Effects of rock fragments on water dynamics in a fire-affected soil

Ángel J. Gordillo-Rivero, Jorge García-Moreno, Antonio Jordán, Lorena M. Zavala
MED_Soil Research Group, Univ. of Seville, Sevilla, Spain

European Geosciences Union
General Assembly 2014
Vienna | Austria | 27 April – 2 May 2014

Introduction

Wildfires are considered an important geomorphological agent in Mediterranean ecosystems and a major cause of water repellency. Fire-induced or enhanced water repellency (WR) in burned areas has been reported by many authors. Recent research has highlighted the role played by surface elements as ash or charred litter, but low attention has been payed to others.

Fire-induced soil WR may be difficult to model because of its extreme spatial and temporal variability. One factor not usually considered when studying the spatial distribution of soil WR is the presence of rock fragments (RF, mineral particles 2 mm or larger in diameter) resting on the soil surface or partly embedded in the soil body.

RFs are common in the surface of Mediterranean semiarid soils (figure 1). Abundant RFs characterize more than 60% of soils from the Mediterranean area. Just in the Iberian Peninsula, for example, very large RF contents between 41% and 90% have been reported in many areas. RFs have important effects on the soil physical and hydrological processes. RFs at the soil surface or in the top layer of soil directly affect the physical properties of the fine earth (bulk density, porosity and organic matter content), physical degradation (surface sealing and compaction) of the soil top layer, hydrological processes affecting runoff generation and discharge (infiltration and percolation) and hydraulics of runoff.

Figure 1. Mediterranean soil near Sevilla (SW Spain), showing a high proportion of surface and partly embedded rock fragments.

Figure 2. Calcareous soil after burning, with rock fragments on its surface.

Figure 3. Burned soil showing abundant rock fragments.

In some cases, RFs in Mediterranean areas have been shown to protect bare soils from erosion risk. Some of these effects are much more relevant when vegetation cover is low or has been reduced after land use change or other causes, as forest fires.

Although very few studies exist, the interest on the hydrological effects of RFs in burned areas is increasing recently (figures 2 and 3).

After a forest fire, RFs may contribute significantly to soil recovery. In this research we have studied the effect of surface and partly embedded RFs on soil water control, infiltration and evaporation in calcareous fire-affected soils from a Mediterranean area (SW Spain).

Objectives

The objective of this research is to study the effect of surface RFs in water holding capacity, soil WR, infiltration and evaporation rates in a calcareous soil under a holm oak (Quercus ilex) forest, recently affected by a moderately severe forest fire.

Methods

Figure 4. Study area.

Selection of areas with:

- similar properties (gradient and south-facing slope),
- Moderate burn severity (Herbs completely consumed; stems thinner than 10 mm were not completely consumed; 50–80% canopy consumed; black and white ash covering soil; organic layer deeply charred; white ash covering part of the soil) and
- similar proportion (20-40% of area covered) and size (10-15 cm) of RFs.

LABORATORY DETERMINATIONS

- Bulk density (core method)
- Particle-size analysis (Bouyoucos method)
- Mean weight diameter of aggregates (dry sieving)

FIELD DETERMINATIONS

- RF cover
- Soil water repellency (WDPT). Previous to WDPT assessment, litter, small branches, residues and coarse mineral particles were carefully removed from the soil surface
- Infiltration rate (minidisk infiltrometer). A thin layer of fine silica was applied to the soil surface. The water volume was recorded at regular time intervals (30 s), and hydraulic conductivity was calculated after infiltration of at least 30 ml of water

Results and conclusions

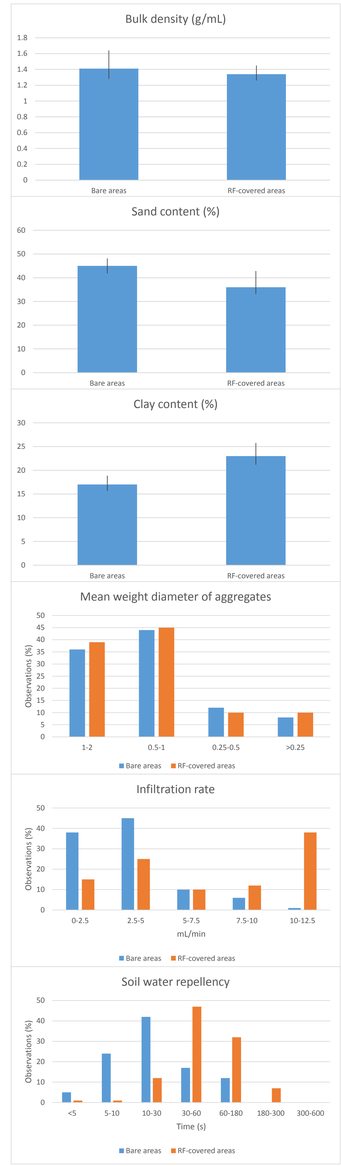
Figure 5. Detail of sampled soil below rock fragments.

Generally, the presence of rock fragments enhanced favorable soil properties. Bulk density and sand contents from bare areas were significantly higher, showing compaction and decreased infiltration rates.

In areas below rock fragments, sand and clay contents were moderate. The size of aggregates was not significantly different below rock fragments and in bare areas.

Although soil properties below rock fragments favored higher infiltration rates, the development of fire-induced water repellency largely inhibited or considerably delayed water infiltration.

Consequently, the presence of rock fragments on the soil surface is suggested to induce an heterogeneous pattern of soil water repellency at least in the short-term after burning, and is a factor to consider for rehabilitation of burned areas.



Acknowledgments
This research has been funded by the Spanish Ministry of Economy and Competitiveness through the project HYDFIRE (CGL2010-21670-C02-01)