Thermal Properties in Soil Particle-Size Fractions of *Andosols*, with Different Land-Use, in the Trans-Mexican Volcanic Range

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Keywords: physical fractionation, thermal analysis, forest degradation

1. INTRODUCTION

In the Cuitzeo Basin (Michoacán, Mexico), land degradation has reduced soil fertility and productivity. The necessity of rural communities of searching resources for improving the local economy has lead to an increase in timber extraction activities during the last years. This practice has been associated to a decrease in the vegetation cover and an increase in the soil surfaces affected by degradation processes. As a consequence, the SOM stored in the soils of this area is in high risk of being lost, especially in the upper soil horizons. Thermal stability of soil organic matter (SOM) refers to its resistance to thermal oxidation during heating treatments and relationships between thermal properties and biological stability have been found (1). Thus, thermal techniques allowing to detect gross changes in SOM as a consequence of land-use changes has also been referred.

The objective of this work was to determine how land use and forest degradation affected the SOM of volcanic soils located at the Mexican Volcanic Belt, using as a tool the thermal responses of the C associated to the silt- and clay- sized fractions.

2. MATERIALS AND METHODS

The study site is located in the Atécuaro catchment, within the Cuitzeo basin (Mexico), 12 km away from the city of Morelia (State of Michoacán, 19º 34' N; 101º 10' W). The dominant soils in the catchment are *Andosols* in the top and slopes and *Acrisols* in the piedmont and valley. The forest succession is pine-oak at the summit, with increasing degradation on the hillside and, finally, maize cultivations on foothills. Six representative plots were selected in the area: a grasslands (P1) previously used as agriculture land and abandoned about 30 years ago; 4 pine-oak forest plots with increasing degradation down slope (P2, P3, P4, and P6); additionally a fuel-wood area (P4) that suffered a forest fire in 2000; and a recently abandoned agricultural land (P5) that followed a fallow management.

Soil samples (0-10 cm) were taken in each site and soil organic C (SOC) was determined. A particle-sized fractionation using ultrasonic energy allowed for the separation of the silt- and clay-sized fractions. Differential thermal (DTA) and thermic-gravimetry (TGA) analysis were performed on the clay- and silt-sized fractions of soil samples. Total weight loss by thermal combustion of samples between 200 and 600ºC was determined; in addition, relationships between the areas of the two main exothermic peaks (EP2/EP1) based on the first derivative of the TGA were calculated according the methodology proposed by López et al. (1).

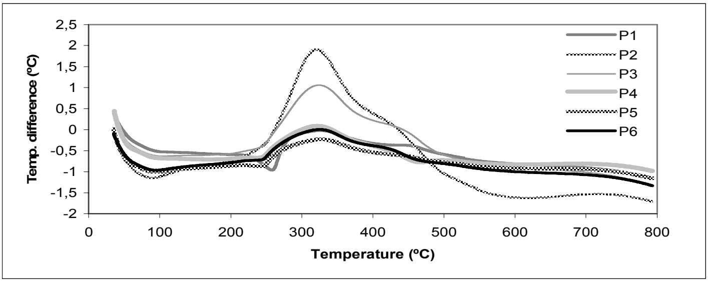
3. RESULTS AND DISCUSSION

- a) Clay-sized fraction: The first exothermic peak (EP1) detected for the clay-sized fraction was very similar for all sites (about 333 ºC; Fig.1); the second exothermic peak (EP2) only appears in P1 (455 ºC); samples of the other sites showed a shoulder more than a real peak. In general, the EP1 accounted for a higher area (i. e., weight loss) than the EP2, excepting the site P4. The best preserved forest area (P2) presented the highest EP1, followed by samples from the P3 and the other forest sites (P4 and P6); these last sites did not show significant differences between them. On the other hand, the weight loss associated to the EP2 was similar for all forest sites. Then, land-use affected the quality of organic C associated to the clay-sized fraction. The soil sample of the P1 (grassland) had a higher EP1, but the EP2 of the P5 (agricultural-land) was higher.

-b) Silt-sized fraction: Samples of the silt fraction showed two well-defined peaks. The EP1 was close to 345 ºC, and the EP2 ranged from 425 to 453 ºC. In this case, the P1 and the P5 presented significantly higher temperatures (>440 ºC) than the forest sites. The EP2 was, in general, wider, indicating that the silt-sized fraction contained more thermal-stable organic C. The height of the EP1 decreased in the order: P2 > P3 > P4 = P6; and that of the EP2: P2 > P3 = P4 > P6. Then, land-use affected more intensely the quality of the C included in the silt-fraction.

EP2/EP1 ratios (relation between the areas of the two exothermic peaks) are exposed on Table 1 and used as a measure of the aromaticity of the organic C (humification index; 2). C linked to the clay-sized fraction seems less aromatic and C associated to the silt-sized fraction was, in general, more aromatic (ratio >1.0). Then, the organic C associated to the silt fraction forms more stable and humified organic-mineral complexes. EP2/EP1 ratios of both particle-size fractions increased moving down slope, which means that the humification intensity of the SOM increases with the forest degradation. That means that labile C is lost when the human activities increase and only the more recalcitrant SOC remains.

a) Clay-sized fraction



b) Silt-sized fraction

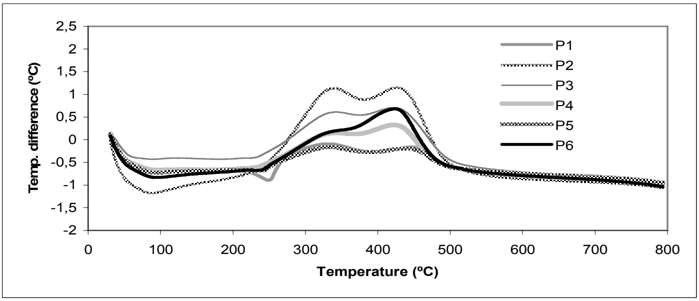


Figure 1. DTA lines of the clay-sized fraction (a) and of the silt-sized fraction (b).

Table 1. Ratios between peaks for the clay- and silt-sized fractions

Sites	Ratios	
Fractions	Clay-size fraction	Silt-size fraction
P1	0.39	0.61
P2	0.36	1.12
P3	0.52	1.36
P4	1.09	1.99
P5	0.70	1.43
P6	0.83	1.48

4. CONCLUSIONS

C associated to the silt fraction is more aromatic (more humified) than the C associated to the clay fraction. Thermal analyses showed that the labile C associated to both fractions is significantly affected by forest degradation. As a consequence of this, only the more stable SOC is stored in the more degraded forest soils. Land-use changes from forest to pasture affected both the amount and quality of C associated to the two considered fractions, but the agricultural use produced even a higher loss of the more thermally stable C associated to the silt fraction. As a consequence of this, a faster decrease of C is promoted by agriculture, remaining only the more recalcitrant SOC.

ACKNOWLEDGEMENTS

The authors gratefully thank the European Union for supporting the REVOLSO Project (INCO Program) and the Spanish *S.E.U.I.* and Mexican UNAM, which partially financed also the Project. The technical aids of R. Velázquez (UNAM) and L.F. Lorenzo (Spanish CSIC) are appreciated.

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Volume I

From Molecular Understanding to Innovative Applications of Humic Substances

Proceedings of the 14th International Meeting of the International Humic Substances Society

Editors

Irina V. Perminova

Natalia A. Kulikova

September 14-19, 2008

Moscow – Saint Petersburg

Russia

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From Molecular Understanding to Innovative Applications of Humic Substances; Proceedings of the 14th International Meeting of the International Humic Substances Society, September 14-19, 2008, Moscow – Saint Petersburg, Russia, Editors: I. V. Perminova, N. A. Kulikova, Vol. II, Humus Sapiens, Moscow, 2008, 380 pp.