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Calculation of an interaction index between extractive activity and groundwater resources

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There are two underground resources intensively exploited in Wallonia (the southern Region of Belgium): groundwater and rock. Groundwater production rate is about 380*106 cubic meter per year from which 80 % is used for drinking water (SPW-DGO_3, 2014). Annual rock extraction is about 73*106 tons per year and 80.6% of the materials are carbonate rocks (Collier and Hallet, 2013) corresponding to the most important aquifer formations.

Given the high population density and environmental pressures, lateral quarry extensions are limited and the only solution for the operators is to excavate deeper. In this context, the aquifer level of the exploited formation is often reached and dewatering systems have to be installed to depress the water table below the quarry pit bottom. This affects the regional hydrogeology and, in some cases, the productivity of the water catchments is threatened.

Using simple geological and hydrogeological parameters, an interaction index was developed to assess the interaction between extractive activity and groundwater resources and, in consequence, to define how far the feasibility study should go into detailed hydrogeological investigations.

The interaction index is based on the equation used in the assessment of natural hazards (Dauphiné, 2003), which gives: Interaction = F (Quarry, Aquifer). The interaction is the risk, which is equal to a function where the hazard is defined from parameters corresponding to the quarry and vulnerability from parameters related to groundwater resources. Six parameters have been determined.

The parameters chosen to represent the hazard of a quarry are: the geological, the hydrogeological and the piezometric contexts. The parameters chosen to represent the vulnerability of the water resources are: the relative position between the quarry and the water catchment (well, spring, gallery, etc.) sites, the productivity of the catchment and the quality of the groundwater. Each parameter was classified into four categories. A quarry matches with a combination of these categories depending on its current state. This quarry state, as will the index, can vary over time according to its extension.

In order to correlate and properly weight these parameters in the calculation of the interaction index, the discrete choice model has been used (Train, 2009). Depending on the interaction index value, the quarry will present a low, a medium, a high, or a very high impact on the regional hydrogeology. This will determine the level of investigation of the feasibility study, namely (1) a geological and hydrogeological contextualization, (2) a continuous piezometric monitoring, (3) a steady flow mathematical modeling and, the most detailed, (4) a non-steady flow transient state model.