MINISTERIO
DE ECONOMIA
Y COMPETITIVIDAD

CSIC
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS
IAS
INSTITUTO DE AGRICULTURA SOSTENIBLE

Final report on collaboration agreement between ICARDA and CSIC on scientific and technological support in the use of sediment tracers for project "Reducing Land Degradation and Farmer´s Vulnerability to Climate Change in the Highland Dry Areas of North-Western Ethiopia"

Authors: Gema Guzmán, José A. Gómez

Date: September 27th 2016

CAMPUS ALAMEDA DEL OBISPO
AVDA. MENENDEZ PIDAL, S/N
14004 CORDOBA
TEL.: 957 499200
FAX.: 957 499252

Background

The understanding of water erosion processes is essential when predicting the effects of soil conservation structures aimed to disrupt connectivity in runoff and sediment transport across the landscape. Experiments (field and laboratory) measuring the overall effect of these structures and model analysis are usually the techniques used to evaluate their effectiveness. However, the use of sediment tracers is an attractive tool to complement those technologies providing insight into the processes acting within the measured area (Guzmán et al. 2013a).

During the last years an erosion tracer methodology based on the application of iron oxides as magnetite, hematite and goethite to tag the top soil profile has been evaluated and validated in several laboratory and field experiments (Guzmán et al., 2010, 2013b, 2015). They have been employed, afterwards, to monitor preferential flows, identify sources of sediments, quantify medium term erosion rates and to map soil redistribution within agricultural fields due to erosion and deposition.

Objectives and tasks

The use of these tracers within the scope of this collaborative agreement had the overall objective of assessing the efficiency of stone bunds and soil spatial distribution due to water erosion processes using iron oxides as sediment tracers. To aim that objective the following tasks were carried out:

1- Tagging different zones at the hillslope scale and in cascade plots to evaluate soil redistribution after erosive events.

2- - Analysis and interpretation of tracers concentration in soil and sediment samples within and from the monitored plots.

CAMPUS ALAMEDA DEL OBISPO
AVDA. MENENDEZ PIDAL, S/N
14004 CORDOBA
TEL.: 957 499200
FAX.: 957 499252

Methodology

In order to assess the preferential flow and spatial distribution of soil, two tracer experiments were set up in the Gumara-Maksegnit watershed in June 2015 with the participation of Dr. Guzmán.

To prepare the tagged soil, 182 kg of blank soil were air dried and mixed with different iron oxides (magnetite, hematite and goethite) by serial dilutions, slightly sprayed with water and air dried. To reach the determined concentrations of tagged soil, 104, 39 and 39 kg of the soil were mixed with 2.6 kg of magnetite, 1 kg of hematite and 1 Kg of goethite, respectively. These mixtures were applied in two different water erosion experiments:

1- An unbounded hillslope trial, with a magnetite strip placed at the top and a stone bund at the bottom of the hillslope.

2- A cascade plots trial consisting in three runoff plots separated each one from the other by a stone bund, and a strip of magnetite, hematite and goethite, placed at the top of the first, second and third plot, respectively.

At the end of August 2015 and for both trials, soil samples of 0-2 cm depth were taken in a 1.5 x 1.5 m grid within the area of the cascade and the hillslope, respectively. For the hillslope experiment additionally soil samples parallel to the stone bund (above and underneath) were taken (0-2 and 2-4 cm) along 16 m to assess the soil movement. Tracer concentrations of soil and sediment samples in both trials were analyzed by CSIC. More information about the trials and the methodology followed can be found in Obereder (2016), Obereder et al. (2016) and Guzmán et al. (2010, 2015), respectively.

CAMPUS ALAMEDA DEL OBISPO
AVDA. MENENDEZ PIDAL, S/N
14004 CORDOBA
TEL.: 957 499200
FAX.: 957 499252

Main results and conclusions

All the analytical results are included in the Excel file (CSIC_report tracers) attached to this file. Plotted figures and tables generated from them, were included in Obereder (2016) and Obderer et al. (2016).

Despite that the rainfall season of 2015 was considered as a dry one compared to the average of the region, measurement of magnetite concentration, using magnetic susceptibility, before and after the season allowed monitoring soil redistribution in both trials, Figures 1 (Hillslope) and 2 (Cascade plots).

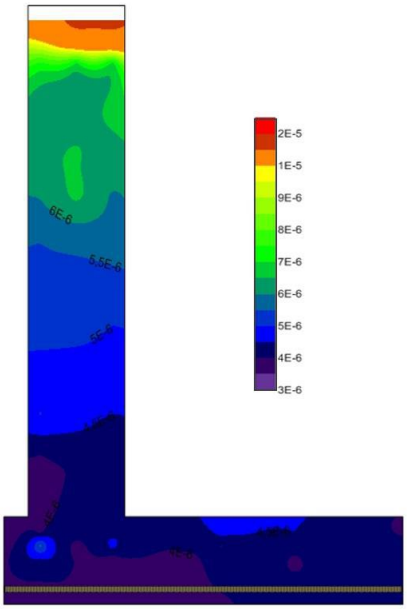

Fig. 1. Redistribution of the top 2 cm tagged soil with magnetite (measured as magnetic susceptibility) at the end of the Hillslope trial.

These measurements indicates a decrease in concentration as the distance from the tagged strip increased suggesting a significant deposition across the plot of sediment detached in the top areas. Nevertheless, slightly higher concentrations of magnetic tracer were found in some of the locations analyzed just above and below the stone bunds.

CAMPUS ALAMEDA DEL OBISPO
AVDA. MENENDEZ PIDAL, S/N
14004 CORDOBA
TEL.: 957 499200
FAX.: 957 499252

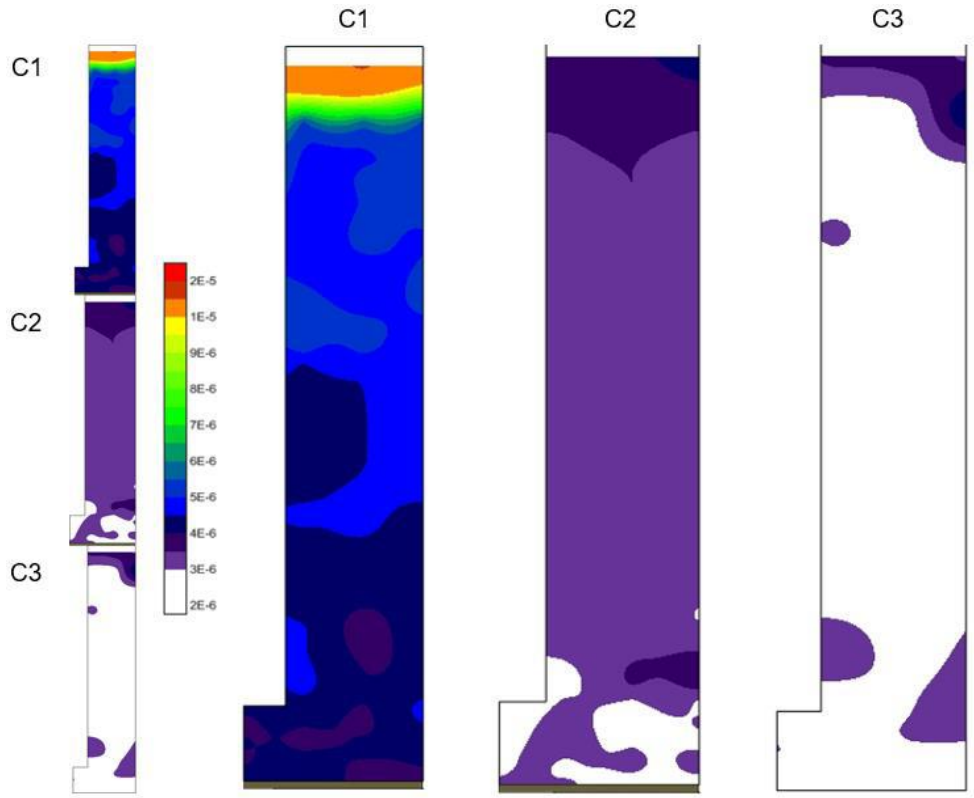

Fig. 2. Redistribution of the top 2 cm tagged soil with magnetite (measured as magnetic susceptibility) at the end of the Cascade plots trial.

Concentration of magnetic tracer in the sediment samples was very close to the background content of this soil indicating that an almost negligible amount of sediment was leaving the plot area during this experimental year.

Due to an, unexpected, very high background concentration of iron in the soil, as a result of their high content in the parent material, the accuracy of analytical determinations using the mass spectrometer, as indicated in Guzmán et al. (2015), cannot provide the precision to use hematite and goethite concentrations for quantitative determinations of sediment delivery and redistribution with the plot. In fact, the accuracy of these determinations in soils with a high background content of hematite and goethite with the precision for tracer analysis remains an open question, under research.

CAMPUS ALAMEDA DEL OBISPO
AVDA. MENENDEZ PIDAL, S/N
14004 CORDOBA
TEL.: 957 499200
FAX.: 957 499252

Therefore, further research, a better characterization of background soil conditions and more measurements from the collected samples should be necessary to be conclusively regarding the use of these iron oxides in this type of soil.

References

Guzmán, G., Laguna, A., Cañasveras, J. C., Boulal, H., Barrón, V., Gómez-Macpherson, H., Giráldez, J. V. & Gómez, J. A. (2015). Study of sediment movement in an irrigated maize–cotton system combining rainfall simulations, sediment tracers and soil erosion models. Journal of Hydrology, 524, 227-242.

Guzmán, G., Quinton, J. N., Nearing, M. A., Mabit, L., & Gómez, J. A. (2013b). Sediment tracers in water erosion studies: current approaches and challenges. Journal of Soils and Sediments, 13(4), 816-833.

Guzmán, G., Vanderlinden, K., Giráldez, J. V., & Gómez, J. A. (2013). Assessment of spatial variability in water erosion rates in an olive orchard at plot scale using a magnetic iron oxide tracer. Soil Science Society of America Journal, 77(2), 350-361.

Guzmán, G., Barrón, V., & Gómez, J. A. (2010). Evaluation of magnetic iron oxides as sediment tracers in water erosion experiments. Catena, 82(2), 126-133.

Obereder, E. M. (2016). Investigation of the impact of stone bunds on erosion and deposition processes combining conventional and tracer methodology in the Gumara-Maksegnit watershed, northern highlands of Ethiopia. Master thesis. BOKU (Vienna); 106 pp.

Obereder, E. M., Wakolbinger, S., Guzmán, G., Strohmeier, S., Demelash, N., Gómez, J. A., & Klik, A. (2016). Investigation of the Impact of Stone Bunds on Erosion and Deposition Processes combining Conventional and Tracer Methodology in the Gumara Maksegnit Watershed, Northern Highlands of Ethiopia. In EGU General Assembly Conference Abstracts (Vol. 18, p. 2455.

CAMPUS ALAMEDA DEL OBISPO
AVDA. MENENDEZ PIDAL, S/N
14004 CORDOBA
TEL.: 957 499200
FAX.: 957 499252

Appendix: Cost analysis

Concept	Number of samples	Unitary cost (€)	Total (€)
Magnetite analysis	**370**	**3,70**	**1369,00**
- *HS*	*108*		
- *C1*	*71*		
- *C2*	*68*		
- *C3*	*68*		
- *blank soil, mixtures and sediments*	*55*		
Hematite and goethite analysis	**51**	**18,20**	**928,20**
blank soil and sediments from C2 and C3	*30*		
initial mixtures	*6*		
calibration curve	*15*		
Total cost (€)			**2297,20**

CAMPUS ALAMEDA DEL OBISPO
AVDA. MENENDEZ PIDAL, S/N
14004 CORDOBA
TEL.: 957 499200
FAX.: 957 499252