THE EFFECT OF VEGETATION REMOVAL ON SOIL ORGANIC CARBON LOSSES: A 9 YEARS EXPERIMENT IN SEMIARID SE SPAIN

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INTRODUCTION

The vulnerability of Mediterranean arid and semiarid lands to human-induced changes in soil use means that the effects of climate change upon these environments will be exacerbated (Scharpenseel & Pfeiffer, 1998). Reduced precipitation or increased temperature accelerates land degradation through the loss of plant cover, biomass turnover, nutrient cycling and soil organic carbon storage, accompanied by higher greenhouse emissions (Ojima et al., 1995). Moreover, if the projected increase in temperature following global climate change occurs, the degradative processes will be aggravated (Kimble et al., 1998).

Long term data series from natural rainfall events in semiarid environments are crucial for studying nutrient dynamics because: i) the soil's response within a few months of vegetation removal may not be sufficient for estimating its long-term behavior; and ii) it is difficult to produce data comparable to natural storms using rainfall simulators (Flanagan & Foster, 1989).

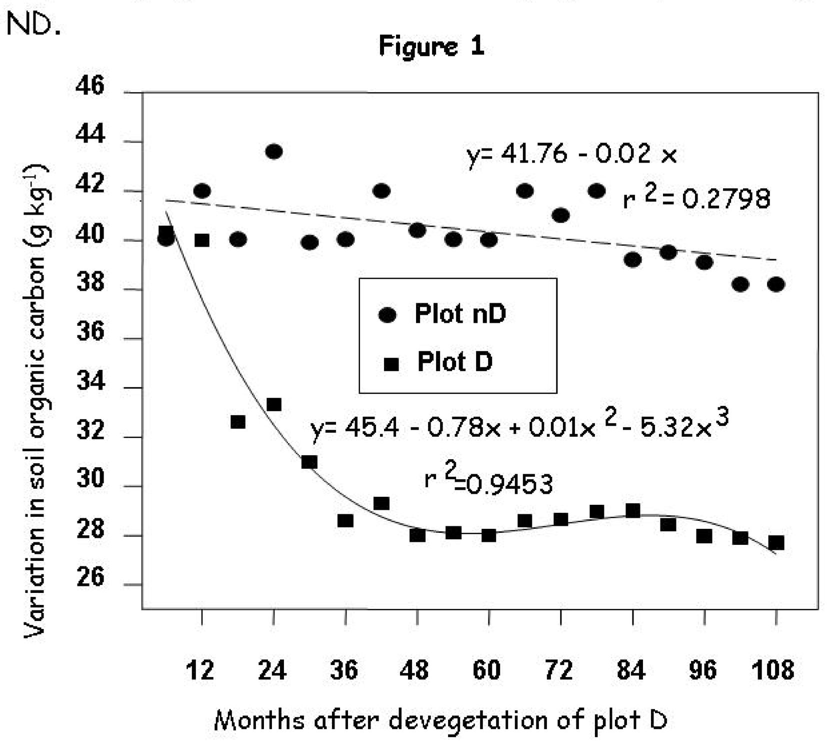
The poster reports data obtained over a nine-year period (1988-1998) concerning changes in soil and sediment organic carbon and nitrogen contents in a non-disturbed vegetated area and an area from which vegetation had been removed and therefore exposed to human induced erosion processes.

RESULTS

1.- Soil organic carbon

The mean soil organic carbon content was 1.33 times higher ($p<0.001$) in plot ND, 40.4±0.5 g kg^{-1}, than in plot D, 30.3±1.3 g kg^{-1}, (the values are the average of 18 samples taken in nine years, twice a year). Two tendencies were observed for organic carbon losses recorded in plot D (Figure 1). In the first 4 years (up to month 48) of the experiment the soil organic carbon content decreased by 12.3 g kg^{-1} (from 40.3 to 28.0 g kg^{-1}, representing a total quantity of 342.4 kg). In the following 5 years (months 48 to 108) the concentration of soil organic carbon decreased by 0.3 g kg^{-1} (from 28.0 to 27.7 g kg^{-1}, representing a total of 8.3 kg). No such pattern was observed in plot ND.

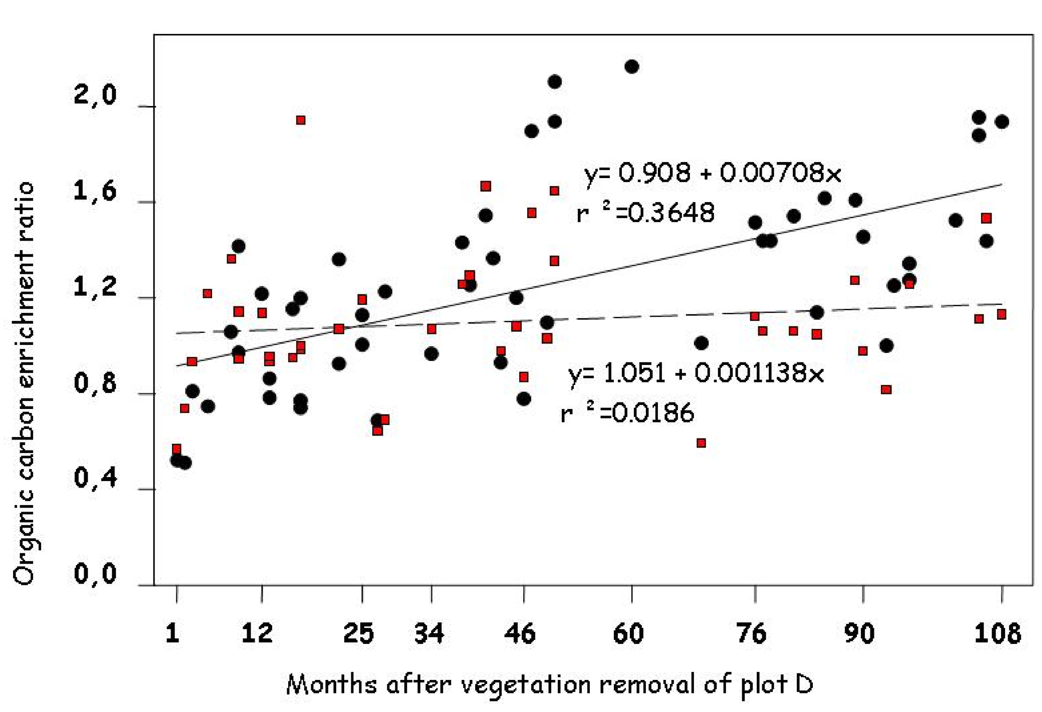
Figure 1



2.- Sediment organic carbon

The total organic carbon content in the sediments of plot D was significantly higher ($p<0.001$) than those in the sediments of plot ND. Two periods were identified in the evolution of the organic carbon in the sediments of plot D: in the first 6 years (up to month 72), a total of 532.7 g of organic carbon was found in the sediment and during the following 3 years (months 72 to 108) this quantity reached 1284.4 g (Figure 2).

Figure 4

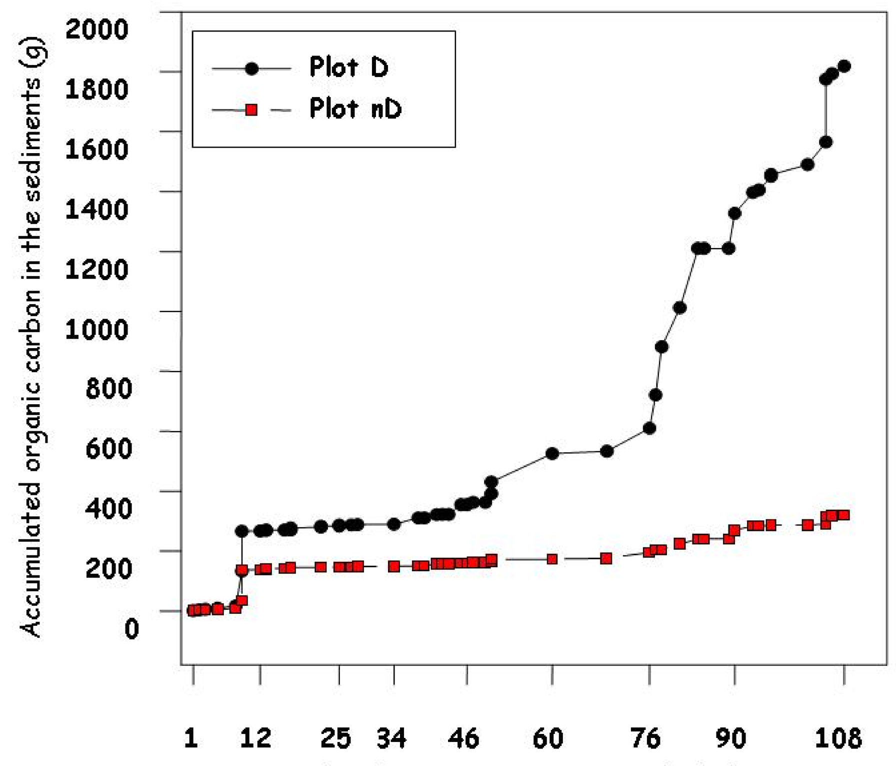


3.- Organic carbon enrichment ratio

The organic carbon enrichment ratio (EROC) significantly increased ($r=0.60$, $p<0.001$ for EROC) with time as a consequence of vegetation removal in plot D. In contrast, in plot ND there was no significant change with time in enrichment ratio during the nine years period which the study lasted.

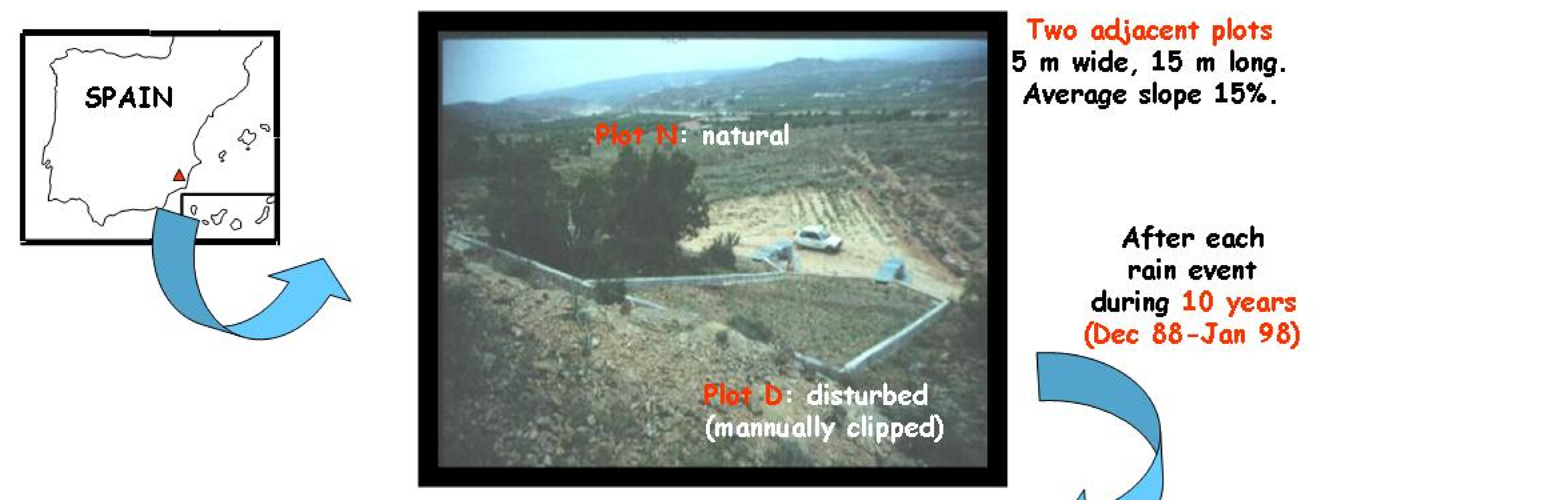
In plot D there was a positive correlation between EROC (Spearman's rank correlation coefficient $rs=0.4750$; $p\leq0.001$) and the kilograms of sediment lost, reflecting the progressive increase in nutrient enrichment of the sediments with increasing erosion rates. In plot ND no significant correlation was observed between soil loss and EROC ($p>0.1$).

Figure 2



STUDY SITE AND METHODS

Two runoff plots (5 m wide, 15 m long) situated in the Experimental Field Station of Centro de Edafología y Biología Aplicada del Segura (CEBAS) in South-Eastern Spain (province of Murcia) were used to carry on the study. The soil is a Lithic Xeric Haploxeroll (Soil Survey Staff, 1998).



1. Collection of sediment samples
2. Determination of organic carbon (oxidation with dichromate)

Additionally:

- Soil samples were also taken from the two plots twice a year and their organic carbon content ascertained.
- Sand (>50μm) and silt+clay (<50μm) fractions were isolated in the soil samples taken from both plots at the end of the experiment and organic carbon were determined in each fraction.

DISCUSSION AND CONCLUSIONS

Nine years after vegetation removal the soil organic carbon content of plot D had fallen by 30.7 % (equivalent to 4.51 Mg ha^{-1} y^{-1}). Since losses from erosion represented only 0.0232 Mg ha^{-1} y^{-1} in the overall study period, we assume than the main cause of carbon losses was mineralization (about 4.49 Mg ha^{-1} y^{-1}). This assumption was supported by two facts: i) the mean higher maximum soil temperature reached in the soil of plot D (29.5ºC) compared to plot ND (25ºC) in the hottest months (Albaladejo et al., 1998), ii) the very low percentage of water soluble carbon, less than 1%, in soil of plot D (García et al., 1997).

Although it seems evident than the main cause of soil carbon loss in plot D was mineralization, it was also seen than soil carbon losses due to erosion increased with time. Thus, in the first 6 years (up to month 72) following vegetation removal, the organic carbon found in the sediment represented 0.16 % (532.7 g) of the total organic carbon lost from the soil, while in the last 3 years (from months 72 to 108) it reached 5.99 % (1284.4 g) of the total organic carbon lost. The large decrease in soil organic carbon observed up to 4th year (48 month) was in agreement with the smaller contribution of erosion to these losses in the overall study period. Similar results have been found in the literature. For example, Gregorich et al. (1998) indicated that mineralization was the predominant process in the decrease in organic carbon in the first years after devegetation of a cultivated Black Chernosem in Saskatchewan, while erosion was the main process in later years.

The lower values observed for the soil organic carbon content linked to the sand fraction in plot D (17.1 grams of organic carbon per kilogram of sand) than in plot ND (25.9 grams of organic carbon per kilogram of sand) suggested that vegetation removal mainly affected losses of the organic carbon linked to coarse particles. According to several authors (Quiroga et al., 1996) the organic carbon fraction linked to coarse particles is less protected against oxidation, while the organic compounds linked to the clay and silt fractions are better protected. As the mineralization process was more rapid during the first four years, intense oxidation of the organic carbon from the fresh remains would have occurred in plot D, after which time the carbon losses would have stabilized.

Vegetation removal led to an increase in the sediment enrichment ratio of organic carbon with time. This was supported by the significant correlation found between the quantity of sediment lost and EROC in plot D.

REFERENCES

ALBALADEJO, J.; MARTÍNEZ-MENA, M.; ROLDÁN, A.; CASTILLO, V. 1998. Soil degradation and desertification induced by vegetation removal in a semiarid environment. Soil Use Manage. 14:1-5

CASTILLO, V.; MARTÍNEZ-MENA, M.; ALBALADEJO, J. 1997. Runoff and soil loss response to vegetation removal in a semiarid environment. Soil Sci. Soc. Am. J. 61: 1116-1121

FLANAGAN, D.C.; FOSTER, G.R. 1989. Storm pattern effect on nitrogen and phosphorous losses in surface runoff. Transactions of the ASAE 32: 535-544.

GARCÍA, C.; HERNÁNDEZ, T.; ROLDÁN, A.; ALBALADEJO, J. 1997. Biological and biochemical quality of semiarid soil after induced devegetation. J. Environ. Qual. 26: 1116-1122

GREGORICH, E.G.; GREER, K.J.; ANDERSON, D.W.; LIANG, B.C. 1998. Carbon distribution and losses: erosion and depositional effects. Soil Till. Res. 47: 291-302

KIMBLE, J.M.; LAL, R.; GROSSMAN, R.B. 1998. Alteration of soil properties caused by climate change. p. 175-184. In: Blume, H.P. et al. (Eds) Towards a sustainable land use. Vol.1. Advances in Geoecology 31. Catena-Verlag. Germany

OJIMA, D.S.; STAFFOR-SMITH, M.; BEARDSLEY, M. 1995. Factors affecting carbon storage in semiarid and arid ecosystems. p. 60-68. In: VR Squires et al. (Eds) Combating global warning by combating land degradation. UNEP, Nairobi. Kenya.

QUIROGA, A.R.; BUSCHAIAZZO, D.E.; PEINEMANN, N. 1996. Soil organic matter particle size fractions in soils of the semiarid Argentinian Pampas. Soil Sci. 161: 104-107

SCHARPENSEEL, H.W.; PFEIFFER, E.M. 1998. Impacts of possible climate change upon soils; some regional consequences. p. 193-208. In: Blume, H.P. et al. (Eds.) Towards a sustainable land use. Vol. 1. Advances in Geoecology 31. Catena-Verlag. Germany