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Effect of vegetation cover on the hydrology of reclaimed mining soils under Mediterranean-Continental climate

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ABSTRACT

Vegetation cover plays a major role in the restoration and stabilization of disturbed systems. The analysis of relationships between restored vegetation and soil hydrology has special relevance for the evaluation and operation of mining reclamation, particularly in Mediterranean-Continental environments, where climatic conditions restrict the development of continuous vegetation cover. The effect of herbaceous vegetation cover on soil hydrology was analysed by means of rainfall simulation (63 mm h^{-1}; 0.24 m^2) in reclaimed soils derived from opencast coal mining (a non-saline and clay-loam textured spoil) in central-eastern Spain. A total of 75 simulation experiments were conducted at three different times throughout the year (late winter, summer and autumn) to control the influence of seasonal climatic fluctuations. Sediment concentrations in runoff and the runoff coefficient decreased exponentially with vegetation cover, while increases in steady infiltration rates were obtained with vegetation cover. Additional delays in runoff responses (longer time to runoff start and stabilization) and increases in the wetting front depth were observed with vegetation cover. Seasonal variations in soil surface state and moisture strongly influenced hydrological responses; although the influence of season on the analysed hydrological responses was attenuated by vegetation cover, especially in the case of infiltration rates. We also determined a practical ground cover threshold for site restoration and evaluation of over 50% vegetation cover, which could help achieve an optimum biological control of hydrological soil responses in the studied environment.

1. Introduction

Reclaimed land from opencast mining activities is particularly sensitive to degradation by accelerated soil erosion (Nicolau and Asensio, 2000; Moreno-de las Heras et al., 2008), especially during the initial stages of site rehabilitation (Loch, 2000). In fact, freshly reclaimed mining soils commonly show unbalanced hydrologic behaviours characterised by a low infiltration capacity and high soil erodibility (Ritter, 1992; Gueber and Gardner, 2001; Ward et al., 1983). This is particularly important when topsoil replacement is not included in the rehabilitation procedure. These characteristics are frequently linked with the generation of important amounts of overland flow, leading to the acceleration of soil erosion processes, with dramatic consequences for on-site rehabilitation and off-site ecosystem damage (Nicolau, 2003).

Encouraging early vegetation establishment is essential in order to reduce the risk of degradation in these artificial systems (Wali, 1999; Whisenant, 2005). Important changes in the hydrological behaviour of reclaimed mining soils are usually driven by vegetation, which increases infiltration rates and prevents soil erosion (Sanchez and Wood, 1989; Loch, 2000). Indeed, vegetation protects the soil surface against the impact of raindrops, reduces the energy of runoff and stimulates the formation and stabilization of soil aggregates (Bochet et al., 1999; Durán-Zuazo and Rodríguez-Plequezuelo, 2008).

There is evidence that the interaction between vegetation and soil hydrology is generally non-linear and often, this is conditioned by sharp thresholds in vegetation cover (Thornes, 2004). As a result two contrasted hydrological behaviours have been suggested for reclaimed mining soils: one characterised by the prevalence of biological controls, where plants actively mediate soil responses; and another characterised by the prevalence of abiotic controls, where crusting and rilling processes control runoff generation and soil erosion (Nicolau and Asensio, 2000). In the latter case, soil hydrology is strongly influenced by seasonal climatic fluctuations (Nicolau, 2002; Martínez-Murillo and Ruiz-Sinoga, 2007). In fact, seasonal variations in soil surface state and soil moisture can lead to large shifts in soil hydrological responses under Mediterranean climate conditions (Cerdà, 1997; Regüés and Gallart, 2004).

Vegetation cover is considered a key indicator of restoration success, as it can reflect critical stages of ecosystem development and functionality (Vallauri et al., 2005). The determination of optimum vegetative cover thresholds which ensure the biological control of hydrological processes has been stressed as an important goal for the

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