Geophysical Research Abstracts
Vol. 14, EGU2012-4142, 2012
EGU General Assembly 2012

Ecohydrology of biological soil crusts in arid sand dunes - integration from the micro-scale to the landscape

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Biological soil crusts are distributed in many ecosystems from the polar, boreal, temperate, and mediterranean to the tropical regions. They are typical in habitats where the vegetation cover is sparse and microclimatic conditions permit their development. They play an important role for ecosystem processes, enhancing surface stability, changing surface properties and influencing hydrological processes and water re-distribution. The spatial distribution and availability of the water resources are the important factors for the vegetation in drylands. Key questions are (i) how the hydrological processes of the BSC are triggering the vegetation pattern on the landscape level and (ii) how we can integrate the hydrological processes on the micro-scale into the landscape processes and patterns?

We studied the interrelations between biological soil crusts and vegetation pattern in arid sand dunes of the north-western Negev. Most of the dunes are covered by biological soil crusts and various types can be distinguished in different exposition and along a 40 km geo-ecological gradient. Rainfall increases from approx. 90 mm in the south to 170 mm in the northern dunes. Biological crusts cover nearly 90% of the sand dunes of the northern Haluza sand field, whereas the parts of the southern dune crests are still mobile. Furthermore, soil lichens plays an important role in the northern dunes, covering 30%-90% of the interdune area as well as of the stable north-/northwest slopes. The surrounding dune slopes are covered by a biological crust with cyanobacteria, green algae, mosses. Upon wetting, infiltration decreases and runoff can be observed in crust cover areas, even in sand dunes. Runoff depends on rainfall intensity, soil thickness and composition.

The change of surface properties counteracts the effects of increasing rainfall on the vegetation along the geo-ecological gradient. Because of the increase in soil crust thickness the infiltration rates decrease in the dune area from south to north. Furthermore, moisture retention by mosses limits water infiltration to deeper depths which may lead to a declining number of deep-rooting shrubs. This means that although rainfall amounts are higher in the north water infiltration is more limited because of the biological soil crusts. This results in a lower water input into the sands. On the other hand, the open sands on top of the dunes are optimal for deep water infiltration. Subsurface flow can be observed within the dune bodies. Furthermore, on the encrusted slopes surface run-off towards the dune base can be observed in a sandy area. Both processes result in a concentration of water and a dense vegetation belt at the dune base.

From the results we can conclude that the vegetation pattern along the geo-ecological gradient is the result of a complex interrelation of opposite process gradients on the meso-scale and micro-scale level. Surface properties like crust and fine material cover largely control water redistribution
on the micro-scale and, thus, vegetation patterns. Infiltration properties of the biological soil crusts counteract on the rainfall gradient and limit soil water availability. Basic patterns of the spatial distribution of higher vegetation may be approximated by a stochastic simulation model.