# Soil organic carbon in fine particle fractions and aggregates in Andosols: influence of land use

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**Résumé**
On a vérifié que les changements d'utilisation peuvent déchaîner dans les Andisoles et les sols andiques des processus graves d'érosion par l'eau. Avec ce travail on prétend vérifier les variations dans les teneurs en carbone dans les différentes fractions granulometriques de ces sols sous l'effet des changements d'utilisation et la transformation de la couverture végétale. L'étude a été menée à bien dans cinq parcelles expérimentales situées dans la zone montana humide des Iles Canaries et correspondant à une séquence de perturbation anthropique : forêt climax, forêt dégradée, plantation forestière et bruyères de substitution. On a effectué l'analyse de trois fractions d'aggrégats (2mm, 0.5-2mm et <0.5mm) et des fractions granulométriques (sables, limons et argiles). Les résultats montrent une réduction du stock total de carbone du sol associé à des processus de dégradation textural et structurelle du sol en coïncidant avec la séquence de perturbation.

## Introduction

Andosols and andic soils are characterized by a predominance of short-range ordination minerals in the fine fraction, that occur commonly associated with organic compounds, thus generating highly aggregated and stable structures with high microporosity, low bulk density and high resistance to microbial decomposition due to physical protection of the organic matter inside the aggregates.

It has been reported that changes of use may lead to severe soil degradation processes (Arbelo et al, 2002). Water erosion in Andosols and andic soils comes generally from a picking off of surface material of larger aggregates, caused by the impact of raindrops. Erosion in these soils involve no particle dispersion prior to being displaced by rainwash, since the mobilization of particles takes place as minor (0.2 - 0.5 mm), low-density, and highly water-stable aggregates (Rodríguez Rodríguez et al, 2002, 2004).

The purpose of this work is to verify the variations of carbon contents in different size fractions of both soil aggregates (> 2mm, 0.5 - 2mm and < 0.5mm) and textural fractions (sand and silt+clay), as well as their contribution to total soil carbon stocks, as related to different soil uses and plant cover transformations.

## Material and Methods

The study has been performed in five experimental plots located at humid mountain zone of the Canary Islands, on the windward side under the influence of humid northeast winds. The typical vegetation in the study area is a laurel forest or *laurisilva*. The five plots correspond to a sequence of anthropic disturbance: mature forest (*Los Aceviños*- AA) – degraded forest (*Palos Pelados*- PP) – wood plantation (*Ravelo*- RA) – substitution brushes (*Pajaritos*-PA and *Siete Lomas*-SL). (Table1). *Aceviños*, *Palos Pelados* and *Ravelo* plots correspond to

forest ecosystems with deep and well-developed Andisols whereas *Pajaritos* and *Siete Lomas* plots are shrubby communities with highly degraded and eroded andic soils. In each plot, surface soil (0-15 cm) was sampled three times along one year. The particle-size distribution and the organic carbon content in three aggregate fractions (<0.5cm, 0.5-2cm and >2mm size range), as well as in fine (silt+clay) and sand particle classes were analysed.

**Table 1.**

| **General characteristics of the experimental plots** | | | |
|---|---|---|---|
| Experimental plot | Soil classification | Type of ecosystem | Dominant plant species |
| Aceviños (AA) | Eutric Fulvudands | Mature forest | *Laurus novocanariensis*<br>*Persea indica* |
| Palos Pelados (PP) | Ultic Hapludands | Degraded forest | *Erica arborea*<br>*Myrica faya* |
| Ravelo (RA) | Ultic Fulvudands | Wood plantation | *Pinus radiata* |
| Pajaritos (PA) | Humic Lithic Dystroxerepts | Substitution scrub | *Erica arborea*<br>*Cistus monspeliensis* |
| Siete Lomas (SL) | Lithic Hapludands | Substitution scrub | *Chamaecytisus proliferus* |

**Results and discussion**

The results show a progressive diminution of the larger aggregates (> 2mm) in favour of the smallest aggregates (< 0.5mm) (Figure 1). A decrease in carbon content in the three aggregate fractions can also be observed, mainly in the intermediate size one (0.5 - 2mm) (Figure 2) as well as a reduction in total sequestered soil organic carbon (SOC) from mature forest with deep, well-developed Andisols (*Aceviños*) to substitution scrubs with highly degraded and eroded soils (*Pajaritos* and *Siete Lomas*) (Figure 3). When the aggregate fractions are studied separately, a marked decrease in the contribution to total soil organic carbon stock in the largest fraction occurs, increasing in the finest one, and remaining almost unchanged in the intermediate aggregate fraction (0.5 - 2mm). This fact implies a redistribution of carbon in soil according to the sequence of disturbance, and could be due to a fragmentation of the larger aggregates by picking off of raindrops, thus enriching soil in smaller sized aggregates. Morover, the fragmentation of the largest sized aggregates would eventually expose carbon pools previously protected inside the larger aggregates to microbial activity.

As far as particle size classes are concerned, the soils in mature ecosystems show a higher proportion of fine elements (silt + clay), as compared those in degraded ecosystems, so that the finer elements (silty-clayey particles) tend to decrease as the disturbance degree increases (Figure 4). Likewise, a diminution in the carbon content of all granulometric fractions (especially in the fine elements) can also be observed (Figure 5) leading to a decrease in total carbon stocks with the degree of disturbance.

The organic C stock undergoes the highest decrease in the fine (silt + clay) fraction, whereas that in the sandy fraction remains basically unchanged (Figure 6). A probable explanation would be the preferential loss of fine particles by erosion, which have also both the highest organic matter content and low bulk density in mature soils. For both reasons, the finer elements are easily removed by water so their loss implies a change in their contribution to the total soil organic carbon stock of both particle size classes, according to the disturbance sequence.

Figure 1. Aggregate distribution

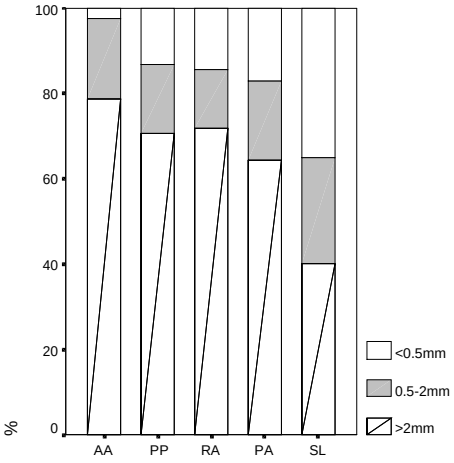



Figure 2. Carbon content vs. aggregate-size

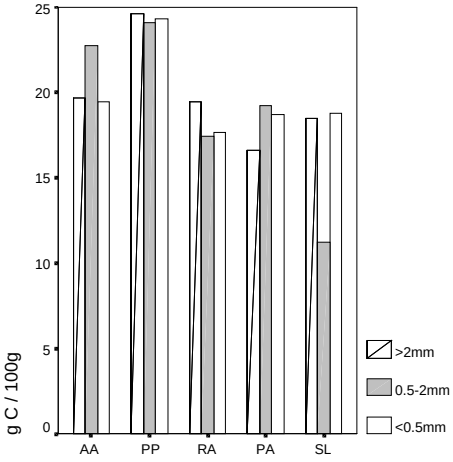



Figure 3. SOC stocks vs. aggregate-size

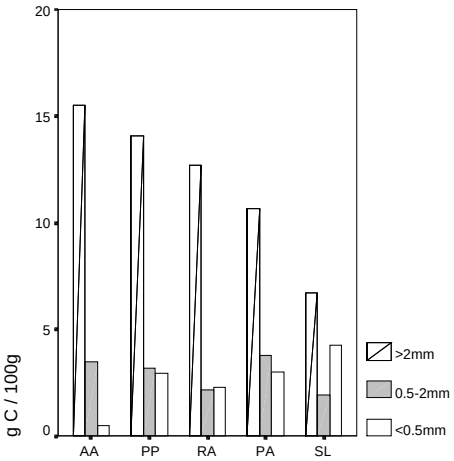



Figure 4. Particle- size distribution

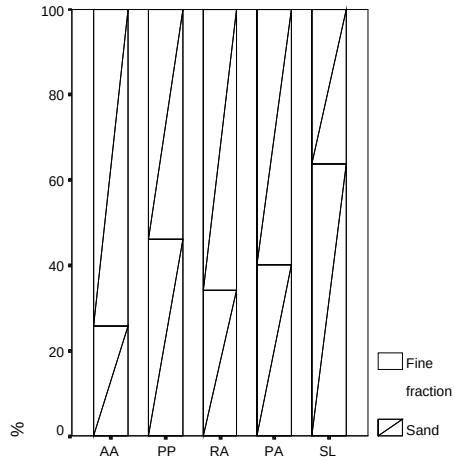



Figure 5. Carbon content vs. particle-size

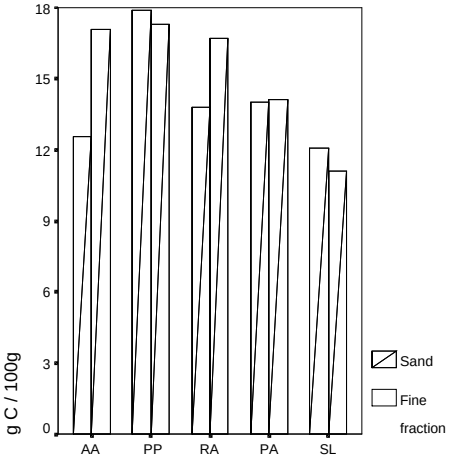
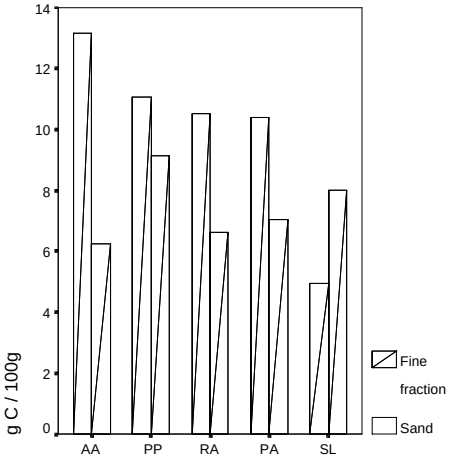



Figure 6. SOC stocks vs. particle-size



## Conclusions

The decrease of the total carbon stock, as related to texture and structure degradation processes, has been observed to take place according to a sequence of anthropic disturbance from forest ecosystems with a different degree of soil and vegetation degradation (*Aceviños, Palos Pelados* and *Ravelo*) to ecosystems which support a scrub plant cover and with highly degraded and eroded soils (*Pajaritos* and *Siete Lomas*). A possible explanation for the observed phenomena lies on the direct water-drop impact on soil aggregates and the picking-off of small particles, mainly made up of fine elements. The separation of these particles favours its removal by water runoff, as seen by the progressive skeletization that affects the soils under study, and also the biological degradation of their carbon content, as seen by the decrease of the carbon percentage in the fine (silt + clay) texture fraction. Moreover, and given the known hydrophobicity of the surficial organic horizons of Andisols, it is necessary to remark the importance of the maintainance of a permanent plant coverage over the soil surface as the most effective conservation practice to prevent soil drying and erosion.

## References

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