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Dynamic effects of wet-dry cycles and crust formation on the saturated hydraulic conductivity of surface soils in the constructed Hühnerwasser ("Chicken Creek") catchment

Christoph Hinz, Sabine Schümberg, Anita Kubitz, Franzi Frank, Zhang Cheng, Tobias Nanu Frechen, and Ina Pohle

Brandenburg Technical University of Cottbus-Senftenberg, Hydrology and Water Resources Management, Cottbus, Germany (christoph.hinz@b-tu.de)

Highly disturbed soils and substrates used in land rehabilitation undergo rapid changes after the first wetting events which in turn can lead to ecosystem degradation. Such changes were detected during the early development of the constructed Hühnerwasser ("Chicken Creek") catchment in Lusatia, Germany. Surface substrates consisting of quaternary sandy sediments formed surface seals during the first rainfall events leading to reduced infiltration and substantially increased surface runoff. Subsequently biological soil crusts formed and stabilised the surface. The aim of this study is to investigate the factors that cause the hydraulic conductivity to decrease using undisturbed and disturbed soil samples. Based on the hypothesis that physical and biological crusts lower the hydraulic conductivity, the first set of experiments with undisturbed soil cores from the Hühnerwasser catchment were carried out to measure the saturated hydraulic conductivity using the constant head method. Measurements were done with intact cores and repeated after the surface crust was removed.
As the quaternary glacial sediments tend to display hard setting behaviour, we further hypothesised that the mobilisation of fine particles within the cores lead to pore clogging and that wet-dry cycles will therefore decrease hydraulic conductivity. A second set of experiments using the same methodology consisted of five repeated measurements of hydraulic conductivity after each drying cycle. These measurements were done with undisturbed core samples as well as repacked cores in order to assess how dry packing affects the dynamics of the hydraulic conductivity somewhat similar to the situation during the first wetting after completion of the catchment construction. For all experiments, the temporal evolution of hydraulic conductivity was measured and the turbidity of the effluent was recorded.
The results clearly demonstrated that the substrate is highly unstable. The first set of experiments showed that the removal of the crust lead generally to a decrease in hydraulic conductivity. The process of crust removal represented a severe disturbance of the surface soil which to our understanding causes particle mobilisation and subsequent pore clogging. The first hypothesis could neither be rejected nor accepted. The second set of experiments showed that the hydraulic conductivity significantly dropped in particular after the first drying event.. This was observed for both undisturbed and repacked samples. The following drying cycles further decreased the hydraulic conductivity in the repacked samples. The decrease in hydraulic conductivity was positively correlated to turbidity values in the effluent of the samples, indicating particle mobilisation in all samples.
The results imply that hydraulic properties in such substrates undergo rapid changes that depend on the temporal dynamics of atmospheric drivers, precipitation and evaporative demand, controlling the degree of wetness and the rate and degree of drying during the very early stage after placement. Associated with the dynamics of the atmospheric drivers are the biological changes due to the formation of biological soil crusts and the establishment of vegetation, both of them contributing to the stabilisation of hydraulic properties.