CARBON DISTRIBUTION IN SOIL PARTICLE-SIZE FRACTIONS ALONG AN ALTITUDINAL GRADIENT IN THE TRANSMEXICAN VOLCANIC BELT

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Abstract

In this work, the impact of land use and forest degradation on changes of soil C contents was evaluated. The C distribution in particle-sizes fractions of two types of volcanic soils (*Andosols* and *Acrisols*) located in a topo-sequence were determined after dispersion and the coarse sand, fine sand, silt, clay, and particulate organic matter (POM) fractions were analyzed. *Acrisols*, due to their high clay content, accumulated about 60% of the SOC in the clay fraction whereas *Andosols* stabilized C mostly in the silt fraction. The POM was the most sensitive fraction to changes of land use managements and could be a useful indicator of long-term changes in soil C contents. The C contents in clay-, silt-, and POM fractions decreased in the *Andosols* with forest degradation.

Introduction

The association of soil organic matter (SOM) with soil-mineral fractions is an important factor controlling the storage and mineralization of SOM (Feller & Beare, 1997). There are a number of papers dealing with the organic material-inorganic fractions association in temperate soils, but less information is available for tropical soils and, specifically, volcanic soils. The aim of this work was to determine how land use and forest degradation affect the content and distribution of C in soil particle-sizes in a topo-sequence, including two types of volcanic soils: *Andosols* and *Acrisols*. Such knowledge may enable a better understanding of the SOM dynamics in both types of soils, abundant in the Transmexican Volcanic Belt.

Materials and Methods

The study site is located at the Atécuaro catchment (Michoacán, Mexico). The most representative land-use systems along an altitudinal gradient were identified. The upper parts were dominated by *Andosols*: grasslands (P1, 2615 m); mixed pine-oak forests, increasing degradation down-slope (P2, 2496 m; P3, 2411 m; P6, 2320 m); fuel-wood area (P4, 2370 m); and agricultural lands (P5, 2330 m). At the piedmont, dominated by *Acrisols* there were cultivated fields (P8, 2281 m) and grasslands (P9, 2290 m). Composite soil-samples were taken from the upper -10 cm. The fractionation procedure consisted of three steps: sonication to completely disrupt aggregates, wet sieving to segregate coarse particles (> 0.05 mm), and centrifugation to separate silt from clay. The fractions obtained were: coarse sand (CS), fine sand (FS), silt (ST), and clay (CY). Particulate organic matter (POM) was separated from CS (POM-CS) and FS (POM-FS). Soil organic C (SOC) and total N (Nt) were determined by dry combustion. Differences among soil types and land uses were subjected to either one-way ANOVA or the Kruskal-Wallis non-parametric test.

Results and Discussion

The results of SOC, soil C/N ratio and the C content and C/N ratio of the separated particle-size fractions are reported in Table 1. SOC and C contents of ST, FS and CS particle-size fractions were significantly lower in *Acrisols* (P7 and P8) than in *Andosols* (P1, P2, P3, P4, P5, and P6). Accumulation of SOM is a characteristic property of *Andosols* (Dahlgren *et al.*, 2004). For that, the two groups were evaluated separately.. In *Acrisols*, 60% of the total SOC was associated with CY indicating a strong linkage, 30% with ST, 1% with the sand fractions, and less than 10% was present as POM. The content of SOC was lower in the agricultural land, which contained less POM both in absolute and relative terms. The C/N ratio in the clay fraction was less than 16, indicating that the C associated to this fraction was more humified and stabilized and less subjected to mineralization. On the contrary, the C/N ratio of SOM associated to the sand fractions and to the POM ranged from 17 and 50 and is probably easily mineralizable (Christensen, 1992).

Table 1. Soil organic carbon and C distribution in soil particle-size fractions

Site	SOC	Clay (CY)	Silt (ST)	Fine sand (FS)	Coarse sand (CS)	POM-FC	POM-CS
				(mg C g^{-1} soil)			
P1	58.6a	27.6ad	32.7ac	0.7a	1.1a	2.7a	1.7b
P2	130b	41.6b	69.1b	0.6a	1.6a	17.8b	21.9a
P3	82.3c	36.7ac	50.1c	0.7a	0.8a	8.2c	10.4a
P4	57.3a	22.8d	38.3a	0.6a	1.0a	8.5c	5.5ab
P5	35.0d	18.6d	23.4d	0.9a	0.8a	2.0a	2.7b
P6	50.5a	21.1d	35.4a	0.8a	0.8a	4.1a	4.3b
P7	14.4a	12.6a	6.7a	0.1a	0.1a	0.7a	0.6a
P8	22.8b	18.8a	10.4a	0.2a	0.1a	1.6a	1.0b
	Recovery			**% referred to SOC**			
P1	103	38.2a	53.4a	1.3ab	1.3a	3.4b	5.0a
P2	100	29.2b	48.6a	0.4b	1.2a	15.2a	12.4a
P3	107	34.5b	47.2a	0.6b	0.7a	9.4a	7.5a
P4	100	28.8b	51.1a	0.9ab	2.4a	7.1a	6.5a
P5	96.8	38.4a	48.6a	1.8a	1.6a	5.6b	4.1a
P6	100	31.7b	53.2a	1.2ab	1.2a	6.4ab	6.2a
P7	100	60.6a	32.3a	0.7a	0.3a	2.9a	3.3a
P8	100	58.4a	32.3a	0.6a	0.4a	3.2a	5.2b
				C/N ratio			
P1	11.8	12.8	14.6	17.5	16.3	28.4	44.3
P2	14.5	13.8	24.1	29.3	29.8	33.5	57.8
P3	14.5	14.0	27.5	27.1	27.2	35.2	48.2
P4	18.3	15.7	34.6	30.6	50.0	58.6	96.5
P5	11.4	10.9	18.7	19.3	20.4	26.7	36.6
P6	13.9	12.7	27.7	26.1	29.8	46.0	57.9
P7	11.8	10.8	18.8	18.2	29.6	27.5	37.6
P8	15.0	11.2	18.8	25.5	23.7	30.2	81.0

(*Different letters within columns indicate significance at $P < 0.05$ level for each site of the same soil type)

In the *Andosol* sites, around 50% of the SOC content was linked to silt, 30% to clay, less than 5% to sand fractions and 5% to POM. The distribution of C in particle fractions was significantly affected by land use. A loss of POM in the fine-sand fraction and an increase of C in the mineral fine-sand and clay fraction was observed in the agricultural land, which was also found by Cambardella & Elliott (1992). The C/N ratios of the bulk organic material, silt- and POM of the fine-sand fraction were higher in the forest than in the grassland and agricultural land. Significant differences were found in C associated to clay, silt and POM between the forest sites. Highest values were found in the better preserved-areas (P2 and P3) and lowest C contents were present in the more degraded forest sites (P4 and P6) as a consequence of human activities.

Conclusions

In Acrisols, most organic matter was stabilized in the clay-sized fraction as a consequence of their high clay content, in spite that *Acrisols* has a very lower C content than the *Andosols*. Furthermore, POM in the coarse-sand fraction was most sensitive to land use management and may be useful indicator of land use management in *Acrisols*. In *Andosols*, C was mostly linked to the silt-sized fraction. Forest degradation could be linked to a decrease of C in clay-, silt- and POM fractions in these soils.

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