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Post-fire effects on hydrological and erodibility factors in a simulated burn and rainfall experiment

S.D. Keesstra (1), L. Wittenberg (2), A. Voogt (1), E. Argaman (3), and D. Malkinson (2)

(1) Wageningen University, Land Degradation and Development Group, Wageningen, Netherlands (saskia.keesstra@wur.nl), (2) University of Haifa, Department of Geography and Environmental Studies, Haifa, Israel, (3) Soil Erosion Research Station, Ministry of Agriculture and Rural Development, Israel

Mediterranean forests are frequently subject to wildfires, inducing risks of runoff and loss of nutrient-rich topsoil. Post-fire causes for soil erosion are hard to separate. These mechanisms are spatially variable due to differences in vegetation density, litter composition, soil texture and structure, and fire intensity. However, the characteristics of soil and surface in the immediate post-fire period are of critical importance to the hydrological response and erosion susceptibility of the burned hillslope and catchment. The mentioned variation is still present in laboratory experiments, however a lot of it can be reduced by using homogeneous litter, uniform soil amounts and texture, controlled temperature and rain regimes and by replicating treatments. Moreover, fire and rain events can be simulated, enabling an imitation of a post-fire period.

In this study we looked at post-fire observations for laboratory fire and rainfall (nozzle-type) simulation experiments to evaluate short-term effects of fire on soil hydrological and erodibility parameters by investigating (i) soil water repellency (WR) levels and distribution, (ii) surface cover features, and (iii) sat. hydraulic conductivity (Ksat), electrical conductivity and values of infiltration, runoff and erosion responses to simulated rain on control (bare and needle covered) and burned (with and without ash cover) samples. In the laboratory experiments we used a novel combination of techniques: (i) prepared trays of soil were manually burned; (ii) WR was measured before, in-between and after rainfall simulations; (iii) assessing of the degree and spatial variation for preferential surface flow; (iv) two rainfall simulations with drying period to simulate a part of a rainy season with cycles of wetting and drying (with its effects on soil hydrology, (re-)establishment hydrophobicity).

The fire-induced surface WR in the lab, tested by grid-wise Water Drop Penetration tests, was moderate but decreased for all treatments after rain. The responses to rain (33 mm h-1) differed for the two simulation runs. The rates of drainage and runoff of the burned samples showed in the first run values in between the values of cover (low runoff, high infiltration) and bare (high runoff, low infiltration). The drainage in the ash-covered samples was twice as high as in the samples where the ash was removed. In the second run both samples showed a similar response compared to bare conditions. After the first run most ash and organic material was washed off and Ksat was low, indicating crust formation. After the first run the EC values showed a significant drop, which represents the infiltration of the cation-binding organic matter, as this is not present for the bare samples. These laboratory observations show that apart from soil crusting, WR and protection by ash are factors to consider in erosion susceptibility of a burned forest soil.