Risk assessment of landslides of contaminated soil into rivers - An example from the Swedish west coast

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Introduction: The aim of this study was to highlight a not yet recognized hazard for mass failure (landslides) of contaminated soils into rivers and to provide an understanding of important interactions of such events [1]. The Göta Älv river valley in Sweden has the highest landslide frequency in the country. The landslides are shallow rotational slides in clayey material, moving very rapidly when occurring. Also, the valley has a long industrial history and hidden legacies from the past. It has now become clear that contaminated sites in areas are subject to risk for landslides and subsequent contamination of the fresh water supply for about 700,000 people. As an example, a landslide in 1957 caused a large part of a sulphite factory to slide into the river. Three people died, the river was repressed and caused a 6-8 m high wave to propagate upstream. Environmental consequences are not known.

The present study focused on evaluating the methods available for assessing landslide risk for the contaminated industrial areas along the south eastern part of the Göta Älv river valley that have been identified as presenting minor to large risks for the health and environment according to the Swedish Environmental Protection Agency (SEPA) classification system. To do this, the spatial information on the risk for landslides has for the first time been combined with the information on the location and characteristics of the contaminated areas according to the mapping by the Swedish Geotechnical Institute (SGI) and the SEPA, respectively.

The objectives of the study were to: (i) Review current Swedish risk assessment methodologies for contaminated areas and landslides, and analyse their capability to quantify the risk of contaminated areas being subject to landslides. (ii) Investigate the presence of contaminated areas at landslide risk along the Göta Älv river valley. (iii) Provide an overview of the national methods for landslide risk analysis and for environmental risk classification, followed by a comparison between the methods and the results from the superposition of the two methods for the study site. (iv) Make a first attempt to conceptualise the release and transport mechanisms under such circumstances, based on reviewed literature.

Methods: The present study investigated this hazard, focusing on the south eastern part of the Göta Älv river valley by combining spatial information on the risk for landslides with the information on the location and characteristics of contaminated areas according to risk mapping by the SGI and the SEPA. The approach by combining risk assessment methods is evaluated and discussed. The release and transport scenario of the hazard is described and conceptualised in general terms in a system that is inherently interdisciplinary.

Results: The slope stability (stability level) and landslide consequence classes from the SGI mapping and the environmental risk class from the SEPA-mapping are visualized on altogether 13 maps and summarised in a table for each industrial site involved in the study. The maps, together with the table, illustrates clearly that the combined analysis reveals certain spots that seem at low risk but are, in fact, at higher risk. Combining the data showed that of 31 potentially contaminated sites at least 8 had moderate to high probability for landslide, and of these 8 sites, 5 were classified as having a high or very high environmental risk. These findings had not been revealed when the data had only been considered separately. In addition, some sites classified as very high environmental risk also have risk for landslide. The "actual" risk could therefore be even higher than the highest environmental risk class actually suggests.

Discussion: While the combined data now provide a more solid basis for decisions, the study also revealed inherent difficulties when combining data based on different methods, and further studies are needed for assessing impact and consequences in combined analyses. The conceptualisation made was a first attempt to describe possible governing processes and properties. Continued study is especially needed given the climate change expected to occur over the next hundred years, which will increase the probability of mass failure in contaminated areas in many parts of the world where precipitation is predicted to increase.

References: [1] Göransson et al. (submitted). Risk assessment of landslides of contaminated soil into rivers: A study of the Göta Älv river valley, Sweden.