

## **Flow in the unsaturated zone to quantify Acid Mine Drainage: numerical and analytical approaches**

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**Abstract** We study flow conditions in the unsaturated zone to quantify Acid Mine Drainage (AMD) in mine-waste piles using the van Genuchten model. Both analytical and numerical methods are applied to estimate the fundamental variables governing flow in the unsaturated zone: water saturation, water velocity (i.e. travel times), Darcy velocity, water pressure and head. We use numerical solutions, obtained with the code MIN3P to estimate saturation and travel times in multi-layered systems, for three hypothetical scenarios. A simple, novel analytical approach is developed for vertical flow in homogeneous media to obtain order-of-magnitude estimates of saturation and water velocity. This solution is applied to the hypothetical scenarios and shows that variability of hydraulic conductivity (up to four orders of magnitude) has little effect on travel times.

**Key words** vadose zone; mine-waste piles; unsaturated flow; groundwater