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Impact of soil characteristics on piping activity in a mountainous area under a temperate climate (Polish Bieszczady Mts., Eastern Carpathians)

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Piping leads to the formation of subsurface channels (pipes) by concentrated flowing water, which may result in the collapse of soil surface and formation of discontinuous gullies. The significance of piping in gully erosion with the recognition of favourable soil properties is widely described in badlands with dispersive materials and in loess-covered hilly regions. Piping conditions in other regions – without dispersive materials or without loess – draw hardly any attention. Therefore, this research aims at a better understanding of the role of soil characteristics in piping activity in a mountainous area with Flysch-derived soils under a temperate climate. The survey was carried out in the Tyskowa catchment, in the Polish Bieszczady Mts. (Eastern Carpathians), where pipes develop at a depth ranging from 0.70 to 1.30 m. We focused on soil characteristics that can impact erodibility, including particle size distribution, structure, consistency, and bulk density. These characteristics as well as selected chemical properties (pH, exchangeable cations, sodium absorption ratio – SAR) were studied in detail for 4 soil profiles with a different position in relation to collapsed pipes (CPs): on a slope with abundant CPs and on one lacking CPs, in the axis of a pipe (above it) and in a piping sinkhole. We tested a hypothesis that soil properties control the occurrence of pipes and we checked if there is any difference in soil properties on slopes with and without CPs. Moreover, we compared soil profiles within the slope with CPs. As to the hypothesis, no clear difference in soils characteristics was observed between the slope with high piping activity and the one without it. At both sites typical Cambisols profiles were developed with high clay-silt content (% silt: mean A=60, standard deviation SD=6.55; % clay: A=27, SD=8.07), which potentially enhances piping. However, the profiles at the site above CPs (in the axis of a pipe, where potentially a pipe will develop) and in a sinkhole are characterised by intense biological activity and development of soil structure in deeper horizons (angular and subangular blocky down to 90-105 cm). Comparing the sites without CPs, this activity is lower and aggregate soil structure is developed down to 50-60 cm. The chemical properties do not differ. The analysed soils are not dispersive (e.g. SAR <0.1). To summarize, intense biological activity favours the development of pipes in the study area. The development of soil structure allows water infiltration down the profile, which is necessary to pipe development. Combining all results from the soil profiles and the depth of pipes indicate that pipes develop between solum (A and B horizon) and subsoil (C horizon).
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