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Vulnerability mapping of a vast karst hydrosystem. Application and adjustments of PaPRIKa method to the Fontaine-de-Vaucluse catchment (France)

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Abstract

The Fontaine-de-Vaucluse spring (south-eastern France) is one of the largest karstic spring in Europe, with an average discharge rate of $20\text{m}^3\text{s}^{-1}$. This spring is the unique outlet of a vast catchment area of about 1100km^2 . Since human activities and global changes increase the pressure on fresh water resources, such a large reservoir needs to be protected for future exploitations. The vulnerability assessment is therefore necessary to sustainable groundwater management. Mapping the vulnerability of Fontaine-de-Vaucluse catchment can guide the evolution of Human activities in order to preserve the groundwater quality.

The intrinsic vulnerability analysis refers to specific hydrogeological settings and highlights the characteristics of the hydrosystem that may increase the vulnerability [2]. Therefore contaminant properties are not considered in this analysis. The intrinsic vulnerability property is a dimensionless quantity relative to the studied area [3]. The multi-criteria method PaPRIKa has been developed for mapping the intrinsic vulnerability of karst hydrosystem [1]. This method is based on four criteria namely the Protection (P), the Reservoir (R), the Infiltration (I) and the Karst features (Ka). Each criterion is mapped independently and classified into five indexes from lowest to highest vulnerability. The final vulnerability map is then calculated by combining the four criteria according to a weighting relation. Consequently, the larger is the

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catchment area, the more time consuming is the task.

This study aims to produce a vulnerability map of the Fontaine-de-Vaucluse catchment with PaPRIKa. The main challenge of applying PaPRIKa to such a vast catchment was to report qualitative information of the vulnerability at the local scale with a consistent representativeness at the regional scale. The extension of the catchment area implies also a larger range of possibilities for each parameter and each criterion and a huge database. For instance we have to deal with a wide range of altitudes (from 89 m to 1912 m a.s.l), a large range of mountain slopes (0 - 90°), various carbonate formations (from marlstone to limestone), the thickness of carbonate series (more than 1500m including an unsaturated zone 750 m thick) and numerous soil types. All these parameters cause a large spectrum of hydrogeological environments and could justify adjustments of PaPRIKa method. As a consequence, a second challenge of the vulnerability mapping was to automate all phases in order to test and improve these method's adaptations. It enables also searching for the most consistent criteria weighting relationship and is less time consuming.

The whole catchment vulnerability map has been carried out. It is made of 4 vulnerability classes. Thus different hydrological environments can lead to a same class. The most vulnerable zones cover 2% of the area, including sinkholes and major faults. Indeed such features can act as a direct transfer zone towards the saturated zone. 45% of the catchment area has a high vulnerability index. These zones correspond mainly to highlands where the infiltration rate is high. An intermediate vulnerability index is attributed to 48% of the area, mainly corresponding to mountainsides. Finally, the lowest vulnerability index is attributed to 5% of the area mainly characterised by very steep slopes where infiltration rate is the lowest.

In conclusion, the PaPRIKa method has been successfully programmed and applied on a vast karst hydrosystem. The obtained distribution of vulnerability classes seems realistic and consistent at both scales, regional and local. At large scale the vulnerability map is globally linked with main geomorphological units. On the other hand, at the local scale the vulnerability map is mostly influenced by karst features that drive hydrodynamics. The vulnerability map provides a relevant support for resource management.

Keyword Vulnerability mapping, PaPRIKa method, karst protection, Fontaine de Vaucluse catchment area.

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