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## **Dynamic geomorphometric study of the erosion of the Zagyvaróna spoil tip using digital photogrammetry**

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Large-scale mining activity took place in the Salgótarján coal basin (Nógrád county, Hungary) until the mid-1900s. The byproducts of the processing of the mined coal and iron ore, saturated in heavy metals, are still exposed to erosion in the form of alien spoil tips in the Medves plain, in the area of Zagyvaróna. Due to global warming, the precipitation distribution in Hungary might show a variable trend, so the number of precipitation events with higher intensity may increase, which could have a major impact on the landscape erosion dynamics. The aim of this study was to analyze the dynamic geomorphometric changes of the spoil tip in the area, particularly due to water/precipitation erosion, and to estimate future morphological changes.

Digital photogrammetry and geospatial techniques were used to determine the rate and dynamics of the changes in the spoil tip due to erosion over the studied period. For the time-series analysis, we used scanned, digitalized versions of archived analog aerial photographs obtained from the Lechner Knowledge Centre. The 3D digital point cloud created from the 1976 aerial photographs was compared with the 3D point cloud generated from the images taken in 1988. Subsequently, UAV surveys were carried to record the current state and to study the dynamics of the erosion of the spoil tip over a period of approximately 50 years. To estimate future changes, 10-minute precipitation data from two automatic National Meteorological Service stations (nearest to the study area) were analyzed for the period of 2002 to 2022. The analysis of the areas most exposed to future erosion was performed in ArcGIS Pro.

A comparison of the point clouds showed that the spoil tip lost almost a quarter of its volume during the study period due to erosion activities. Further volume analyses revealed that the volume loss of the slag cone resulting from erosion activities is estimated to be 600 m<sup>3</sup> per year on average. Despite the variable trend in the climate of Hungary, due to the local topography, no significant increase in rainfall intensity is expected in the near future, but the steep morphology of the spoil tip is expected to increase the erosion rate.

Due to increased erosion, more contaminants could be transported to the surrounding soils and groundwater. Continuous monitoring of the erosion activity and the spread of contaminants will provide a more accurate conclusion on the environmental impact of the spoil tip.