Print

Proceedings

Study and quantification of the loss of fertility by water erosion

Bienes, R.[1 y 2].; Marqués, M.J.[1]; Jiménez, L..[1] y Pérez, R. [1]
[1]*Instituto Madrileño de Investigación y Desarrollo Rural, Agrario y Alimentario* (I.M.I.D.R.A.)
Apdo 127. 28800-Alcalá de Henares, Madrid.
[2]*Dpto. de Geología. Universidad de Alcalá de Henares*
E-mail: ramon.bienes@madrid.org

Résumé

Dans ce travail on expose les résultats obtenus sur la perte de nutriments par erosion hidrique. Les données ont été obtenues pendant les années 1994-1997. On a employé 16 parcelles expérimentales USLE de 4m de largeur x 20m de longueur. Les traitements étudiés ont été : sol nu (avec herbicide), orge (minimum labourage), végétation spontanée et pâturage. Les essais ont été simultanément répétés dans 4 localités du centre de l'Espagne. Les sédiments et les écoulements furent rassemblés après chaque événement érosif et furent analysés postérieurement. L'objectif était de quantifier la perte de nutriments qui avait lieu dans des terres agricoles abandonnées, ainsi qu'observer l'évolution de la végétation spontanée et l'efficacité de l'implantation d'un pâturage à base de légumineuses qui ne recevraient aucun traitement postérieur

Abstract

In this work we expose the results obtained on the loss of nutrients by water erosion. The data correspond to period 1994-1997. Sixteen USLE plots of 4m of width x 20m of length were used. The studied treatments were: bare soil (with herbicida), barley (minimum tillage), pasture and spontaneous vegetation. The tests were repeated simultaneously in 4 localities of the center of Spain. The sediments and run-offs were collected after each erosive event and analyzed later. The objective was to quantify the nutrient losses in agricultural and abandoned lands, as well as to observe the evolution of the spontaneous vegetation and the effectiveness of the implantation of a pasture with leguminosas that would not receive any later treatment.

Introduction

One of the most studied aspects related to the water erosion problem in Spain, has been the consequence of the abandoned lands due to the socioeconomic transformations as well as to the Agrarian Community Politics of the EU (GARCÍA-RUIZ & LASANTA, 1994; LASANTA & GARCÍA-RUIZ, 1996). Nevertheless, they are few studies on nutrient loss due to water erosion.

In general, it has been verified a progressive plant recovery in abandoned lands with the consequent fall of runoff and water erosion. Nevertheless, in arid and semiarid areas, vegetation is not able to develope and the abandonment can lead to an increase of runoff and water erosion (GARCÍA-RUIZ *et al*., 1991; LASANTA *et al*., 1994; LÓPEZ-BERMÚDEZ & TORCAL, 1996). In this article we have analyzed how affect the different land uses on the nutrient losses in different Mediterranean environments of the center of the Iberian peninsula**.**

Materials and methods

The studied treatments were: bare soil with herbicide, barley (minimum tillage), spontaneous vegetation and pasture in closed USLE plots of 80 m^2 (4 m x 20 m). This work was carried out in 4 localities of the center of the Iberian peninsula: Encín (Madrid), Marchamalo (Guadalajara), Aranjuez (Madrid) and Albaladejito (Cuenca). In all the cases,

Print

Proceedings

the plots were in agricultural areas with very uniform slopes: 6, 12.3, 10, and 8.9 % respectively

In Albaladejito the plots are situated on a Calcic Haploxeralfs; in Aranjuez the plots are on a Xeric Haplogypsid (USDA, 2.003); In Encín the plots are placed on a Typic Calcixerepts and those of Marchamalo on a Calcic Rhodoxeralfs.

During the period 1994-1997, we have proceeded to collect samples of runoff and sediments after every erosive event. We have caried out the following analytical determinations:

a) In runoff: Nitrates, Phosphates, Chlorides, Bicarbonates, Ca, Mg, Na y K.
b) In sediments: oxidable organic matter (Walkey-Black), P_2O_5 (Olsen), exchange cations: Ca, Mg, Na y K (NH_4Ac 1N).

Results and discussion

The information relative to the mean annual nutrient losses held in the runoff is exposed in the table 1 and in the table 2 the nutrient losses held in sediments, for all localities took into account. In all the studied areas, the barley has presents a drastic reduction of runoff, similar to those observed one by MARTÍNEZ-RAYA et al (2005).

Table 1: Average annual nutrient losses in runoff in the different studied areas. Different letters indicate significant differences between treatments for p < 0,05 (test de Kolmogorov-Smirnov).

Treatment	Runoff (m^3/ha)	Nitrates (kg/ha)	Phosphates (kg/ha)	Cl^- (kg/ha)	HCO_3^- (kg/ha)	Ca (kg/ha)	Mg (kg/ha)	Na (kg/ha)	K (kg/ha)
Albaladejito (Cuenca)									
Bare soil	187,8 a	6,97 a	1,31	0,66 a	1,75 ac	2,21 a	0,77 a	3,96 a	1,43 a
Burley	16,1 b	0,45 b	0,33	0,09 a	0,20 a	0,33 b	0,06 b	0,24 a	0,94 a
Spontaneous vegetation	23,7 c	0,001 b	0,0003	0,0001 b	0,0003 b	0,0004 c	0,0001 c	0,0005 b	0,0003 b
Pasture	34,9 ac	0,62 a	0,37	0,59 c	1,14 c	0,77 d	0,19 ad	0,28 a	0,53 a
Aranjuez (Madrid)									
Bare soil	382,7 a	8,19 a	1,86 a	2,98 a	9,47 a	20,88 a	2,15 a	9,23 a	3,14 a
Burley	51,1 ab	0,94 b	0,28 a	0,56 a	1,12 a	1,99 b	0,27 b	0,61 b	0,80 ab
Spontaneous vegetation	46,9 b	1,03 b	0,54 a	0,81 a	5,13 a	1,82 b	0,57 b	0,63 b	1,11 b
Pasture	118,5 b	0,02 c	0,02 b	0,01 b	0,15 b	0,03 c	0,02 c	0,02 c	0,06 c
Marchamalo (Guadalajara)									
Bare soil	407,6 a	8,41 a	2,31 a	1,74 a	7,16	10,79	1,52	3,40 a	2,63 a
Burley	26,4 b	0,79 b	0,20 b	0,36 b	1,24	0,46	0,08	0,19 b	0,15 b
Spontaneous vegetation	34,9 b	1,06 b	0,30 bc	0,72 b	2,06	0,90	0,14	0,37 b	0,20 b
Pasture	34,6 b	1,06 b	0,30 c	0,79 b	2,05	0,90	0,14	0,14 b	0,20 b
Encín (Alcalá de Henares)									
Bare soil	362,2 a	5,216	1,67 a	2,39 a	9,42 a	11,53 a	1,35 a	3,55 a	4,32 a
Burley	29,0 b	0,334	0,06 b	0,08 b	0,30 b	0,39 ab	0,06 b	0,20 b	0,20 b
Spontaneous vegetation	34,5 c	0,457	0,17 c	0,17 b	0,49 b	0,51 ab	0,09 b	0,28 b	0,11 b
Pasture	51,5 bc	0,390	0,13 bc	0,14 b	0,66 b	0,70 b	0,09 b	0,22 b	0,41 b

Also we have observed that the bigger losses for any of the nutrients in the runoff, they take place in bare soil. The rest of treatments (barley, spontaneous vegetation and pasture), do not present significant differences for the majority of the nutrients studied in runoff water (table 1). In consequence, the minimum tillage of the cereal (barley) presents a very similar behavior to that of the pasture and spontaneous vegetation

Like other authors (PAPINI et al., 2001), we have observed that the cereals were associated with the highest loss of nitrate in each year, and showed very high nitrate concentration in runoff water during the autumn, although differences between cereal and herbaceous vegetation or pasture were not significant.

The development of the herbaceous spontaneous vegetation is closely related with rainfall; so that, in the most arid zone studied (Aranjuez), the spontaneous vegetation presented a scarce development , and the plant cover was not effective even after several years. In Albaladejito, the most humid zone studied, the response was the opposite: a rapid spontaneous vegetation development took place and the loss of nutrients was slight and smaller than those

Print
Proceedings

recorded for barley and pasture; this could be due to the hydrophobicity of leaves which does not allow the water to arrive to the soil. The plots from Encín and Marchamalo presented an intermediate rainfall compared with the other two, and the differences between natural vegetation, pastizal and barley were practically zero**.** The decrease of runoff was due to the accumulation of plant debris (BOEKEN et al. (2001).

When we analyzed the average annual nutrient losses and organic matter for the period 1994/9**7** (Table 2), we observed that the barley presented the same losses that the spontaneous vegetation and pasture. The annual losses of C organic observed were very superior to those recorded by Malinda et al (1996) applying simulated rainfall of high intensity. With the exception of the soil loss yield in bare soil (table 2), we did not observed significant differences between losses from barley, spontaneous vegetation and pastizal for organic matter and nutrient losses. The only treatment that presented significant differences was the bare soil respect to the others.

Table 2: Mean annual losses of organic matter and nutrients in sediments. Different letters indicate significant differences between treatments for p < 0,05 (test de Kolmogorov-Smirnov).

Treatment	Sediment	OM	P_2O_5	Ca	Mg	Na	K
Albaladejito (Cuenca)							
Bare soil	1988,9 a	99,3 a	146 a	5277 a	443 a	446 a	952 a
Burley	31,6 b	0,9 b	5 b	72 b	9 b	12 b	14 b
Spontaneous vegetation	19,0 b	1,6 b	3 b	47 ab	3 a	5 a	4 b
Pasture	25,5 b	1,3 b	3 b	47 ab	4 a	9 a	19 ab
Aranjuez (Madrid)							
Bare soil	10375,3 a	442,1 a	933 a	42590 a	2404 a	3262 a	4544 a
Burley	931,0 b	55,0 b	87 b	2098 b	86 b	81 b	164 b
Bare soil	583,2 c	26,5 b	39 b	1699 b	105 b	168 b	256 b
Burley	2495,4 bc	126,9 ab	101 b	11973 b	623 ab	763 a	1475 a
Marchamalo (Guadalajara)							
Bare soil	27957,9 a	386,2 a	1300 a	172660 a	9118 a	10867 a	15099 a
Burley	80,7 b	2,0 b	10 b	244 b	21 b	31 b	57 b
Spontaneous vegetation	48,4 bc	1,2 b	2 b	222 b	16 b	36 b	23 b
Pasture	44,1 c	1,3 b	3 b	153 b	15 b	24 b	29 b
Encín (Alcalá de Henares)							
Bare soil	7395,8 a	125,7 a	248 a	22820 a	1240 a	1563 a	2110 a
Burley	110,7 b	2,4 b	7 b	295 b	23 b	26 b	66 b
Spontaneous vegetation	50,9 c	1,4 b	2 c	33 b	3 b	3 b	7 b
Pasture	799,1 bc	18,7 b	3 bc	110 b	11 b	12 b	23 b

In Table 3, we can see that in all the studied areas, the mean content in oxidable organic matter in sediments was more than the double of those from the inicial content in the soil, and in some cases is up to 6 times. The plot of bare soil presented the smallest increase (50 %). Similar results similar were obtained by Shinjo (2000) for cultivated areas.

Table 3: Mean contents of organic matter and nutrientes in the sediments compared with the initial content in soil

Treatment	OM	P_2O_5	Ca	Mg	Na	K
Albaladejito (Cuenca)						
Bare soil	4,21	64	2318	195	191	404
Burley	2,06	79	1806	215	310	360
Spontaneous vegetation	6,58	110	3138	193	356	257
Pasture	4,22	106	2181	196	409	897
Initial content of the soil	0,63	92	1771	96	135	144
Aranjuez (Madrid)						
Bare soil	4,36	95	3465	198	276	369
Burley	5,12	66	4635	193	194	373
Spontaneous vegetation	4,54	66	2695	168	268	411
Pasture	5,15	41	3798	202	247	468
Initial content of the soil	2,2	37	1237	206	46	387
Marchamalo (Guadalajara)						
Bare soil	1,39	56	5101	270	321	447

Burley	3,56	78	3102	252	340	745
Spontaneous vegetation	2,52	47	3538	253	583	364
Pasture	2,28	57	2756	266	426	527
Initial content of the soil	1,12	--	--	--	--	--
Encín (Alcalá de Henares, Madrid)			8838	557	--	27
Bare soil	1,61	39	3474	196	260	329
Burley	2,27	49	2269	189	211	554
Spontaneous vegetation	2,85	119	2521	241	201	564
Pasture	2,23	86	3393	347	378	716
Initial content of the soil	1,11	8	4582	137	123	278

The mean concentrations of P_2O_5, Ca, Mg, Na and K in sediments were normally higher than those of the initial soil. The monovalent cations (Na and K) were lost in major quantity, whatever was the treatment.

In the next table (table 4) is exposed the mean content of organic matter and nutrients in sediments by treatments, with independence of the study area. The enrichment of sediments in nutrientes in relation to the soil content is a consequence of the selective deposition of particles during the transport (Hashim et al, 1998). The concept "enrichment ratio" is vital in order to predict nutrient loss from soil loss data. Nevertheless, the enrichment ratio is not a constant, it varies with soil type, erosion event and scale of measurement (plot size). This enrichment ratio is close to 1 for big plots (HASHIM et al, 1998). This explains that sediments from bare soil presented less organic matter than the rest of the treatments, whatever was the area studied **.**

Table 4: Average contents of organic matter and nutrients in the sediments by treatments (period 1994-1997)

Treatment	OM	n	P_2O_5	n	Ca	n	Mg	n	Na	n	K	n
Bare soil	2,89		63		3589		215		262		387	
Burley	3,25		68		2953		212		264		508	
Spont. vegetation	4,12		86		2973		214		352		399	
Pasture	3,47		72		3032		253		365		652	
Soil content	1,27		46		3000		179		78		270	

Aknowledgements: Data come from the research project SC93-022-C2 financed by the "Programa Sectorial I+D Agrario y Alimentario del INIA del Ministerio de Agricultura, Pesca y Alimentación" and by funds FEDER of the EU.

Literature cited

BOEKEN, B; ORENSTEIN, D. 2001. The effect of plant litter on ecosystem properties in a Mediterranean semi-arid shrubland. *Journal of Vegetation Science* 12: 6, 825-832.

GARCIA-RUIZ, J.M.; RUIZ-FLAÑO, P.; LASANTA, T.; MONTSERRAT, G.; MARTINEZ-RICA, J.P. and PARDINI, G. (1991) "Erosion in abandoned fields, what is the problem?". In Sala, Rubio and García-Ruiz (Eds) "Soil erosion studies in Spain". Geoforma ediciones. Logroño, pp: 97-108.

GARCÍA-RUIZ, J. M., and LASANTA, T., Eds, (1994). *Efectos geomorfológicos del abandono de tierras*. Zaragoza: Sociedad Española de Geomorfología. Instituto Pirenaico de Ecología (C.S.I.C). Institución Fernando el Católico.

HASHIM, GM; COUGHLAN, KJ; SYERS, JK; PENNING DE VRIES, FWT (ED.); AGUS, F (ED.); KERR, J. 1998. On-site nutrient depletion: an effect and a cause of soil erosion Soil erosion at multiple scales: principles and methods for assessing causes and impacts. Vol 1998, 207-221.

LASANTA, T., PÉREZ RONTOMÉ, M. C., and GARCÍA RUIZ, J. M., (1994). Efectos hidromorfológicos de diferentes alternativas de retirada de tierras en ambientes semiáridos de la Depresión del Ebro. In: (García-Ruiz, J. M. and Lasanta, T., Eds.), *Efectos geomorfológicos del abandono de tierras*, pp. 69-82. Zaragoza: Sociedad Española de Geomorfología. Instituto Pirenaico de Ecología (C.S.I.C). Institución Fernando el Católico.

LASANTA, T., and GARCÍA-RUÍZ, J. M., Eds, (1996). *Erosión y recuperación de tierras en áreas marginales*. Logroño: Instituto de Estudios Riojanos. Sociedad Española de Geomorfología.

LÓPEZ-BERMÚDEZ, F., and TORCAL, L., (1996). Procesos de erosión en túnel (piping) en cuencas sedimentarias de Murcia (España). Estudio preliminar mediante difracción de rayos X y microscopio electrónico de barrido. *Papeles de Geografía Física, 11: 7-20*Mesón & Montoya, 1993

MALINDA, DK; FAWCETT, RG; LITTLE, D; BLIGH, K; DARLING, W. 1996. The effect of grazing, surface cover and tillage on erosion and nutrient depletion. Advances in Geoecology. Vol 31: 1217-1224.

MARTÍNEZ RAYA ,A., DURÁN ZUAZO,V. H.,FRANCIA MARTÍNEZ,J. R. 2005. Soil erosion and runoff response to plant-cover strips on semiarid slopes (SE Spain). Land Degradation & Development Early View (Articles online in advance of print). Published Online: 18 Apr 2005.

Print

Proceedings

PAPINI, R; BAZZOFFI, P; PELLEGRINI, S; PAGLIAI, M (ED.); JONES, R. 2001. Effect of land use systems on erosion and nutrient loss in the Mediterranean. Advances-in-Geoecology. vol No.35, 459-470.

SHINJO, H; FUJITA, H; GINTZBUGER, G; KOSAKI, T. 2000. Impact of grazing and tillage on water erosion in Northeastern Syria. *Soil Science and Plant Nutrition*. vol 46: 1, 151-162.

USDA (2003) "Soil Taxonomy". Agriculture Handbook nº 436. Washington.