Mathematical and Computer Modelling 54 (2011) 1823–1828

Contents lists available at ScienceDirect

Mathematical and Computer Modelling

journal homepage: www.elsevier.com/locate/mcm

Use of machine learning techniques to analyse the risk associated with mine sludge deposits

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ARTICLE INFO

Article history:
Received 14 October 2010
Received in revised form 9 November 2010
Accepted 17 November 2010

Keywords:
Sludge deposits
Risk
Machine learning

ABSTRACT

Sludge deposits resulting from mine extraction activities and accumulating in the proximity of production centres have an important potential impact on their surroundings.

This potential impact needs to be evaluated by quantifying the risk of an accident on the basis of a joint study of factors affecting the probability of occurrence, environmental, populational and infrastructural vulnerability factors and intrinsic and extrinsic risk factors.

The problem is non-linear, and this fact, combined with the high number of risk conditioning variables, justifies using machine learning techniques to estimate risk. A comparison of results for supervised versus non-supervised learning techniques confirms that the former adapts better to the problem than the latter.

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1. Introduction

Intensive mining in the Autonomous Community of Galicia in northwest Spain has a significant environmental impact on the area in the vicinity of the mines. The environmental risk frequently arises from sludge deposits, which could overflow or whose retaining walls could erode or break.

Therefore, sludge deposits, an inevitable consequence of mining and transformation activities, require the risk associated with the accumulated sludge to be evaluated, measured and quantified.

In recent years, a number of institutions and environmental agencies [1–3], and also researchers [4–7], have developed methodologies to evaluate the environmental risk in various fields. Traditional methodologies have calculated the environmental risk by estimating and rigidly weighting each of the factors conditioning the risk.

In our article, we propose a more flexible approach to constructing a risk index from the criteria of an expert familiar with each deposit studied and capable of assigning, on the basis of technical criteria, a hazard rating to each deposit that indicates the potential impact on the environment were the retention walls to fail. Once expert criteria were defined, with a view to implementing automated simulation, different machine learning techniques were implemented and compared by analysing and processing a set of input variables that condition the probability of a retaining wall failure in terms of the vulnerability of the population, the vulnerability of the infrastructure, the vulnerability of the environment and the intrinsic and extrinsic hazards associated with an event.

The large number of variables evaluated for risk, combined with the small sample size and the need to develop a flexible model (with no rigid weighting of the input variables) that would be capable of simulating, generalizing and adapting to expert criteria in evaluating the particularities of the deposits studied, justified the use of machine learning techniques to construct the index. In our research, therefore, we examined the potential of this kind of algorithm for resolving this problem. In [8–12], other indexes and expert systems applied in different mining fields and modelled using machine learning techniques are described.

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doi:10.1016/j.mcm.2010.11.066