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Implications of biocrust removal on soil organic carbon losses by water erosion in a badlands area

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In arid and semiarid ecosystems, soils are characterized by having low organic carbon (OC) content and low fertility. In these systems, runoff, often generated in interplant soils, plays a crucial role in OC redistribution from source (interplant) areas to sink (vegetation) patches. Far from being bare, interplant soils in most arid and semiarid ecosystems are commonly covered by communities of cyanobacteria, algae, lichens and mosses, known as biocrusts, which may reach up to 80% of soil cover. Biocrusts fix atmospheric C and increase the soil OC pool by several folds respect bare soils. In addition, biocrusts form a film on the surface that strongly protects soils against water erosion and prevents from OC losses. However, the role of BSCs in reducing OC losses associated to runoff and erosion may depend on the type and development of biocrust. On the other hand, loss of BSCs provoked by frequent disturbances in arid and semiarid areas leads to an increase in runoff and erosion, which may have important effects on OC losses and nutrient impoverishment in interplant areas. Despite their recognized role, very few studies have explicitly evaluated OC losses from runoff and erosion in soils covered by different types of biocrusts and, more importantly, the effects of biocrust disturbance on OC losses. The aim of this study was to analyse the influence of two biocrust types (cyanobacteria and lichens) as well as of biocrust removal on dissolved and sediment OC losses, in a badlands site of southeastern Spain. Runoff and erosion after rain were measured in small field plots (1 m2) during one hydrological year and water samples collected for determination of dissolved OC and OC bonded to sediments. Our results showed that total OC losses decreased with biocrust development and that biocrust removal caused a dramatic increase in OC losses. The first rain after biocrust removal contributed the most to OC losses as runoff and, more noticeable, erosion greatly increased immediately after biocrust removal. In the following rains, OC losses decreased in biocrust-removed soils due to the formation of a physical soil crust and the subsequent early colonization by cyanobacteria and less remaining available OC in these soils. Sediment OC losses represented between 61 and 91% of total OC lost. Annual OC losses were up to 9 times higher in biocrust-removed soils than in biocrust-covered soils. While C uptake by biocrusts is able to compensate OC losses by water erosion, OC losses in soils devoid of biocrusts largely exceed C inputs, thus resulting in a net annual balance of C loss. Our findings highlight the key role of biocrusts in increasing spatial heterogeneity of soil OC in arid and semiarid areas and the consequences of biocrust removal on OC depletion in interplant soils and their possible implications on nutrient redistribution from interplant to vegetated patches, which may have profound consequences on vegetation functioning in these vulnerable and nutrient-limited ecosystems.