Erosion and sediment yield in Mediterranean badland areas

Estela Nadal-Romero [1, 2], Juan Francisco Martínez-Murillo [3], Matthias Vanmaercke [1], Jean Poesen [1]

[1] Division of Geography Department of Earth and Environmental Sciences. K.U. Leuven, Celestijnenlaan 200 E bus 2409, 3001 Heverlee, Belgium. [2] Department of Geography, University of Zaragoza, 50009 Zaragoza, Spain. [3] Department of Geography, University of Malaga, Campus de Teatinos. 29071 Málaga, Spain.

Introduction

Badlands are usually defined as "intensely dissected natural landscapes where vegetation is sparse or absent and which are useless for agriculture". Badlands are characterized by features such as the absence of vegetation, steep slopes and high density drainage network, and hence tend to be among the most significant areas of erosion in the world.

The main **objectives** of this study are: **(i)** to investigate the relationship between area-specific sediment yield (SY) and contributing area (A) in Mediterranean badland areas, and **(ii)** to discuss the effects of several possibly controlling factors of SY in badlands: i.e. measuring methods, dominant erosion process, lithology, mean slope gradient, the fraction of bare areas or badland areas, mean annual precipitation and mean annual air temperature.

Data colection and analyses

• A database (Nadal-Romero et al., 2011) was compiled with **154 entries** representing **16 571 plot- and catchment-year data** on specific sediment yield at **87 study** sites in badland areas of the Mediterranean (Spain, France, Italy, Albania, Greece, Turkey, Israel, Morocco and Tunisia).

• The sediment yield data used in this study were obtained by **bathymetric surveys** in reservoirs, sediment transport measurements at **gauging stations**, detailed **topographic surveys**, **erosion pins**, and **runoff plot** data.

• All data are subdivided into five classes according to **dominant erosion processes**: i.e. splash erosion, interrill erosion, interrill and rill erosion, gully erosion or catchment sediment yield.

• The effect of the different **lithologies**, mean **slope gradient**, **% bare areas or % badland areas**, and **climatic characteristics** (mean annual precipitation depth and mean annual air temperature) is studied.

Figure 1. (A) Yesa reservoir in the Aragón River (Central Pyrenees, Spain) for which bathymetric surveys were made; (B) Gauging station in the Araguás catchment (Central Pyrenees, Spain) (IPE-CSIC); (C) Sediment collector device linked to runoff plots in Bardenas (Spain) (Univ. of Zaragoza; (D) Erosion pins on a badland slope located in Bardenas Reales (Spain) (Univ. of Zaragoza).

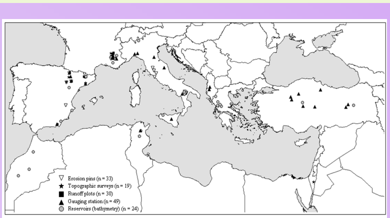


Fig. 2. Location of SY measurements sites in badlands and methods used

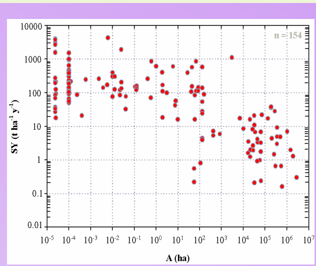


Fig. 5. SY from badlands against A

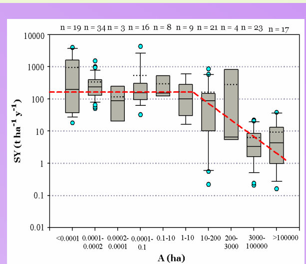


Fig. 6. Box plot of SY from badlands against A

Fig. 3. Study sites and plot- and catchment-year in relation to precipitation, mean annual temperature and mean slope gradient

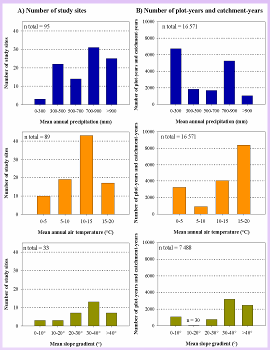
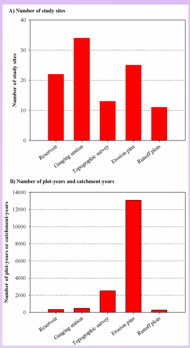


Fig. 4. Study sites and plot- and catchment-year corresponding to the different methods

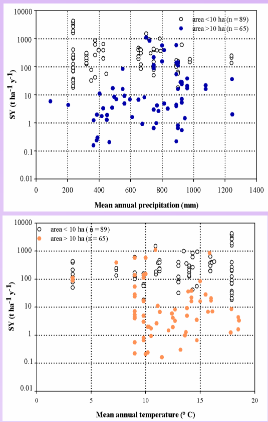


❑ Badlands in Mediterranean environments (Fig. 2) can develop under different climatic conditions → a high variability of mean annual precipitation and temperature is observed (Fig. 3).

❑ Slopes were found to be generally steep with most slopes gradients ranging from 30 to 45°C (Fig. 3).

Results

Fig. 8. Relation between SY and (A) mean annual precipitation and (B) mean annual air temperature



❑ Fig. 5 displays the SY data from all entries versus drainage area, revealing:

➢ a high variability of SY

➢ mean value = 316 t ha⁻¹ y⁻¹ and median = 91 t ha⁻¹ y⁻¹

❑ The data set reveal 2 trends (Fig. 6):

➢ For A <10 ha SY remains very high and rather constant (mean SY = 475 t ha⁻¹ y⁻¹),

➢ whereas for A > 10 ha, SY decreases non-linearly with increasing A (mean = 75 t ha⁻¹ y⁻¹)

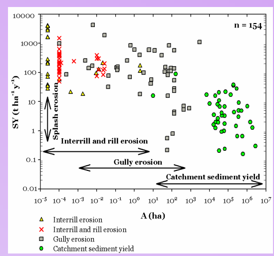


Fig. 7. SY versus A according to dominant erosion processes

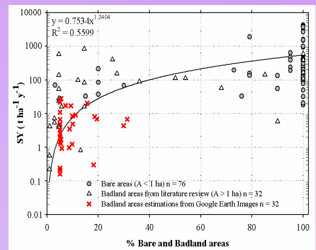


Fig. 8. Relation between SY and % bare and badlands areas

❑ There is no standard protocol to measure SY in badland areas: i.e. the dataset contains more than 13000 plot-years of erosion pins measurements (Fig. 4).

❑ SY remains very high at spatial scales where splash, interrill, rill and gully erosion processes dominate (Fig. 7).

❑ Fig. 8 shows the relation between the % bare areas and the % of badland areas and SY. It indicates a non lineal increase in SY .

❑ Scatter plots of SY and mean precipitation and mean annual air temperature, do not show any clear trends (Fig. 9).

Discussion and Conclusions

✓ This review indicated that SY in badland areas is very high and is characterized by a large variability.

✓ Different A-SY relationships have been studied for various regions (de Vente and Poesen, 2005).

✓ The relationships between SY and A is complex in Mediterranean badlands environments and it is different from the previously reported relation for other Mediterranean environments (Fig. 9).

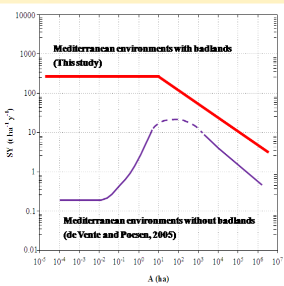


Fig. 8. Structural model illustrating the relation between SY and A for different Mediterranean environments

✓ The main reasons to explain this relation are the reduced possibilities for sediment storage for areas < 10 ha and the increases in sediment deposition with increasing drainage area and heterogeneous land uses and land covers.

✓ The results of this study have implications for extrapolations SY data for large areas.

✓ More research is needed to investigate the effects of (1) the location of badlands within catchments on SY and (2) the effect of temporal scales on the A-SY relations.

References

de Vente, J., Poesen, J. (2005). Predicting soil erosion and sediment yield at the basin scale: Scale issues and semiquantitative models. Earth-Science Reviews 71(1-2): 95-125.

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