Use of Beryllium-7 to assess soil redistribution by erosion in two contrasting Mediterranean environments

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Abstract In the Mediterranean region there is growing concern for the potential increase in erosion risk associated with climate change and increasing storm frequency. The central Ebro basin is the region facing the greatest problems of desertification in northern Spain and there is a need to assemble information on short-term erosion rates associated with individual storm events. The ^{7}Be technique offers considerable potential to document short-term erosion rates, but to date there has been little attempt to use it in Spain. This contribution reports the results of a study aimed at using the ^{7}Be technique to document short-term erosion rates associated with storm events in two study areas within the central Ebro basin and to investigate the influence of land use and slope gradient on the rates and patterns of soil redistribution. These study areas were located in the central gypsiferous plain and the mountainous area bordering the basin. In the mountain location, the ^{7}Be areal activity density in the stony soils sampled along a 24% slope transect showed large variations (between 16.4 and 262.1 Bq m^{-2}). Erosion dominated at most sampling points and estimated soil losses ranged between 5.5 and 40 Mg ha^{-1}. On the gentler slopes of the central plain, ^{7}Be inventories ranged between 20 and 170.3 Bq m^{-2} and there was greater evidence of deposition as well as erosion. The highest soil redistribution rates (–42 and 33 Mg ha^{-1}) were found on cultivated soils. The ^{7}Be inventories suggest that soil surface characteristics, such as stone and litter cover, in addition to land use and slope gradient, may affect the pattern of soil redistribution. The two case-studies reported provide evidence of relatively high short-term erosion and soil redistribution rates associated with individual storm events and confirm the potential for using ^{7}Be to assemble information on erosion and soil redistribution rates in Mediterranean environments.

Key words ^{7}Be; fallout radionuclides; radiotracing; soil erosion; soil redistribution; stony soils; Mediterranean environments; central Ebro valley, Spain

INTRODUCTION

In the Mediterranean region, concern for the potential impact of climate change has highlighted the likelihood of increasing erosion risk in semiarid and temperate sub-humid areas, as a result of the increased frequency of storm events. In order to develop an improved understanding of soil erosion in these areas and the potential for increased erosion risk associated with climate change, there is a need to obtain information on erosion rates associated with individual storm events and their spatial and temporal variability. Cultivation exerts a key influence on soil erosion in these environments (Navas *et al*., 2005) and there is a need for information on the magnitude of erosion associated with individual storm events under different land-use practices. Use of traditional monitoring techniques, and more particularly erosion plots, to obtain this information faces many problems in terms of cost and the representativeness of the results. The use of environmental radionuclides to document erosion rates (e.g. Zapata, 2002; Walling, 2006) is increasingly seen as offering considerable potential. To date, most work involving the use of environmental radionuclides to document soil erosion rates, both in Spain (e.g. Quine *et al*., 1994; Navas *et al*., 1997, 2007) and elsewhere in the world has focused on the use of caesium-137 (^{137}Cs). However, this radionuclide provides information on longer-term mean erosion rates over periods of approx. 50 years. The need to assemble information relating to individual storm events and short periods of heavy rain, and for changing land-use and land-management practices, has recently directed attention to the use of short-lived environmental radionuclides, and more particularly beryllium-7 (^{7}Be) for documenting short-term erosion rates (e.g. Walling *et al*., 1999; Wilson *et al*., 2003; Yang *et al*., 2006; Schuller *et al*., 2006; Sepulveda *et al*., 2008).

^{7}Be is a cosmogenic fallout radionuclide produced by cosmic rays in the upper atmosphere and its short half-life of 53.3 days makes it well suited to documenting soil erosion occurring during individual events (e.g. Wallbrink & Murray, 1994; Walling *et al*., 1999; Matisoff *et al*., 2002). By

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providing the potential to study erosion rates over short periods, ^{7}Be also offers important opportunities to document the spatial and temporal variability of soil erosion in response to land use and land management practices (e.g. Schuller *et al*., 2006). To date there have been few attempts to exploit the potential for using ^{7}Be to document erosion rates in Spain, where the stony soils are seen as introducing possible problems with the approach and the resulting need for different approaches to soil sampling. This paper presents the preliminary results of studies aimed at testing the approach within semiarid and temperate sub-humid areas of the country.

The central Ebro basin is the area suffering the highest soil erosion in northern Spain. The most important rainfed crops in the region, namely, cereals, olive orchards and vineyards are widely cultivated on sloping land, which increases the erosion risk. Furthermore, vineyards and olive orchards are commonly clean tilled to maintain a bare soil surface, in order to increase the efficiency of water use. In addition, with cereal crops the soil surface generally remains unprotected after the harvest, when the most erosive storm events occur (López-Vicente *et al*., 2008). There is an important need to implement soil conservation measures throughout the area to ensure the sustainability of the soil resource and this has generated a need for increased information on soil erosion rates. The work described in this paper was undertaken in this region. Attention has focused on two study areas, one within the central gypsiferous plain and the other within the mountainous depression border, with the aim of quantifying erosion rates associated with periods of storm rainfall and assessing the influence of both land use and slope gradient on erosion rates. The existence of stony soils in the study areas was seen as providing a good basis for a more general assessment of the potential for using the ^{7}Be techniques under such conditions and therefore within the semiarid and temperate sub-humid regions of Spain and other Mediterranean countries more generally.

THE STUDY AREA

The central Ebro basin, which is located in NE Spain (Fig 1), is characterized by a well-defined physiographic zonation, which includes arid-semiarid steppes occupying an area of relatively low relief around the central Ebro River valley, and a transition to temperate sub-humid mountain landscapes on the northern border of the Ebro basin depression.

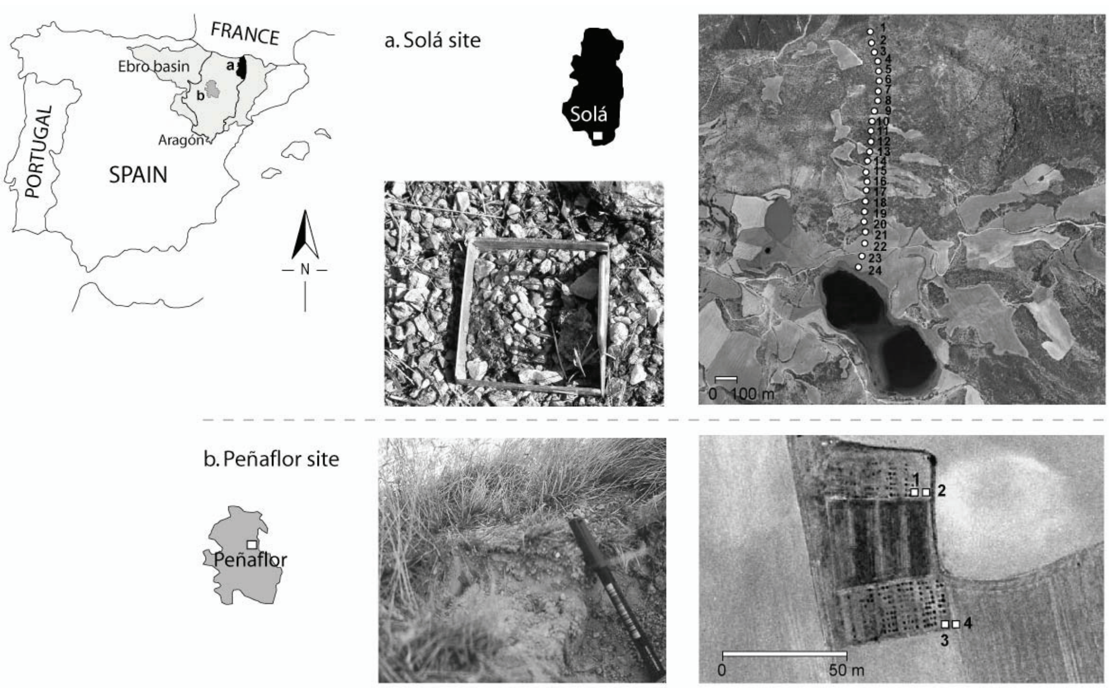

Fig. 1 The location of the study areas and the sampling sites within the central Ebro basin and the soil surface characteristics at the Solá (a) and Peñaflor (b) sites.

The Ebro basin is underlain by Tertiary strata, which range from evaporite deposits in the central steppe areas to carbonate lithologies in the mountains of the depression border. The central steppe area occupies a large area at about 300 m a.s.l. and is characterized by gentle hills developed on the gypsiferous rocks and an annual rainfall of about 250 mm. Gypsisols are the most abundant soils in this area and are widely used for cereal cultivation. The northern border of the Ebro depression is marked by a mountainous area of moderate altitude (800–1000 m a.s.l.) with an average annual rainfall of approx. 550 mm. Stony Regososls and Calcisols are the dominant soil types and the traditional land use on the sloping fields combines cereals with olive trees and vineyards. In response to the contrasting climatic conditions, areas of natural vegetation within the temperate mountains are marked by pine and oak forests, whereas in the central steppes they are marked by sparse scrubland.

METHODS

Two sampling sites were selected for the study. One was located in the steppe zone in Zaragoza county and the other in the mountain zone in Ribagorza county (Fig. 1). Within each sampling site, soil cores were collected from a range of sampling points selected to cover a representative range of local conditions, particularly land use and slope gradient. At the Solá site in Ribagorza county, sampling focused on a 1250-m transect down a south facing slope, which terminated at the shore of Estanya Lake. The altitude at the head of the transect was 894 m a.s.l. and this decreased to 678 m a.s.l. at its base. The transect was characterized by a 24% slope and the sampling points were located at 50 m intervals along the transect. Three different land uses: natural forest, abandoned fields and cultivated fields were found along the transect and the soil sequence included Leptosols, Regosols, Calcisols and Gleysols, which were restricted to the area surrounding Estanya lake. The variation in soil type is accompanied by changes in stone content, with values ranging from 0 to 90%. The spatial distribution of ^{7}Be along the transect was documented in April 2007, after a spring rainfall event of totalling 22 mm, which followed an extended dry period. The preceding conditions were judged to conform to the requirements for minimising the spatial variability of ^{7}Be inventories prior to the rainfall event (see Walling *et al.*, 1999). A total of 22 core samples were collected along the transect to a depth of 5 mm, using a 10 cm × 10 cm steel box corer. Sampling points 2 and 6 coincided with rock outcrops and it was not possible to collect samples from these points. The reference site selected to establish the local ^{7}Be reference inventory was located at the head of the transect on a flat area under natural forest. A replicate set of 22 core samples was collected from points immediately adjacent to the first set of sampling points to a depth of 10 mm, in order to establish whether in stony soils, where it can prove difficult to collect very shallow 5 mm cores, reliable measurements of the ^{7}Be inventory for the sampling points can be obtained from 10 mm deep cores. Deeper cores will be characterized by a lower mass activity density, which will increase measurement uncertainty and may approach the detection limit when the inventory is low.

On the gentler slopes of the gypsiferous steppe in Zaragoza county, a site at Peñaflor was selected. This was characterized by fields planted with pines. The reference site was located 1500 m from the main study site and the nine samples used to establish the local reference inventory were collected from a relatively flat area covered with grass between the rows of pines, using a 3 × 3 sampling grid. At the main Peñaflor site, two fields planted with pines about 50 m apart and separated by a field cultivated for cereals, were selected for sampling. The upper field has a 5% slope and two sampling areas were established at the bottom of the field, one was located in the pine plantation (1) and the other at the same height (2) was located on the tilled area. Within each of these areas, three sampling points separated by 50 cm were sampled (1.1, 1.2, 1.3; 2.1, 2.2, 2.3). A similar sampling strategy was adopted in the lower field that is characterized by a gentler 2.5% slope. Three points were sampled within the two areas (3: 3.1, 3.2, 3.3; 4: 4.1, 4.2, 4.3). At all sampling points, core samples were collected from two depth increments, 0–5 and 5–10 mm. The ^{7}Be inventories at the Peñaflor site were sampled and measured after an autumn rainfall event of 13 mm (2007), with antecedent conditions that were judged to have caused minimal variation of ^{7}Be inventories across the site prior to the storm event.

The steel box corer used to collect the core samples for ^{7}Be analysis was designed to penetrate stony soils. The device has four sides, one is left open to permit slicing of the soil *in situ* over a surface area of 10 × 10 cm. Samples are collected by sliding a steel plate between the slots inserted along two sides of the device.

The methodology used for ^{7}Be analysis closely followed that described in the literature (see Walling *et al*., 1999). The ^{7}Be activities of a total of 86 samples were measured using a Canberra high resolution, low background, hyperpure germanium coaxial gamma detector coupled to an amplifier and multichannel analyser. The detector had a relative efficiency of 30% and 1.9 keV resolution (shielded to reduce background) and was calibrated using standard samples with the same geometry as the measured samples. Prior to assay, samples were air dried, ground to pass a 2-mm sieve and loaded into plastic containers for gamma assay at 477.6 keV. Count times of 24 h provided an analytical precision of approx. ±10% at the 95% level of confidence. ^{7}Be activity was expressed per unit mass (Bq kg^{-1}), as the mass activity density, or per unit area, as the areal activity density or inventory (Bq m^{-2}).

Estimation of soil redistribution from ^{7}Be measurements assumes that ^{7}Be fallout occurs primarily as wet fallout in association with rainfall and that the fallout occurring during individual storms is rapidly fixed by the surface soil (see Wallbrink & Murray, 1996). Since the ^{7}Be fixed by the soil is retained within the upper few mm of the soil and its depth distribution is characterized by a well-defined exponential form, the depth of soil removed by erosion associated with the storm event can be estimated from the degree of reduction of the inventory at the sampling point relative to the local reference inventory (see Walling *et al*., 1999; Schuller *et al*., 2006). Where a sampling point is characterized by deposition, the measured inventory will exceed the local reference inventory. The conversion model or procedure used to estimate soil redistribution rates was based on that described by Walling *et al*. (1999) and Schuller *et al*. (2006). At the Solá and Peñaflor sites relaxation mass depths of 1.5 and 3 mm, respectively, were assumed, based on the soil stone content, previously reported ^{7}Be soil depth distributions from the literature and available information on ^{7}Be depth distributions for the study areas.

In order to provide complementary information on soil properties, measurements of grain size composition and total organic carbon (TOC) content were performed on the soil samples collected for ^{7}Be analysis. The sand, silt and clay contents (%) of the samples were determined using a Coulter laser granulometer, after pre-treatment with 10% H_20_2 heated at 80°C, to remove the organic matter, and subsequent stirring and ultrasonic dispersion. A Leco elemental analyser was used for TOC analyses.

RESULTS

Soil redistribution rates at the Solá mountain site

Along the transect established at the Solá site, measurable ^{7}Be activity was found in most samples collected from both depths (0–5 mm, 0–10 mm) under both natural forest and in cultivated areas (Table 1). For the 5 mm depth samples, the mean ^{7}Be areal activity density for the transect was 103.6 (s.d. 58.4) Bq m^{-2}. However, considerable variation occurred along the transect, with values ranging between 16.4 and 260.4 Bq m^{-2}. For the 10 mm depth samples, the dilution effect reduces the values of ^{7}Be mass activity density by almost 50%, but for most sampling points the values obtained were sufficiently in excess of the detection limit to provide reliable inventory values. The mean ^{7}Be inventories for the samples collected along the transect to a depth of 10 mm was 102.6 (s.d. 66.3) Bq m^{-2}. The reference inventories based on the means of the samples collected to depths of 5 mm and 10 mm are 241.2 and 193.1 Bq m^{-2}, respectively. The mean soil redistribution rates estimated for the sampling points along the transect from the ^{7}Be inventories are –12.2 (s.d. –6.7) Mg ha $^{-1}$ for the 5 mm deep samples and –14.7 (s.d. –12.1) Mg ha $^{-1}$ for the 10 mm deep samples. The two mean values are quite similar, although the estimates of soil redistribution rate obtained for the 10 mm deep samples show greater variability. These results suggest that a 10 mm sampling depth can provide meaningful estimates of soil erosion rates in stony soils, where it is difficult to obtain smaller depth increments.

Table 1 Values of ^{7}Be mass activity and areal activity density and estimates of erosion rates for the 5 mm and 10 mm depth samples along the transect at the Solá study site.

Point	S (%)	L	Stones (%)		^{7}Be (Bq kg^{-1})		^{7}Be (Bq m^{-2})		Soil redistribution (Mg ha^{-1})	
			5	10	5	10	5	10	5	10
1		F	59	63	26.7	14.8	241.2	193.1	0.0	0.0
3		F	44	29	14.9	17.6	105.7	190.9	–12.4	–0.2
4		F	68	66	18.9	16.7	114.7	137.2	–11.2	–5.1
5	24	F	32	35	6.4	5.2	78.8	74.3	–16.8	–14.3
7		F	60	85	18.4	19.4	96.3	80.2	–13.8	–13.2
8		F	58	57	17.9	0.0*	106.8	20.0	–12.2	≥ –34.0
9		F	70	55	10.2	0.0*	46.2	20.0	–24.8	≥ –34.0
10		C	67	67	10.9	15.9	58.3	125.8	–21.3	–6.4
11		A	79	78	16.5	9.5	74.9	65.5	–17.5	–16.2
12		F	80	53	62.8	0.0*	136.0	20.0	–8.6	–34.0
13		C	80	71	39.4	12.2	148.9	89.0	–7.2	–11.6
14	22	F	0	3	5.5	30.7	20.2	222.0	–37.2	2.4
15		C	10	15	21.8	16.9	260.4	262.1	1.3	5.8
16		C	61	60	18.1	4.2	87.7	38.2	–15.2	–24.3
17		F	0	38	0.0	0.0*	20.0	20.0	≥ –37.3	≥ –34.0
18		F	84	70	16.5	13.1	47.7	85.5	–24.3	–12.2
19		A	47	52	16.4	9.8	167.7	89.9	–5.5	–11.5
20		A	40	45	13.7	8.8	127.8	132.9	–9.5	–5.6
21		A	90	57	8.5	0.0*	16.4	20.0	–40.3	≥ –34.0
22	16	C	31	30	23.8	6.8	156.2	97.4	–6.5	–10.3
23		C	10	20	14.2	0.0*	151.9	20.0	–6.9	–34.0
24		C	17	17	13.0	11.6	152.1	146.5	–6.9	–4.1

F, forest; A, abandoned fields; C, cultivated fields; S, slope; L, land use.
*Zero activity denotes activity below the detection limit. An inventory of ≤20 Bq m^{-2} was assumed for these points.

Considering the erosion rate estimates derived from the ^{7}Be measurements undertaken on the 5 mm deep samples, since these correspond more closely to the expected initial depth distribution of the radionuclide (see Walling *et al.*, 1999), the magnitude and variation of the ^{7}Be inventories recorded along the transects suggest that appreciable soil mobilisation and redistribution had occurred along the transect during the preceding storm event. The variation of the ^{7}Be inventories, and thus the soil redistribution rates along the transect appear to be related to variations in grain size, stone content and TOC values. As can be seen in Fig. 2 and Table 1, high ^{7}Be inventories are frequently associated with sampling points with high clay contents (e.g. points 1, 8, 13, 15, 19). On the contrary, the lowest ^{7}Be inventories correspond to sampling points 14 and 17 that are the only points along the transect where the soil is free from stones and where the soil also has a high organic content. At points 14 and 17 the soil surface was covered in litter and these points are marked by the highest TOC contents and the lowest clay contents. Point 21 represents another outlier which is characterized by the highest stone content in combination with a low clay content and a high TOC value.

The estimates of erosion rate provided by the 5 mm deep samples collected along the transect are presented in Fig. 3. Considering the land use, the transect can be divided into three main parts. Along the first part of the transect, the natural forest is quite dense and the average slope is 24%.

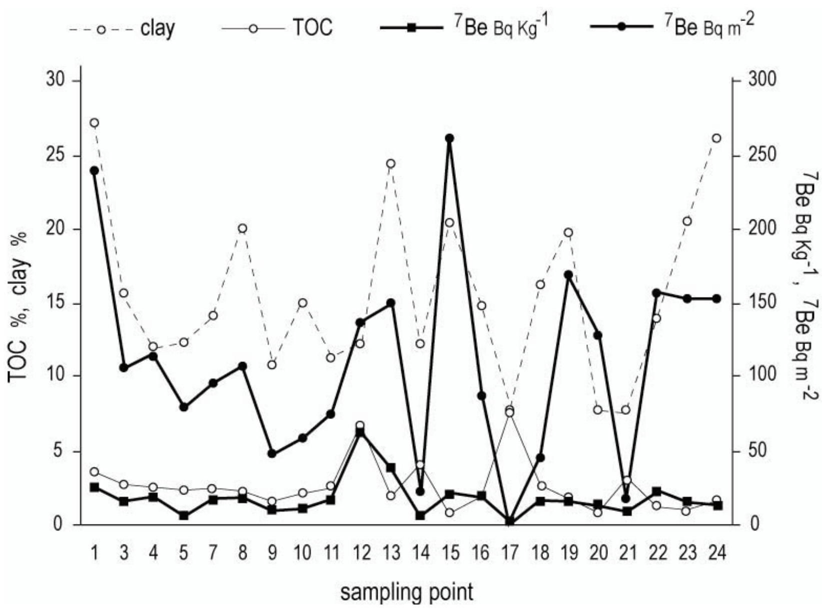

Fig. 2 The distribution of ^{7}Be mass activity and areal activity densities and of the clay and TOC content of the soil along the transect at the Solá study site.

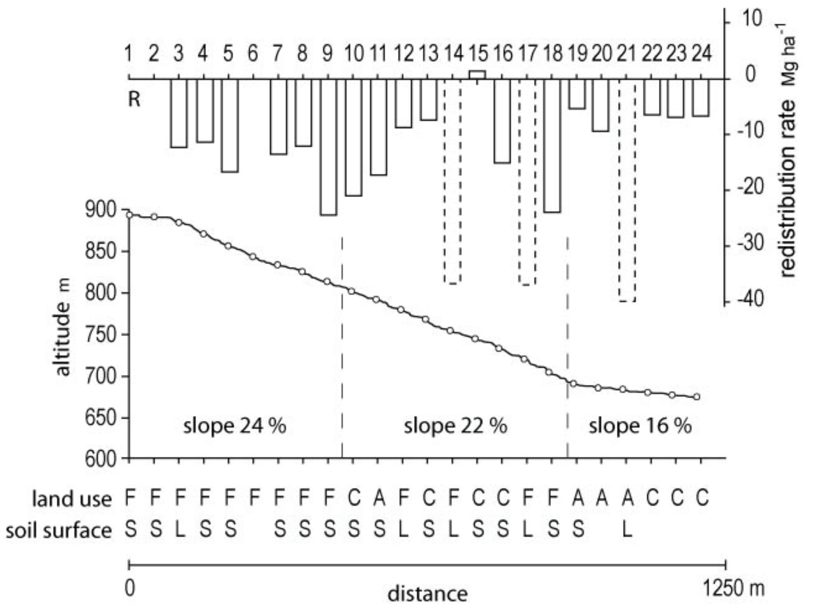

Fig. 3 Estimates of soil redistribution rates associated with the preceding storm event obtained for the sampling points along the transect at the Solá study site. Information on land use (forest, cultivated, abandoned) and soil surface characteristics (stones or litter) is also provided for the sampling points.

Here the erosion rates are fairly constant (i.e. approx. 11–17 Mg ha^{-1}) until point 9, where a change in slope results in increased erosion (25 Mg ha^{-1}) which is supported by the field evidence of an existing stone pavement. The next segment of the transect (points 10–18) has an overall slope of 22% and all three land uses existing in the area are represented. Areas with both cultivated and abandoned fields are interspersed with patches of natural forest and the slope shape is highly variable, with relatively flat terraced fields alternating with regular straight slopes, as in the upper part of the transect. As a result, the erosion rates within this part of the transect are the most variable and deposition is found at point 15. The two points (14, 17) with rich organic soil, for which very high values of erosion were found, are viewed as outliers. Along the lower part of the transect, the slope decreases to 16% and the land use includes a combination of abandoned fields and fields cultivated for cereals. This part of the transect has the lowest soil losses, apart from point 21. The values of mean erosion rate calculated for the three parts of the transect and presented in Table 2 indicate that the highest erosion rates occur on the steepest part of the transect, that the greatest variability is associated with variations in land use and slope gradient (i.e. the middle segment), and that the lowest erosion rates occur at the base of the transect where the slope gradient is lowest.

Soil redistribution rates at the Peñaflor steppe site

The Gypsisol soils found in the central gypsiferous steppe are much less stony than the soils at the Solá mountain site. Based on the samples collected from the 3 × 3 sampling grid in the pine plantation, the ^{7}Be reference inventory for this site was estimated to be 82 Bq m^{-2}. This value is almost half that for the Solá site, but the difference is consistent with the lower rainfall of the steppe site. The average ^{7}Be inventory for the soil samples collected from the Peñaflor site was 100.5 (s.d. 43.9) Bq m^{-2}. No ^{7}Be was found below 5 mm in the soils of the areas under pine forest, but the radionuclide was found in some of the samples collected from the 5–10 mm depth in the cultivated area (Table 3).

Table 2 Mean values of ^{7}Be mass activity and areal activity density and soil redistribution rate for the three segments of the transect at the Solá study site.

		^{7}Be (Bq kg^{-1})			^{7}Be (Bq m^{-2})			Soil redistribution (Mg ha^{-1})		
	n	mean	sd	range	mean	sd	range	mean	sd	range
slope 24%										
0–5 mm	6	14.5	5.1	6.4–18.9	91.4	25.3	46.2–114.7	–15.2	5.1	–24.8 to –11.2
0–10 mm	6	9.8	9.1	0.0–19.4	87.1	67.1	20.0–190.0	–16.8	14.3	–34.0 to –0.2
slope 22%										
0–5 mm	7	26.6	18.3	10.9–62.8	116.3	74.0	47.7–260.4	–13.3	8.9	–24.3–1.3
0–10 mm	7	10.3	6.2	0.0–16.9	98.0	80.3	20.0–262.1	–14.1	12.7	–34.0–5.8
slope 16%										
0–5 mm	5	16.2	4.4	13.0–23.8	151.1	14.5	127.8–167.7	–7.1	1.5	–9.5 to –5.5
0–10 mm	5	7.4	4.5	0.0–11.6	97.3	49.3	20.0–146.5	–13.1	12.1	–34.0 to –4.1

Table 3 Values of ^{7}Be mass activity and areal activity density and of stone content, grain size composition and TOC of soil samples collected from the sampling points at the Peñaflor study site.

Point	S	L	^{7}Be (Bq kg^{-1})		^{7}Be (Bq m^{-2})	% stones	% sand	% silt	% clay	TOC %
	%		0–5 mm	5–10 mm	0–5 mm			0–5 mm		
1.1		F	6.3	0.0	50.0	1	59.7	30.8	9.5	2.42
1.2		F	13.4	0.0	64.6	13	63.2	29.2	7.6	2.03
1.3	5	F	20.5	0.0	97.5	7	61.6	30.7	7.8	2.02
2.1		C	10.0	12.4	170.3	8	54.5	34.5	11.0	0.76
2.2		C	6.1	10.8	140.1	10	52.6	36.1	11.3	0.87
2.3		C	8.6	5.1	95.9	7	55.4	33.6	11.1	0.79
3.1		F	19.4	0.0	134.0	1	29.9	46.0	14.1	2.28
3.2		F	10.7	0.0	96.7	4	48.2	38.7	13.1	1.96
3.3	2.5	F	19.3	0.0	167.1	3	37.7	48.0	14.4	2.32
4.1		C	9.5	1.9	98.4	3	21.6	58.3	20.1	0.64
4.2		C	0.0	0.0	20.0	4	18.5	58.1	23.4	0.66
4.3		C	7.5	0.0	71.9	4	19.3	59.5	21.2	0.67

S, slope; L, land use; F, pine forest; C, cultivated.

The soil redistribution rates estimated for the sampling points in the field with 5% and 2.5% slopes are presented in Fig. 4. The soil loss and gain ranges between –42.2 Mg ha^{-1} and 32.6 Mg ha^{-1}, respectively. Within the forested area in the fields with a 5% slope (1) two of the three points are eroded, whereas within the cultivated area (2) all three points evidence deposition. The opposite situation is found for the field with a 2.5% slope, since here the sampling points in the forested area (3) provide evidence of deposition, whereas within the cultivated area (4) two points show erosion and one deposition. The grain size distributions indicate that in both fields the clay percentages are greater for the cultivated sites than for the forest sites, whereas TOC values are higher in the forest than in the cultivated area (Table 3). One explanation for the soil redistribution pattern in the field with a 5% slope could be that runoff generated within the cultivated area mobilises substantial amounts of soil which are readily detached due to the low TOC content of the soil and that this material is deposited at the bottom of the field. In contrast, in the forested area less surface runoff occurs and, in the absence of significant deposition at the bottom of the field, erosion still occurs. On the 2.5% slope, the lower gradient of the slope may reduce the transport capacity and promote deposition at the lower end of the forested area (3), where runoff will be limited. In contrast, within the cultivated area (4) a more variable pattern of erosion and deposition is found.

At both study sites, the patterns of soil redistribution associated with the rainfall event that occurred immediately prior to sample collection are characterised by high spatial variability. The substantial deviations from the reference inventory documented for the sampling points within the steppe site provide evidence of both erosion and deposition. For the transect within the mountain area, however, erosion dominates for all land-use types and this can be seen as reflecting the influence of the steeper slopes compared to the gentler slopes of the central steppe area.

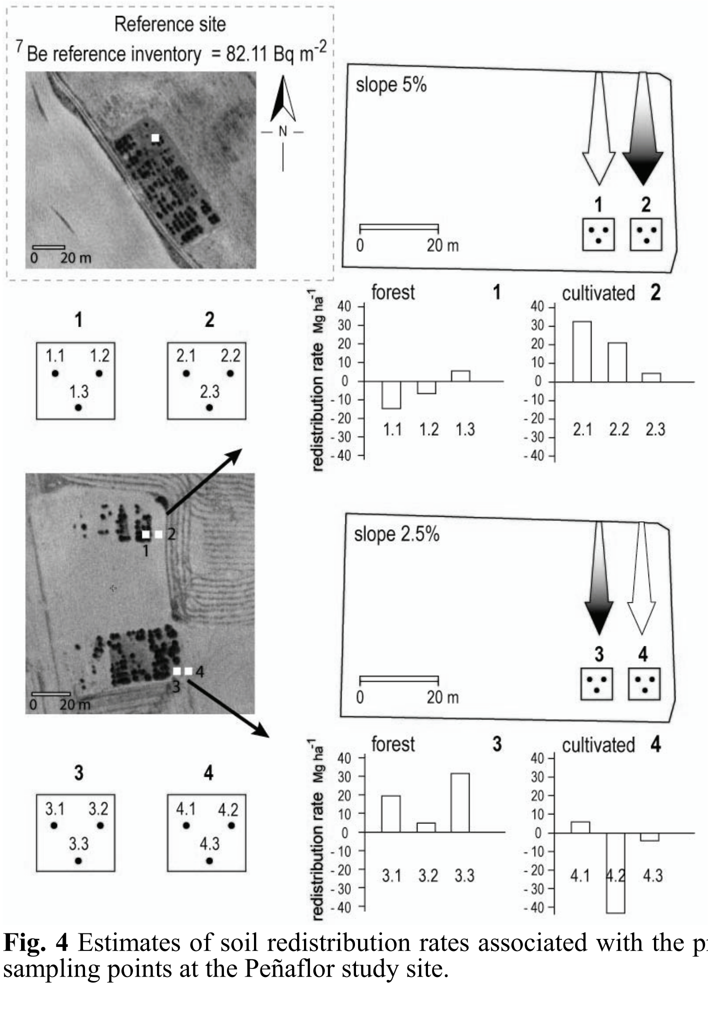

Fig. 4 Estimates of soil redistribution rates associated with the preceding storm event obtained for the sampling points at the Peñaflor study site.

CONCLUSIONS

The study reported above has demonstrated that ^{7}Be provides an effective method of quantifying short-term soil redistribution rates associated with storm events within both the semiarid steppe and temperate mountain areas of the central Ebro basin. Good results were obtained from the mountainous area, despite the high stone content of the soils. The results for the storm events investigated demonstrate that erosion was dominant on the transect within the temperate mountain area, whereas on the flatter gyspsiferous steppe, both erosion and deposition occurred and there was greater evidence of soil redistribution within the sampling area, as distinct from sediment export. The short-term soil redistribution rates documented for both study areas are relatively high, and it is clear that both slope gradient and land use exert important controls on soil redistribution rates. Both the magnitude of the documented soil redistribution rates and the complex patterns of erosion and deposition have important implications for developing and applying best management practices aimed at conserving the soil resource. The stone content of the soil and the presence or absence of litter cover may exert an important influence on the distribution of ^{7}Be within the landscape and should be taken into account when planning sampling strategies for applying the ^{7}Be technique to document soil redistribution rates in Mediterranean environments. The high spatial variability of the ^{7}Be inventories in both study areas highlights the need for further investigation of small-scale patterns of soil redistribution and their interaction with the post fallout redistribution of ^{7}Be in such environments, where skeletal soils with a high stone content are common.

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