

GULLY EROSION IN FRAGILE LANDSCAPES. GEOMORPHODYNAMICS AND FORMS IN SPAIN, MAROKKO AND BURKINA FASO

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The research project MoGul (Large-scale Monitoring of Gully Erosion in Semi-Arid Landscapes) at Trier and Frankfurt University investigates the various gullies types, development and dependencies of gullies as well as geomorphological processes involved in.

Key words: erosion, gully, geomorphological processes.

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ЕРОЗИЯ ГРУНТІВ НЕМІЦНИХ ЛАНДШАФТІВ, ЯКА ВИКЛИКАНА РОЗМИВАМИ. ГЕОМОРФОЛОГІЧНА ДИНАМІКА ТА ЇЇ РІЗНОВИДИ В ІСПАНІЇ, МАРОКО ТА БУРКІНА-ФАСО

Результати роботи отримані при роботах проекту MoGul (великомасштабне спостереження за ерозією, яка виникає внаслідок розмивів на посушливих територіях) університетів Трира та Франкфурта. Було вивчено різні типи ерозії, викликані розмивами та оврагами, їх зміни у часі, фактори впливу, а також геоморфологічні процеси.

Ключові слова: ерозія, розмиви, геоморфологічні процеси.

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ЭРОЗИЯ ПОЧВ НЕПРОЧНЫХ ЛАНДШАФТОВ, ВЫЗВАННАЯ РАЗМЫВАМИ. ГЕОМОРФОЛОГИЧЕСКАЯ ДИНАМИКА И ЕЕ РАЗНОВИДНОСТИ В ИСПАНИИ, МАРОККО И БУРКИНА-ФАСО

Результаты представленной работы получены в ходе работ проекта MoGul (крупномасштабное наблюдение за эрозией, возникающей из-за размывов на засушливых территориях) университетов Трира и Франкфурта. Изучению подверглись различные типы эрозии, вызванной размывами и оврагами, их изменения во времени, факторы влияния, а также геоморфологические процессы.

Ключевые слова: эрозия, размывы, геоморфологические процессы.

The research project MoGul (Large-scale Monitoring of Gully Erosion in Semi-Arid Landscapes) at Trier and Frankfurt University investigates the various gullies types, development and dependencies of gullies as well as geomorphological processes involved in. The investigations are carried out at different sites following a transect from the semi-arid Ebro Basin in Northeast Spain, through sub-humid Baza and Guadalentin Basins in Southeast Spain, arid Drâa Valley in South Morocco to the semi-arid Oudalan in Sahelian Burkina Faso.

In semi-arid landscapes the contribution of gully erosion to sediment production can reach about 80 % (Poesen & Hooke 1997). The resulting problems due to siltation issue a severe challenge to the water supply in dry regions. The aspired stabilization of morphodynamics due to reforestation often failed and is going to be even less successful under changed climate conditions. The abandoned field areas generate high amounts of overland flow inducing rill erosion (Ries 2009). Accordingly, more water reaches the gully headcut, resulting in higher retreat rates. Thus these anyhow fragile landscapes become even more active.

METHODS

The research methods include large-scale aerial photographic surveys, mapping of the regional surroundings and experimental measurements of surface runoff and infiltration capacity, with strong emphasis on monitoring and modelling of gully development with photogrammetry and GIS.

Investigations on short-term gully change are mostly realised using field methods for quantification of linear headcut retreat rates. The lack of image resolutions corresponding to the magnitude and dynamics of gully erosion usually prevents the use of remote sensing data, which in contrast to field measurements allow for the rapid and spatially continuous coverage of a site (Marzolff, 1999; Ries & Marzolff 2003). The objective of this paper is to present an overview of the first results of the MoGul project on gully monitoring which employs large-scale aerial photography taken from remote-controlled platforms (hot air blimp and kites). The high-resolution images (pixel sizes <10 cm) are employed for photogrammetric and GIS analysis to quantify gully development with linear, areal and volumetric measures (Marzolff & Poesen 2009).

Runoff and erosion data were collected by different experiments within the gully catchments. Infiltration rates were measured by a single ring infiltrometer. Runoff coefficient and erosion rate were determined by plot scale rainfall simulations (Seeger 2007). The geomorphologic mapping of the catchments enables a detection of the spatial distribution of erosion processes.

RESULTS

Linear headcut retreat rates for 12 gullies were analysed in order to investigate their relation to patterns of runoff and infiltration behaviour in the gully headcut surroundings.

Retreat rates for South Moroccan sites ($0\text{--}0.31\text{ m a}^{-1}$) were found to be lower than those obtained for Spanish gullies ($0.07\text{--}0.51\text{ m a}^{-1}$); however, by far the highest maximum retreat was observed in the West-African Sahel ($3.16\text{--}9.85\text{ m a}^{-1}$).



Barranco Rojo, Province of Zaragoza (Spain); aerial photography, March 2002
(left side; flying altitude 150 m, wide angle lens),
and aerial photography of the detail indicated by the red rectangle, April 2006
(right side; flying altitude 70m, normal angle lens)

Infiltration measurements, runoff coefficients and erosion rates show differing ranges but always high variability within the gully catchments. Ranges of minimum and maximum values for the soil erosion parameters results in the same ranking of study regions as ranges for maximum linear headcut retreat. This indicates a clear association between runoff behaviour and gully headcut retreat with respect to their spatio-temporal variability. The causal relationship of low infiltration rates, high overland flow generation as well as high erosion risk in the gully catchment and the consequently high headcut retreat rates can be proven.

2D change quantification with detailed maps derived from the large-scale aerial photography provide additional information about the differences in headcut retreat behaviour which cannot be described by linear measures. The 2.5 dimensional quantification of gully development by means of detailed DEM derived from high resolution aerial photographs give a good insight into the diverse morphodynamics at the headcut and at the side walls. Both, erosion as well as accumulation areas become visible and also volume loss assessment is enabled. This illustrates the benefits of high-resolution aerial photography for the monitoring and for the understanding of gully erosion processes. Geomorphological mapping remains necessary for the detection of linear structures, which are important for the transport of water to the headcut.

For gullies in Spain the following statement can be issued: Young fallow land and almond plantations produce the highest growth rates concerning gully erosion. Due to the agricultural policy of the EU, especially concerning almond cultivation and set-aside programmes, gully erosion is still promoted. Linear and mostly treatment induced erosion forms in the catchment are more decisive for the water amount that reaches the headcut, and thus for the short-term rate of development, than the catchment size.

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