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RESILIENCE OF GREAT SEDIMENTARY BASIN AQUIFERS: WATER SECURITY AND SPAs

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1. Introduction

- The resilience of the aquifers is unknown in many cases and it is a key capacity to get a sustainable management.
- In this poster an analysis of the resilience capacity of a great detrital sedimentary basin aquifer is made through the case study of the Las Salinas spring (an old discharge area today dissapeared due to the intensive groundwater exploitation).
- The concepts of resilience and water security has an intensive relationship. The resilience of an aquifer is defined as the capacity to deal with perturbations without modifying its structure and functioning. The concept of water security is defined as the reliable provision of quantitatively and qualitatively acceptable water for health, the production of goods and services, and the livelihoods, along with an acceptable level of water-related risks (Gray and Sadoff 2007).

2. Methodology

- Long term trends analysis of quantity and quality data.
- Explorating the aquifer's resilience components.

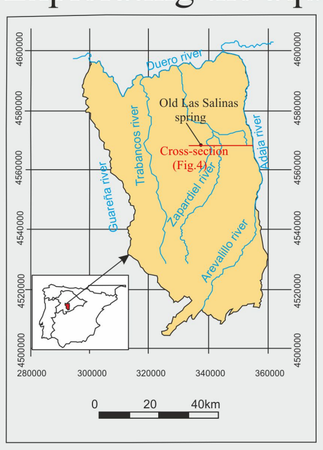

Fig. 1. Location of the old Las Salinas spring in the Medina del Campo GWB and cross-section of Fig. ?.

- The analysis of the resilience of an aquifer implies an in-depth knowledge of the aquifer system, in its physical aspects (geometry, storage volume, etc), but also, fundamentally, in its dynamics aspects, either for qualitative and quantitative processes.
- Case study: Las Salinas spring (Fig. 1), an old discharge area located in Medina del Campo groundwater body, an intensively exploited aquifer since the 1970's (Figure 3, Table 1).

3. Historical evolution

Las Salinas spring. There are references dating from the XVII century reporting the influx of people to this place in search of mud baths.

The Palacio de las Salinas spa was born in 1891.

Current shallow well to supply Palacio de Las Salinas spa.

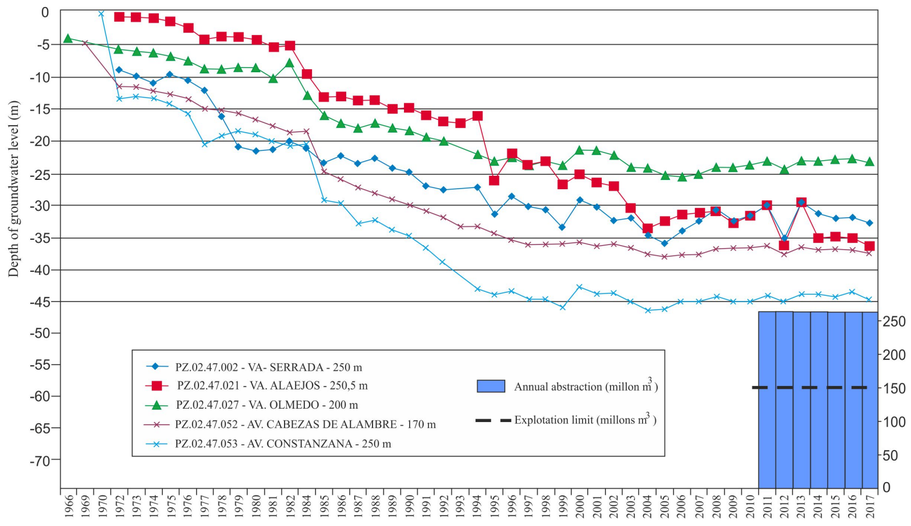

Fig. 3. Historical records available of some piezometers in the Medina del Campo aquifer. The most intensive groundwater exploitation took place between 1970 and 2000. Since 2001 the system seems to reach a new state of equilibrium.

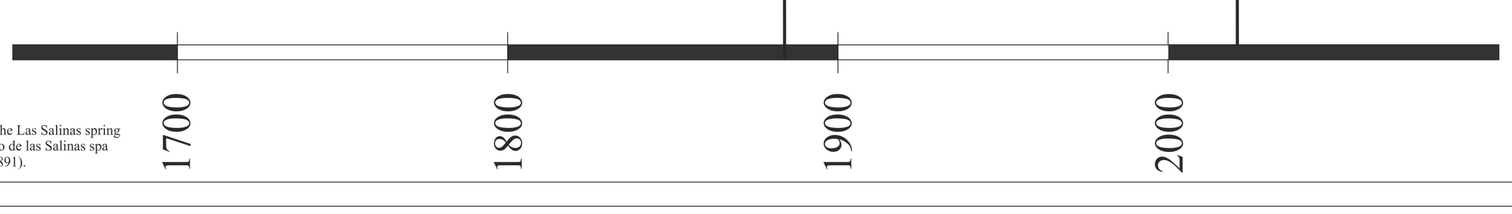

Fig. 2. Historical evolution of the Las Salinas spring location and birth of the Palacio de las Salinas spa (still functioning today since 1891).

Table 1. Main characteristics and components of the aquifer water balance (for Medina del Campo GWB) (data from MIRAME-Duero, 2020).

Aquifer extension	3,700 km^2
Recharge	149 Mm^3
Estimated pumpings (2011-2019)	273 Mm^3

4. Results and discussion

- Large sedimentary basins often host large detrital aquifers whose resilience to various impacts is, a priori, large.
- However, accumulation of shocks at the local level leads to changes at regional level.
- Basis of the resilience analysis: from what to what? From groundwater abstractions (identified as the main impact) to the aquifer.
- This analysis takes into account an integration of previous literature data and reports, and new data obtained by the authors under the NAIAD H-2020 Project.
- Key data: chemical analysis pictures which lead to define the chemical evolution conceptual model shown in Figs 4 and 5.
- The GWB of Medina del Campo may present symptoms of water insecurity, which is a contradiction to its dimensions as an aquifer, and a manifestation of the deterioration of its resilience.

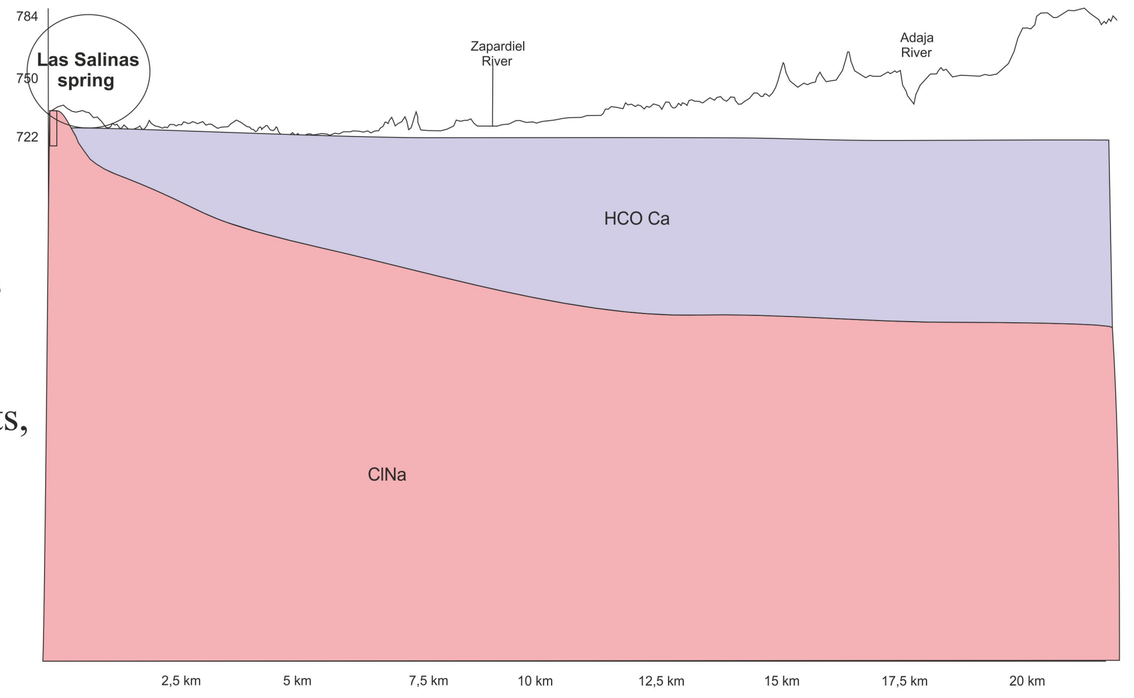

Fig. 4. Graphical schemme of hydrochemical facies in a W-E cross section from Las Salinas spring till Adaja river.

1892 — Flowing well — **1927** — No flowing well — **1997** — **2000's** — Increase of groundwater decline HCO3 Ca water inputs — **2019** — Replacement of ClNa waters by HCO3 Ca waters

Ministerio de Fomento (1892):
Anhydrous salts in 1L-water sample:

Sodium sulfide	0.0496 gr
Sodium bromide	0.0045 gr
Sodium chloride	55.9419 gr
Magnesia chloride	4.9789 gr
Soda sulfate	4.9020 gr
Lime sulfate	2.5980 gr
Organic material	0.0300 gr
Iron oxide, Phosphoric acid, Potash, Litide, Lodine	Minimum quantities

TOTAL.....72,6541 gr

Within a radius of 150 m there were: one spring or main well, 3 similar water pools and up to 53 ponds for obtaining mother waters (Ministerio de la Gobernación, 1892, 341).

Castells y Ballespí (1913) reports 4 wells called: Tenacidad, Manolito, Santa Elisa and Anita, all of them with sodium chloride waters.

GOEBAME (1927) reports 3 wells called: Tenacidad, Manolito, Santa Elisa.

GOEBAME (1927): Manolito well

Cl	9.369720 gr
HCO	0.571980 gr
SO	6.629722 gr
Na	7.087239 gr
K	0.041 gr
Mg	0.870717 gr
Ca	0.628490 gr
CE	-
Tª	-
pH	-.

GOEBAME (1927): Santa Elisa well / Tenacidad well (Only information on cations is provided)

	Santa Elisa well	Tenacidad well
Cl	-	-
HCO	-	-
SO	-	-
Na	2.620086 gr	1.218431 gr
K	0.041 gr	0.009100 gr
Mg	0.223786 gr	0.130401 gr
Ca	0.307106 gr	0.309418 gr
CE	-	-
Tª	-	-
pH	-	-

IGME (2001): (Sample not specified)

Cl	1060.9 mg/L
HCO	192.8 mg/L
SO	283.2 mg/L
Na	400 mg/L
Mg	83.6 mg/L
Ca	303 mg/L
CE	3,640 MicroS/cm
Tª	17 ºC
pH	7,7

Hydrochemical facies:

SIEMCALSA (2007): Manolito well

Cl	266.2 mg/L
HCO	137.3 mg/L
SO	139.5 mg/L
Na	163.3 mg/L
Mg	26.8 mg/L
Ca	116.7 mg/L
CE	1425 MicroS/cm
Tª	13.9 ºC
pH	8.51

Hydrochemical facies: Bicarbonate water-sodium-calcium chloride

Protection perimeter: 500 m (insufficient).

Sample taken in June-2019 by the authors: (current well to supply the spa)

Cl	225 mg/L
HCO	426 mg/L
SO	299 mg/L
Na	313 mg/L
K	11 mg/L
Mg	49 mg/L
Ca	56 mg/L
CE	1680 MicroS/cm
Tª	
pH	7,95

Hydrochemical facies: Bicarbonated sodical

Fig. 6. View of the external pool of the current Palacio de las Salinas spa.

Fig. 5. Key data of chemical analysis of groundwater taken from wells inside the Palacio de las Salinas spa (in different wells and different years).

5. References

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6. Acknowledgements

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