

## **Piping dynamics in mid-altitude mountains under a temperate climate: the Bieszczady Mts., the Eastern Carpathians**

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Soil erosion is caused not only by overland flow, but also by subsurface flow. Piping which is a process of mechanical removal of soil particles by concentrated subsurface flow is frequently being overlooked and not accounted for in soil erosion studies. However, it seems that it is far more widespread than it has often been supposed. Furthermore, our knowledge about piping dynamics and its quantification currently relies on a limited number of data available for mainly loess-mantled areas and marl badlands.

Therefore, this research aims to recognize piping dynamics in mid-altitude mountains under a temperate climate, where piping occurs in Cambisols, not previously considered as piping-prone soils. The survey was carried out in the Bereźnica Wyżna catchment (305 ha), in the Bieszczady Mts. (the Eastern Carpathians, Poland), where 188 collapsed pipes were mapped. The research was based on the monitoring of selected piping systems located within grasslands (1971-1974, 2013-2016).

The development of piping systems is mainly induced by the elongation of pipes and creation of new collapses (closed depressions and sinkholes), rather than by the enlargement of existing piping forms, or the deepening of pipes. It draws attention to the role of dense vegetation (grasslands) in the delay of pipe collapses and, also, to the boundary of pipe development (soil–bedrock interface). The obtained results reveal an episodic, and even stochastic nature of piping activity, expressed by varied one-year and short-term (3 years) erosion rates, and pipe elongation. Changes in soil loss vary significantly between different years (up to  $27.36 \text{ t ha}^{-1} \text{ y}^{-1}$ ), reaching the rate of  $1.34 \text{ t ha}^{-1} \text{ y}^{-1}$  for the 45-year study period. The elongation of pipes also differs, from no changes to 36 m during one year.

The results indicate that soil loss due to piping can cause high soil loss even in highly vegetated lands (grasslands), which are generally considered as areas without a significant erosion problem. The scale of piping in the study area is at least by three orders of magnitude higher than surface erosion rates (i.e. sheet and rill erosion) under a similar land use (grasslands), and it is comparable to the scale of surface soil erosion on arable lands. It means that piping is an important sediment source for fluvial systems, and it leads to significant soil loss in mid-altitude mountains under a temperate climate.

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