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Impact of soil characteristics and land use on piping erosion – a case study from Belgium.

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Soil piping or tunnel erosion refers to the formation of linear voids by concentrated flowing water in soils or unconsolidated sediments, which can cause topsoil collapse and formation of discontinuous gullies. Piping has been associated primarily with semi-arid environments, yet piping is considered to be a critically important soil erosion process in a wide range of climatic regions. Soil characteristics and land use play an important role in the development of piping. In this study the hypothesis is tested that discontinuities in the soil profile favour piping erosion in loess-derived soils in a temperate humid climate. We focus on discontinuities in soil profile characteristics such as texture, saturated hydraulic conductivity, penetration resistance and bulk density; all measured for each soil horizon until a depth of at least 40 cm below the pipes (ca. 1.30 m). The biological activity in the soil is studied for the different land use types at the same depths on horizontal cross-sections of 1 m^2. Twelve sites were selected in the Flemish Ardennes (Belgium): 4 pastures with collapsed pipes, 4 pastures without collapsed pipes, 2 sites under arable land without collapsed pipes and 2 sites under forest without collapsed pipes. Furthermore, the effect of the land use history on pipe collapse occurrence was evaluated for a database of 84 parcels with collapsed pipes and 84 parcels without collapsed pipes.
Against all expectations, no clear discontinuities in saturated hydraulic conductivity, penetration resistance or texture were found at soil depths where subsurface pipes occurred. However, pastures with piping had significantly more earthworm channels and mole burrows at larger depths (at > 120 cm depth: more than 200 earthworm channels m^{-2} on average) than pastures without piping, arable land or forest (at > 120 cm depth: few or no earthworm channels left). Although the small horizontal surface area (1 m^2) studied, the same trend was observed for mole burrows. The presence of moles is related to the abundance of earthworms, being their major food. Throughout the soil profiles, the saturated hydraulic conductivity was generally low (median of 0.12 mm/h for all pastures) but highly variable. The highest values (maximum 275, 174 and 1710 mm/h for pasture, arable land and forest resp.) observed at shallow depths are explained by macropore flow (e.g. earthworm channels). Earthworm activity favours rapid vertical infiltration through macropore flow and mole burrows may favour lateral flow in the soil profile (during rising water tables) which may lead to piping. It can therefore be hypothesized that piping is triggered by high temporary water tables together with important biological activity (earthworms, moles) in pastures if other conditions in terms of topography (i.e. zone with subsurface flow convergence) and lithology are met. Although no textural discontinuity was observed at the depth of the pipes, the deeper clay layers below the loess layer may have an indirect influence by creating temporary water tables and springs on hill slopes. The land use history was not different for the pastures with and without piping. The results indicate that the biological activity, in combination with a sufficiently high water table, controls the development of soil pipes. Yet more research is needed to better understand the interactions between groundwater table positions, biological activity and piping.