

SUSTAINABILITY IN THE EXPLOITATION OF AN AQUIFER FOR AGRICULTURE AND URBAN WATER SUPPLY USES

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Abstract

To the unconfined aquifer Montes Torozos (Spain). The high vulnerability characteristics and the most dangerous elements were taken under consideration (e.g. inmision of return irrigation from agricultural products) fertilizers, Hydrocarbons, radioactive materials). The identification of their source. The simulations took into consideration the connection between the capital of the province (Valladolid) to Villanubla airport and between Valladolid to the electrical transformer substation too, located in the south-west edge of the hydrogeological unit of the Montes Torozos.

Keywords: water management, aquifers, vulnerability, sustainability.

INTRODUCTION

The perception of water as a limited and fragile resource, due to deterioration by human actions, represents a limiting factor when considering the region's sustainable development. The water in Monte Torozos aquifer drains to the Douro river watershed and goes through the provinces of Valladolid and Palencia (Spain), occupying an area of 1000 km² (Figure 1). The population exceeds 47000 inhabitants spread over 48 municipalities. A dry Mediterranean climate predominates in the study area, with a median temperature value of 11.14°C, precipitation of 456 mm/year and evapotranspiration of 312 mm/year, as the main climatic features¹.

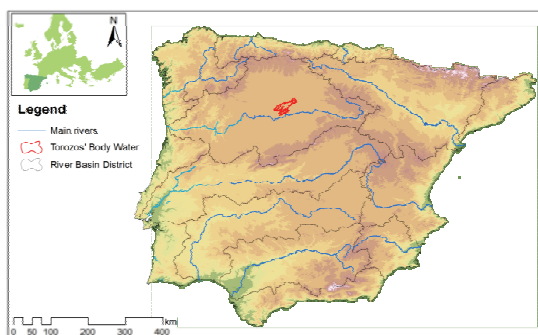


Figure 1. Situation map

The water balance shows 178 mm/year of useful rainfall that can reach and recharge the aquifer. Through processes of infiltration the substances present on the surface, accordingly to the respective dissolution constants and the particle size are transported, reaching the groundwater.

The aim of this paper is a risk and vulnerability analysis into the aquifer of Montes Torozos using the DRASTIC index map, and a sustainability water management assessment.

The regulatory framework according this goals in Spain are the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR), "Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy, and the CAP framework regulatory established by EC No 1782/2003 that establishing common rules for direct support schemes under the common agricultural policy and this amending Regulations

MATERIALS AND METHODS

In this approach two vulnerability methods were used: DRASTIC index and the Susceptibility index (SI). The DRASTIC

method is a method for measuring the intrinsic vulnerability (Aller et al., 1987), and it's well accepted in many studies (e.g. M.T.D., Albuquerque et al., 2013) On the other hand, SI stands for the extrinsic or specific vulnerability. The specific vulnerability assessment method, (Ribeiro, 2000), is an adaptation of the DRASTIC and was created for evaluating aquifer vulnerability to land use impact. The impact of natural and anthropogenic activity assessment is a target issue to a sustainable groundwater resources' policy guidance in overcoming urban water governance challenges.

The period analyzed in this study was 1960-2010. The data, collected from CORINE Land Cover project of European Environmental Agency (EEA), have been statistically processed and interpreted, to characterize the spatiotemporal evolution of land use. The results has been contrast using remote sensing and photo interpretation techniques.

RESULTS AND DISCUSSIONS

The Tertiary sedimentary free aquifer is included in the Douro river watershed with a slight tilting towards south-west. Geologically, could be considered as a horizontal limestone strata laying on a detrital mixed formation named as Facies Cuestas (Sanchez F.J., 2013). The Facies Cuestas is the lower substrate formed by limestone and a series of soft clay loam-gypsum materials. The limestones are grey, hard and showing a microcrystalline structure in banks of varying thickness separated by marly intercalations. The area corresponds to an atectonic zone only modified by diagenetic fracturation, allowing the development of karst channels.

The Torozos aquifer, consists on horizontal limestone (Miocene) with loamy collations supported on the detrital Tertiary (Figure 2). Its overall thickness is approximately 6-10 meters, but can reach 30 meters promptly and works as an unconfined aquifer.

The aquifer recharge is due to rainfall and drains radially, along the aquifer's perimeter, through spring and feeding the river's base flow and the extraction wells. The aquifer shows issues of quick crack of the water levels due to its low regulatory capacity. The amount

of water resources is enough, showing an annual or biennial regulatory capacity, depending on rainfall to sustain the supply of the population, though. Due to its nature, the unconfined aquifer is extremely vulnerable to topical and diffuse pollution.

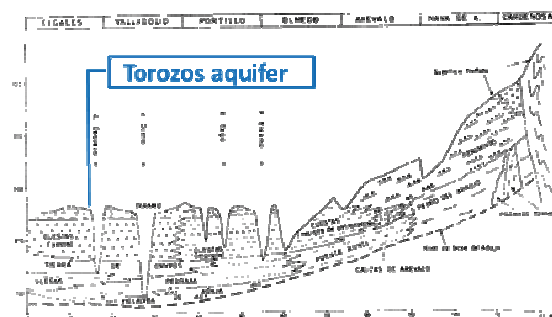


Figure 2. Regional geological profil

The occurrence of dangerous substances in core sites such as the airport of Villanubla, the electrical transformer plant of Mudarra, the Villanubla prison, the Villanubla industrial area combined with the traffic of dangerous goods through the entire area, and mainly the agricultural activities, all of them makes the Torozos aquifer a sensitive unit in need of accurate monitoring strategies (Figure 3).

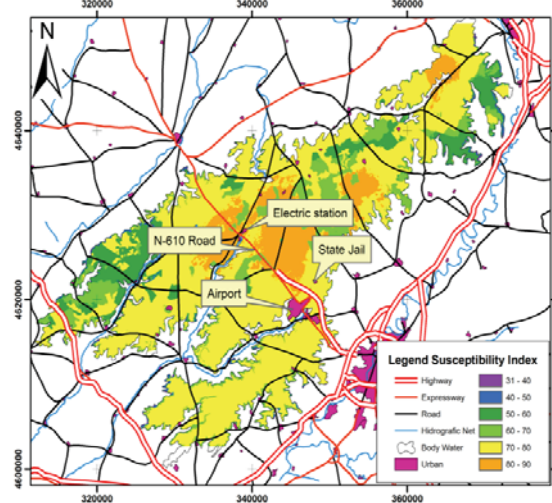


Figure 3. IS and hazard elements map

The identification of dangerous goods source location and the transportation of them has been the starting point of this study. This work aims the fitting of a numerical dispersion model for the most likely sources of emission and impact of pollutants into groundwater. The dispersion simulations took into consideration the connection between Valladolid, the capital

of the province, to Villanubla airport and between Valladolid to the electrical transformer substation, located in the south-west edge of the hydrogeological unit of the Montes Torozos.

The aquifer's hydrogeological conceptual model can be represented by the following scheme (Figure 4), where the existing inputs and outputs are represented.

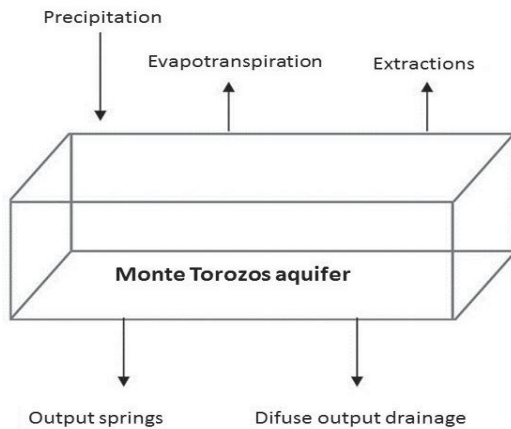


Figure 4. Aquifer's hidrogeological conceptual model

The starting dataset concerns to the following attribute1:

- ETR - homogeneous and isotropic, estimated from the Turc's equation (312 mm/year)
- Recharge - homogeneous and isotropic precipitation, minus the ETR (178 mm/year)
- Edge Drainage - estimated (10 hm³/year)
- Initial Piezometric has been computed using visual modflow
- 211 pumping wells grouped into 63 wells fields (total extracted volume 9 hm³/year)
- 32 perimeter springs (output 10 hm³/year)

The computed outputs are: parametric evolution, flow vectors, fluid balance, and direction of the particles over a year (Figure 5).

SUSTAINABILITY ASSESMENT

The sustainability assessment in water resources management is carried out from the weighting of the following indicators and drafted on Figure 6:

- reliability of the water supply,
- Resilience against environmental impacts
- System vulnerability assessment
- Integrity of the environmental system,

- Equity on distribution of water
- Economic feasibility of the water exploitation.

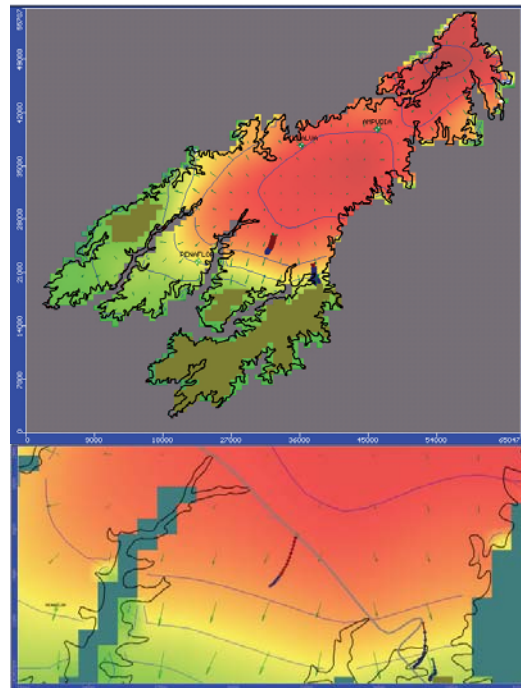


Figure 5. Model outputs

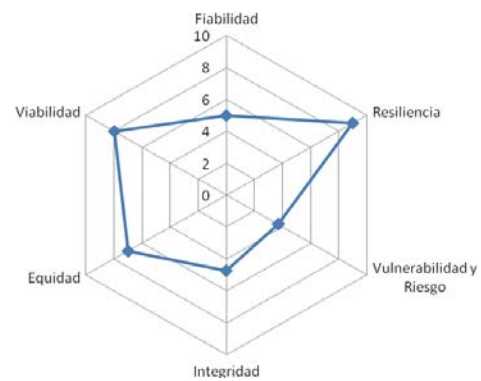


Figure 6. Aquifer's sustainability assessment

CONCLUSIONS

The main conclusions extracted from the Torozos Limestone aquifer study can be summarized on:

1. The hydrological budget is positive, with estimated resources (100 hm³/year), more than the annual withdrawal and recharge sum (20 hm³/year).
2. Being an unconfined aquifer is extremely vulnerable to direct emission of pollutants from topical and diffuse, showing high

values of intrinsic and extrinsic vulnerability indicators.

3. Despite the existence of enough water volume it must be stressed its low quality since there are strong restrictions on its use and management.
4. The fine flow model calibration has allowed to detect an annual inertia response of four months and a water renovation period of two years.
5. This model can be used for scenarios predictions for different management situations.
6. By the high sensitivity observed concerning seasonal variations, this aquifer can easily be retrieved without a hard and expensive intervention, only with the adoption of good farming practices.
7. The sustainability of the water body is good, primarily due to its high resilience and viability management.

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