Geophysical Research Abstracts,
Vol. 11, EGU2009-9086, 2009
EGU General Assembly 2009

Influence of development stage and disturbance of physical and biological soil crusts on soil water erosion

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Most soils exposed to rainfall are prone to sealing and crusting processes causing physical soil crusts (PSCs). When climate and soil stability conditions are suitable, PSCs can be consolidated by a complex community consisting of cyanobacteria, bacteria, green algae, microfungi, lichens and bryophytes, which are collectively known as biological soil crust (BSC). The influence of soil crusts on erosion processes is complex: crusts may reduce detachment, increasing soil stability and protecting soil against raindrop impact, although that protection will depend on the type of soil crust and the stage of development; they can also build up runoff, suggesting that downstream erosion may actually be increased or favoured water harvesting to vegetated areas. On the other hand, BSCs have been demonstrated to be very vulnerable to disturbance which in turn can lead to accelerate soil erosion and other forms of land degradation. Incorporation of the response of different type of soil crusts and the effects of their disturbance is highly likely to improve the prediction of runoff and water erosion models in arid and semi-arid catchments.

The objective of this work is to analyse the erosional response of PSCs and BSCs in different stages of their development and subject to distinct disturbances when extreme rainfalls intensities are applied at plot scale in semiarid environments. Small plots on the most representative crust types, corresponding to different stages of crust development, in two semiarid ecosystems in SE Spain, El Cautivo (in the Tabernas Desert) and Amoladeras (in the Natural Park Cabo de Gata-Níjar), were selected and three disturbance treatments were applied on each crust type: a) no disturbance (control), b) trampling, stepping 100 times over the crust and c) scraping. Two consecutive rainfall simulation experiments (50 mm/h rainfall intensity) were carried out on each plot: the first on dry soil and the second, 30 minutes later, on wet soil conditions. Samples of runoff were collected regularly during the rainfall simulation and sediments in runoff extracted later in laboratory. Erosion rates were significantly different at both sites, being lower in Amoladeras than in El Cautivo due to a flatter topography and a higher infiltration capacity of the sandy soils with higher organic matter content. There were not significant differences on total erosion rates between the first and the second rainfall event, as consequence of the increase of runoff under wet conditions. In El Cautivo, the erosion rates significantly decreased as crust development stage increased. However, in Amoladeras, the erosion was low in all crust types and there were not significant differences on erosion rates among the crust development stages. Among treatments, in El Cautivo, scraping and trampling promoted significant higher erosion rates than undisturbed crust, but no significant differences were found between both treatments, except for the lichen-dominated crust. In Amoladeras, no significant differences on erosion rates between the undisturbed and the trampled crust were found since in this area trampling did not have an important effect. Although the removal of the crust in semiarid environments, at local scale, always increased erosion, the effects of crust disturbance on erosion varied depending on the ecosystem, with stronger erosional effects in bad-land areas with a silty substrate and steep topography than in areas with a flat topography and a coarser soil texture.