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Gully erosion control and carbon sequestration through filter dams in three different land uses

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Abstract: The object of this study was to compare and quantify carbon sequestration and erosion control in two type soil and three land uses. Direct measurements of sediment retained in dams with mesh and branches have been taken. In conclusion it may indicate that these dams are an efficient filter control on gully erosion, which is higher in cropland. The capture of organic carbon was higher in natural vegetation due to higher content of organic matter in soil.

Keywords: carbon sequestration, filter dams, gullies, land uses,Tamulipas, Mexico

Introduction

Carbon is a key ingredient of soil organic matter (57% by weight). Well-decomposed organic matter forms humus, a dark brown, porous, spongy material that provides a carbon and energy source for soil microbes and plants. When soils are tilled, organic matter previously protected from microbial action is decomposed rapidly because of changes in water, air, and temperature conditions, and the breakdown of soil aggregates accelerates erosion. Soil erosion is a dominant mechanism for transporting terrestrial carbon (C). However, the relationship between C transport and soil erosion is complex and non-linear, which impends a direct extrapolation of erosion studies to understanding C movement. As more erosion occurs and total suspended solid concentration increases, the %C of this material often decreases (Ludwig et al. 1996).

Concurrent with increased erosion force, large aggregates are broken apart thereby reducing the physical protection from decomposition associated with soil structure (Baldock & Skjemstad 2000; Telles et al. 2003). Coupled with the process of erosion a sizeable proportion of the transported organic carbon may be mineralized during transport (Jacinthe & Lal 2001; Jacinthe et al. 2002; Jacinthe et al. 2004). Furthermore, the magnitude of erosion can vary substantially with the scale of analysis. The material was transported to the river with terrestrial carbon was depleted in comparison with the materials stored locally, resulting in a difference in quality to the scale (Chaplot et al. 2005).

Thus erosion can serve to enrich recipient systems of labile C, deplete source systems of labile C, and directly lead to CO_2 flux to the atmosphere (Lal 2003). However, predicting the magnitude of these changes is dependent upon rates of erosion, antecedent condition, and soil characteristics.

Accelerated erosion, by water or wind, is a selective process and involves preferential removal of the light (e.g., low density) and fine (e.g., small size including clay and silt) fractions (Bajracharya et al. 2000). Being concentrated in the surface soil and of low density, soil organic matter is preferentially removed by surface runoff and blowing wind. Thus, the enrichment ratio of eroded sediments is greater than 1 and often as much as 5 (Lal 1998). The displaced material is either redistributed over the landscape or deposited in depression sites. The high soil organic carbon (SOC) content of depression sites is attributed to the deposition of SOC-enriched sediments. The aim of this study was to compare and quantify carbon sequestration and erosion control in areas with two soil classes managed with three different land uses.

Methodology

This study was conducted in the Northwest part of the state Tamaulipas, Mexico between latitudes 25°35'N and 98°45'N and 98°24'W and 98°40'W. Farm covers an area of 53,291 ha. This region has a substantially wavy underscored with a slight slope (about 4%) from West to East and is regarded as a production area of sediment being influenced by the continuing excesses of the surface currents (Carrillo-Rendón 2002). The climate is Warm Semiseco with an irregular and low rainfall of 540 mm and annual temperature of 24.3°C and extreme thermal fluctuations, widespread drought conditions and temperatures in the area.

According to the FAO classification (1988), dominant soil types in the area are Calcisols, Kastanozems, Vertisols, and Leptosols the main vegetation

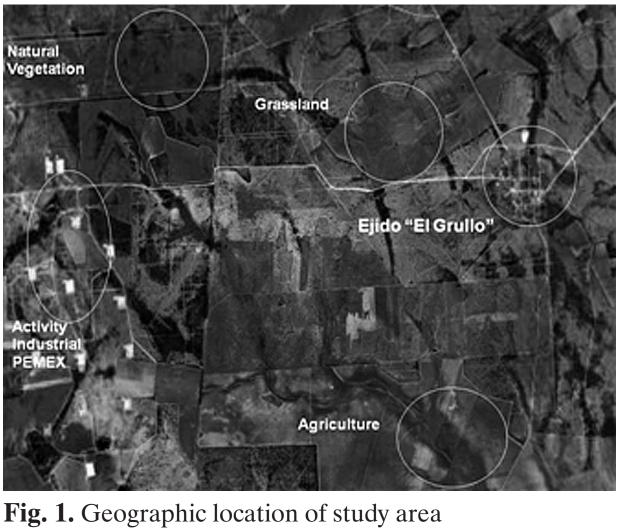

Fig. 1. Geographic location of study area

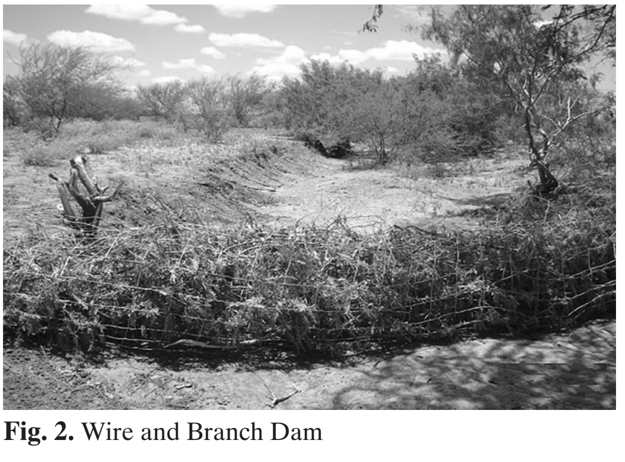

Fig. 2. Wire and Branch Dam

Fig. 3. Soil retained in dam

types are mesquite (microphyll deciduous forests vegetation) and Tamaulipas thorn scrub (INEG,I 2001).

To evaluate the efficiency in capturing sediment dams established a series of wire mesh filter and branches of vegetation in the months of May and June, before the erosive events (Fig. 1). It established five dams for each soil use (agricultural, grassland and thorn scrub) and distributed in two soil types (calcisol and kastanozem).

The research was conducted between June to October 2009. Soil samples were taken out of the sediment retained in dams with mesh and branches (Fig. 2). Soil samples were taken and physico-chemical properties were performed to quantify the amount of organic carbon. The variables evaluated were: quantity of sediment (m^3), organic matter (%), carbonates (%) and sediment (%).

The database was analyzed using the statistic software (SAS 1998). We used the experimental design of randomized complete block with split plot arrangement with five replications; main plots were represented by soil type and the small plots by the land use. The data were analyzed using analysis of variance, with the subsequent application of the Tukey test at 5% significance for comparison of means.

Results

Table 1 shows the averages for erosion, organic carbon, carbonate and percentage of retained particle size (sand, silt and clay), and the relative percent of total deposits. The highest percentage of particles size was corresponding to sands with 55.82% followed by 32.91% clay and silt, with 11.27%. It was fount that, the largest erosion has been observed in *Kastanozem* soil type (74% more than in the *Calcisols*). The significant difference ($p < 0.05$) between to soils uses, and the retained amount of soil was higher (400%) in agricultural use.

Table 1. Some characteristics of sediment under different land use on Kastanozem (K) and Calcisol (C)

Land Use	Agriculture		Grassland		Thorn scrub	
Type soil	K	C	K	C	K	C
Erosion (m^3)	9.26	4.64	1.28	1.10	1.56	1.40
% Relative	48.13	24.12	6.65	5.72	8.11	7.28
CO (%)	0.87	0.79	0.64	0.55	1.15	1.67
CO_3^{-2} (%)	24.36	33.82	21.24	26.56	23.62	27.78
Clay (%)	37.56	34.50	32.72	29.70	25.20	37.80
Silt (%)	9.56	16.70	8.98	8.70	7.84	15.82
Sand (%)	52.88	48.82	58.30	61.60	66.96	46.38

CO – Organic carbon, CO_3^{-2} – Carbonates

Table 2. Mean values and statistically significant differences of erosion (E), carbonates (CO_3^{-2}), organic matter (OM), and sand (S) content

Land Use	E (m^3)	CO_3^{-2} (%)	MO (%)	Sand (%)
Agriculture	6.95a	29.1a	1.43b	50.85a
Thorn scrub	1.48b	25.7b	2.43a	56.67a
Land grass	1.19b	23.9b	1.10b	59.95a

Sequestration carbon showed no significant differences between soil classes, but changed significantly ($p < 0.05$) between uses, being highest (70%) for the natural vegetation, compared to cropland and grassland (Table 2).

Regarding the size of particles retained, no significant differences were found between type and soil use. However, the greatest proportion of textural classes was in the sand range (56% of total). The carbonates were significant between type and soil use ($p < 0.05$), where agricultural use was higher (17%) than to grassland and to the natural vegetation. The Calcisol soil showed a higher value (29.5%) *vs* Kastanozem.

Final result shows that dams are an efficient filter for control gully erosion, which is highest in cropland. The organic carbon capture was higher in natural vegetation cover, owing to higher organic content in the soil.

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