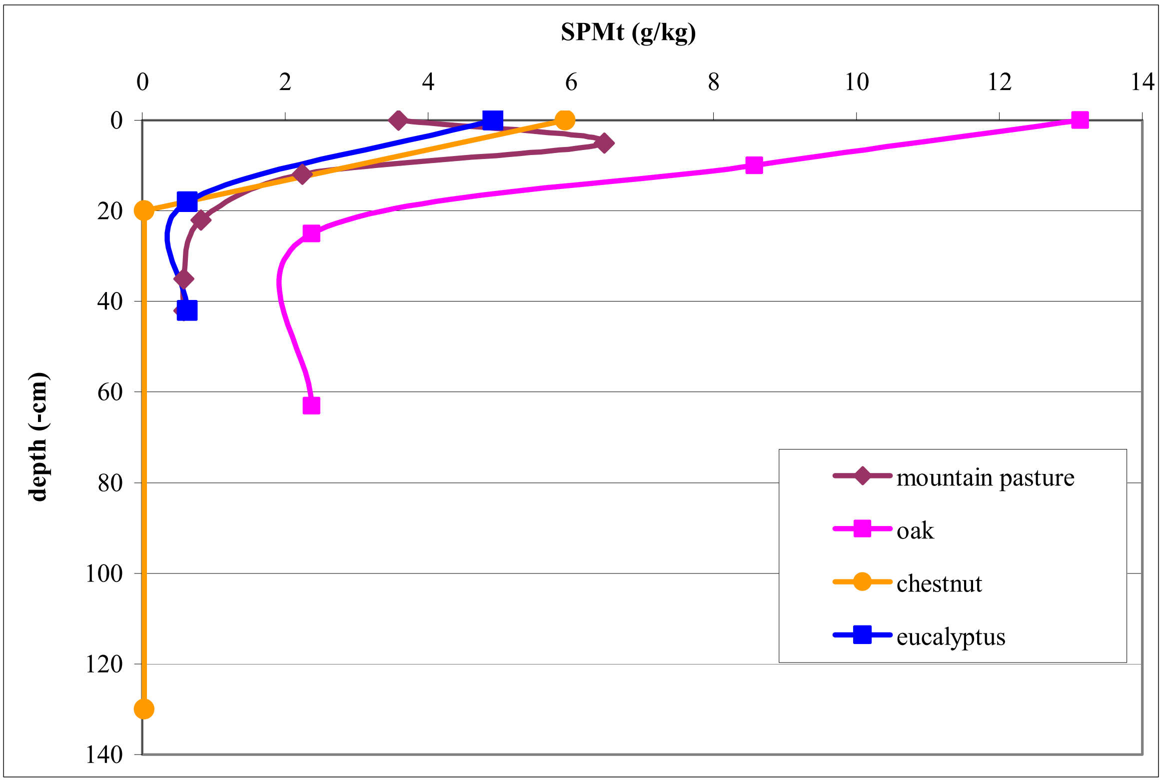

Figure 3 Soil phenolic matter distribution along profiles under mountain pasture, oak, chestnut and eucalyptus