United Nations Educational, Scientific and Cultural Organization · Intergovernmental Hydrological Programme

DRIN CORDA

Global Water Partnership Mediterranean

IW LEARN

Session 5
Groundwater quality monitoring and data reporting

Dr. Josep Mas-Pla

UNESCO Technical Webinar - October 2020
Guidelines for Monitoring Strategies in Transboundary Aquifers: Goals, Methods and Tools.
The Case of the DRIN project (ALB-MTN)

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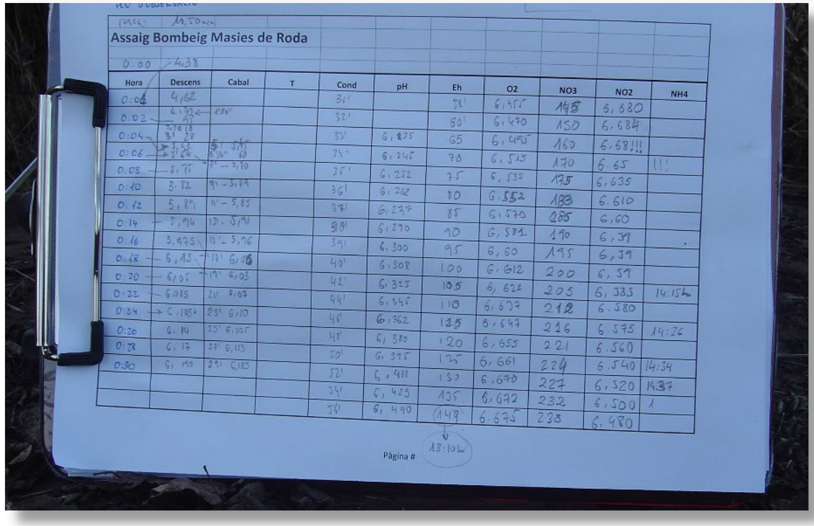

Photos: J M-P

1. Justification

Gathering data must be based on common and well-established methods.

They should consider,

a) Fulfilling the ***legal requirements***,

b) Meeting high ***field-work*** and ***analytical*** standards,

c) Adequate ***data treatment & plotting***,

d) Interpreting results according to the problem need, which may require some geochemical modelling.

Photos: J M-P

2. Monitoring quality requirements

For surveillance monitoring:

a) The **core suite** will comprise DO, pH, EC, nitrate, ammonium, temperature, a suite of major and trace ions plus, where appropriate, selected indicators. Include redox potential (Eh) as well,

b) Parameters indicative of the **risks to** and **impacts on** groundwater from identified pressures,

c) It is not necessary to monitor each of the **priority substances** including in the WFD and subsequent legislation.

2. Monitoring quality requirements

For operational monitoring:

a) In addition to the core parameters, **selective parameters** will need to be monitored at specific locations, where groundwater bodies can be "at risk".

b) Groundwater **threshold** values must be taken as references for quality status.

c) Parameter selection will be made on a **case-by-case basis**, and be influenced by other information including existing water quality data and local knowledge.

d) The chemical monitoring suites must be **reviewed on a regular basis** to ensure that they provide representative information.

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3. Gathering quality field data

Why hydrochemistry?

a) Water is not just H2O; it has ***solutes*** in it.

b) Solutes inform about ***geochemical processes***, bringing up some knowledge about the hydrogeological system.

c) Some solutes may be ***harmful*** for human uses, even for the whole environment in a broader sense.

d) It is an indicator of environmental health and determines which ***actions*** must be conducted to preserve water resources quality.

e) … and it is fun!!!

Photos: J M-P

3. Gathering quality field data

What data are we looking for?

Table 10.2 Common Inorganic Solutes in Water

Cations	Anions	Other
	Major Constituents	
Calcium (Ca^{2+})	Bicarbonate (HCO_3^-)	Dissolved CO_2 ($H_2CO_3^*$)
Magnesium (Mg^{2+})	Chloride (Cl^-)	Silica ($SiO_2(aq)$)
Sodium (Na^+)	Sulfate (SO_4^{2-})	
Potassium (K^+)		
	Minor Constituents	
Iron (Fe^{2+}, Fe^{3+})	Carbonate (CO_3^{2-})	Boron (B)
Strontium (Sr^{2+})	Fluoride (F^-)	
	Nitrate (NO_3^-)	

Plus, metals ot trace elements, organic produits (natural and man-made) and isotopes.

Fiits, 2013.

Photos: J M-P

3. Gathering quality field data

Field sample collection: how?

Photos: J M-P

a) Collecting samples is an easy, … but ***tricky*** task!
b) Empty the borehole ***volume*** three times at least, and wait for constant EC and T.
c) Select the right type of ***bottle*** (material, color, sterilized, acid rinse, …), the necessary water volume, if additives are needed, … Avoid air-bubble! Filter the sample! Store it cold!
d) Check ***procedures*** at "Standard Methods",
e) Ask the lab, ask ***colleagues***, …
f) So, … take a ***large car*** (or van) to the field!!!

3. Gathering quality field data

Field sample collection: how?

Photos: J M-P

4. Data treatment and plotting

Solutes in groundwater mainly depend on the following ***processes***:

a) Water-rock interaction: mineral equilibria
b) Ion exchange / sorption
c) Mixing between different sources
d) Seawater intrusion
e) Groundwater pollution: non-natural introduced chemicals

For most of these processes, we assume that the governing reactions are in ***equilibrium***; that means, the ratio between products (solutes) and reactants (minerals) depend on the equilibrium constant.

4. Data treatment and plotting

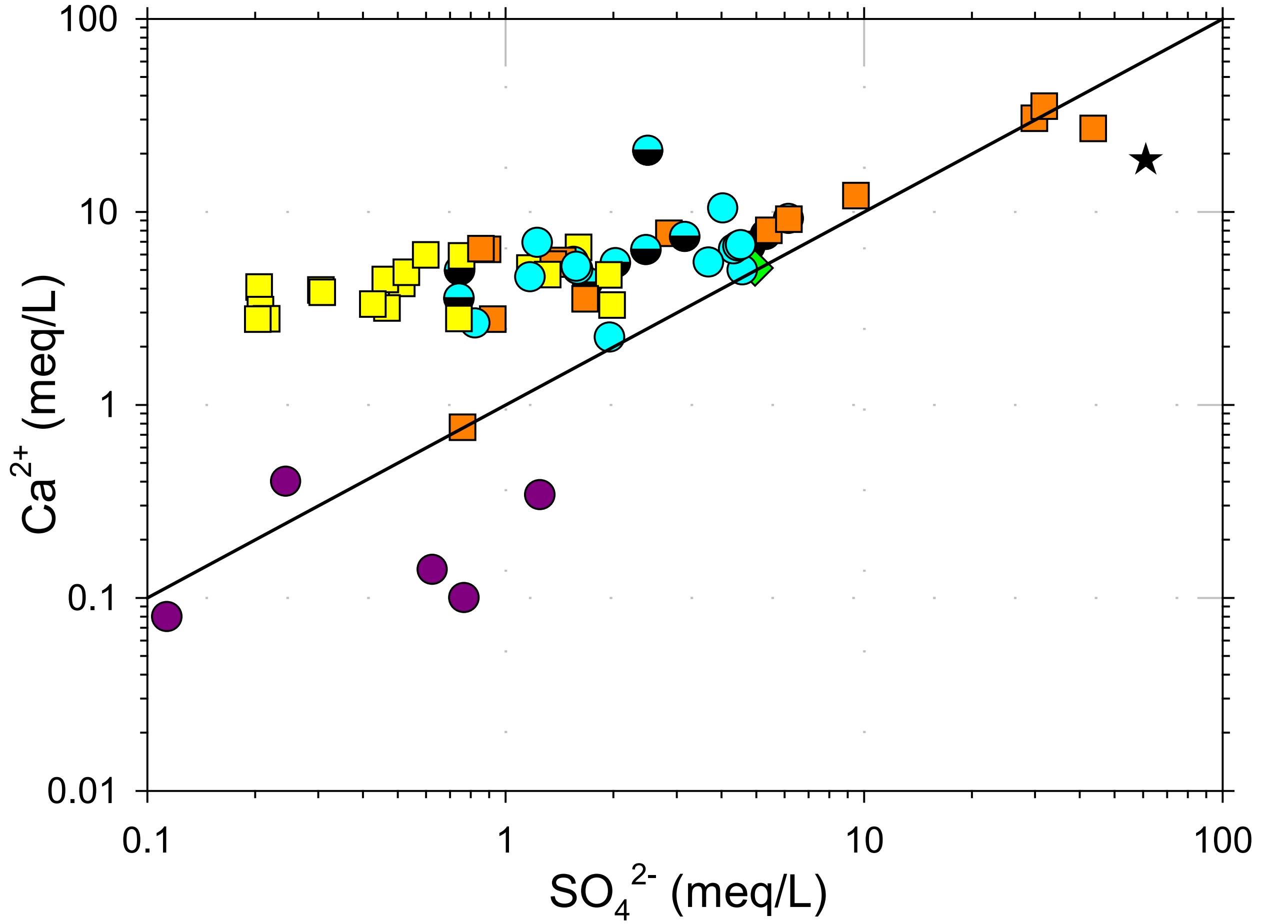


Table 10.7 Reactions and Solubility Products for Common Minerals at 25°C and Atmospheric Pressure

Mineral	Reaction	Log(K_{so})	
Salts:			
Halite	$NaCl \rightleftharpoons Na^+ + Cl^-$	1.54	(1)
Sylvite	$KCl \rightleftharpoons K^+ + Cl^-$	0.98	(1)
Fluorite	$CaF_2 \rightleftharpoons Ca^{2+} + 2F^-$	−10.6	(2)
Sulfates:			
Gypsum	$CaSO_4 \cdot 2H_2O \rightleftharpoons Ca^{2+} + SO_4^{2-} + 2H_2O$	−4.58	(2)
Anhydrite	$CaSO_4 \rightleftharpoons Ca^{2+} + SO_4^{2-}$	−4.36	(2)
Barite	$BaSO_4 \rightleftharpoons Ba^{2+} + SO_4^{2-}$	−9.97	(2)
Carbonates:			
Calcite	$CaCO_3 \rightleftharpoons Ca^{2+} + CO_3^{2-}$	−8.48	(2)
Aragonite	$CaCO_3 \rightleftharpoons Ca^{2+} + CO_3^{2-}$	−8.34	(2)
Dolomite	$CaMg(CO_3)_2 \rightleftharpoons Ca^{2+} + Mg^{2+} + 2CO_3^{2-}$	−17.1	(2)
Siderite	$FeCO_3 \rightleftharpoons Fe^{2+} + CO_3^{2-}$	−10.9	(2)

Fiits, 2013.

4. Data treatment and plotting

Electroneutrality principle (meq/L):

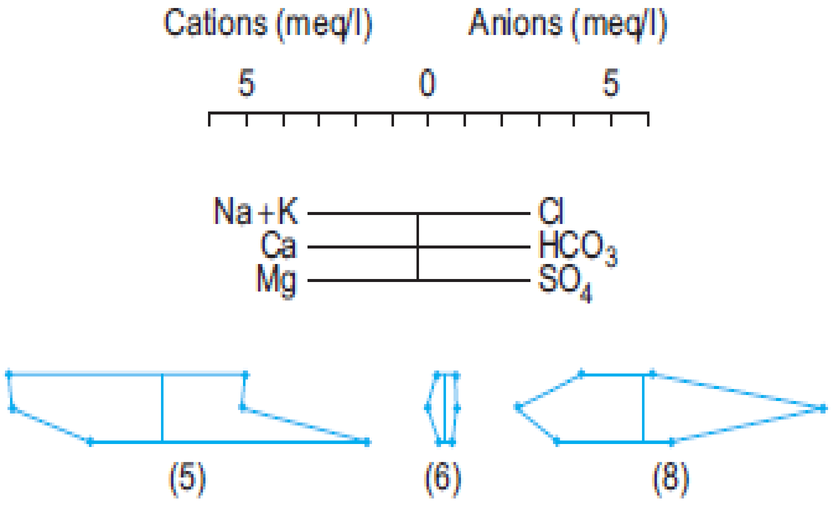
$$\sum \text{anions} = \sum \text{cations}$$

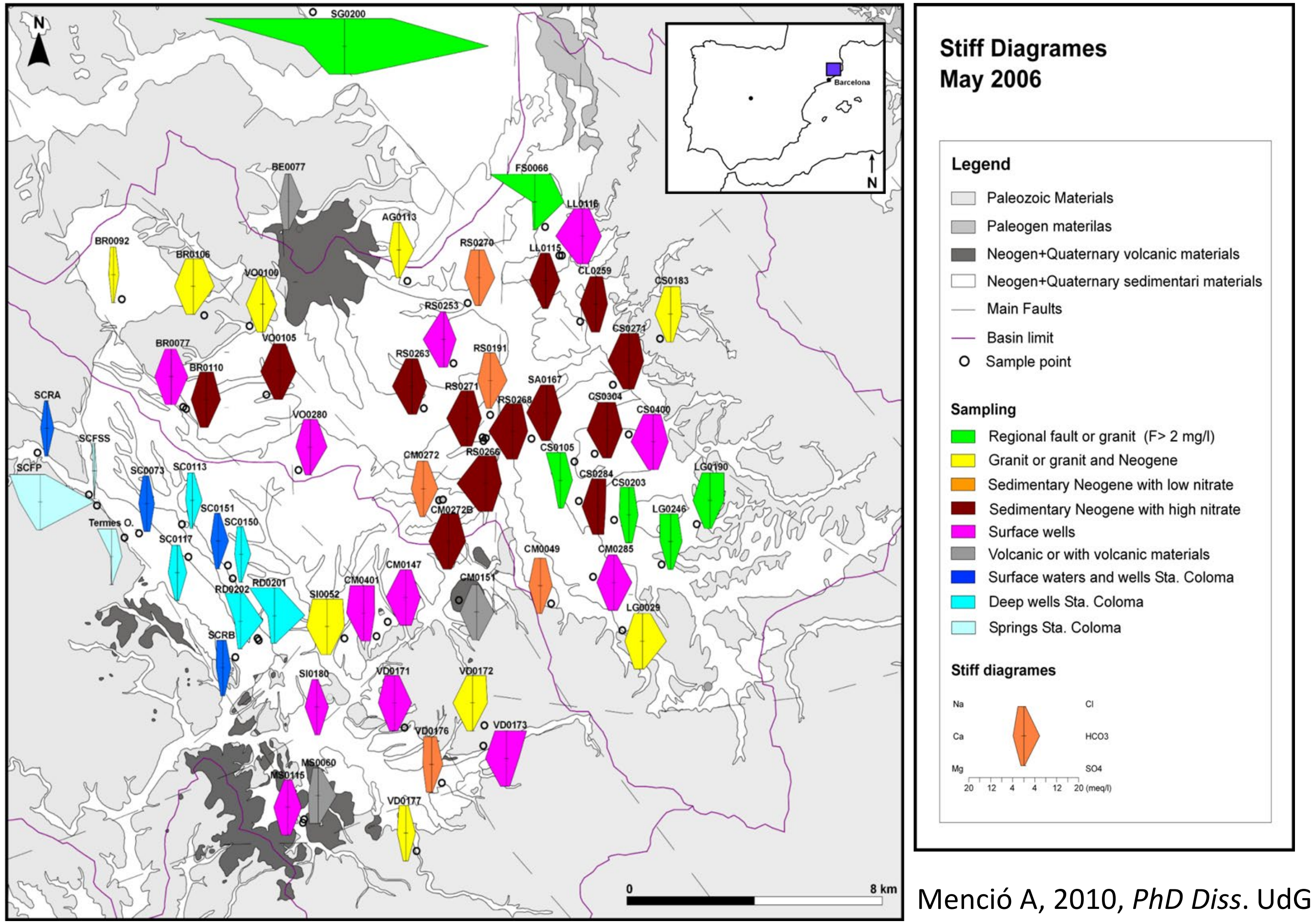
$$Error\ (\%) = 100\ \frac{\sum cations - \sum anions}{\sum cations + \sum anions}$$

Σ Anions (meq/L)	Accepted error
0 – 3.0	± 0.2 meq/L
3.0 – 10.0	± 2%
10.0 - 800	± 2-5%

4. Data treatment and plotting

Stiff diagram; units: meq/L

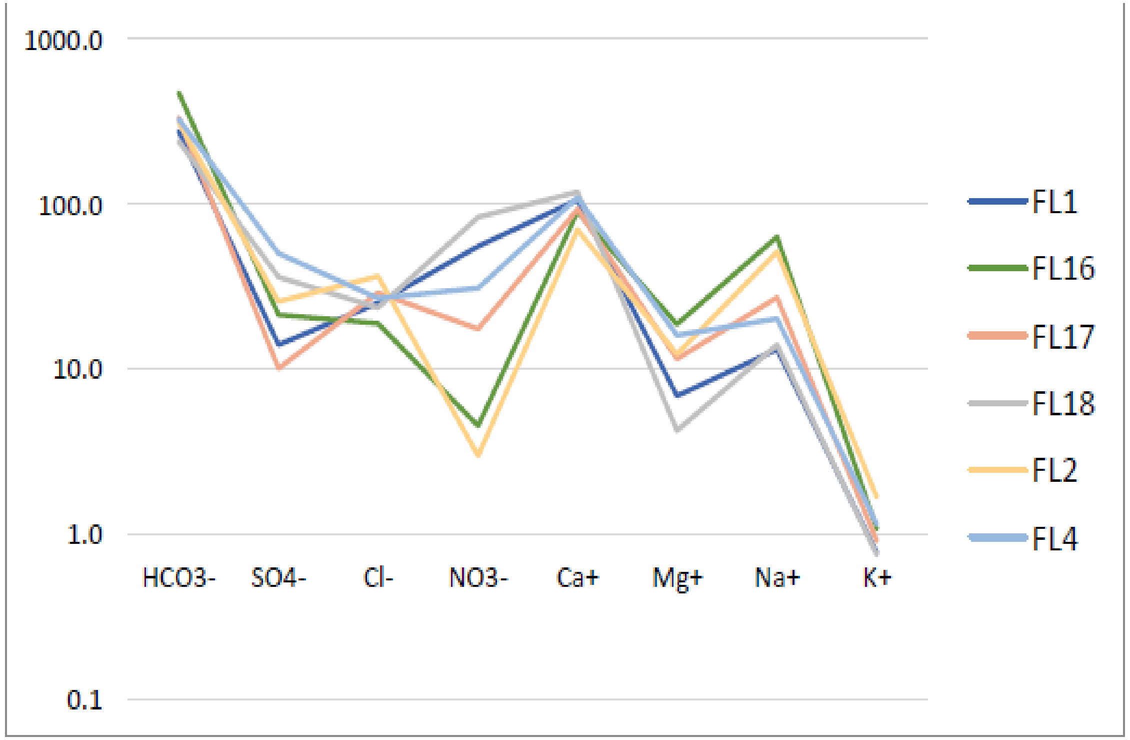




Menció A, 2010, *PhD Diss*. UdG

4. Data treatment and plotting

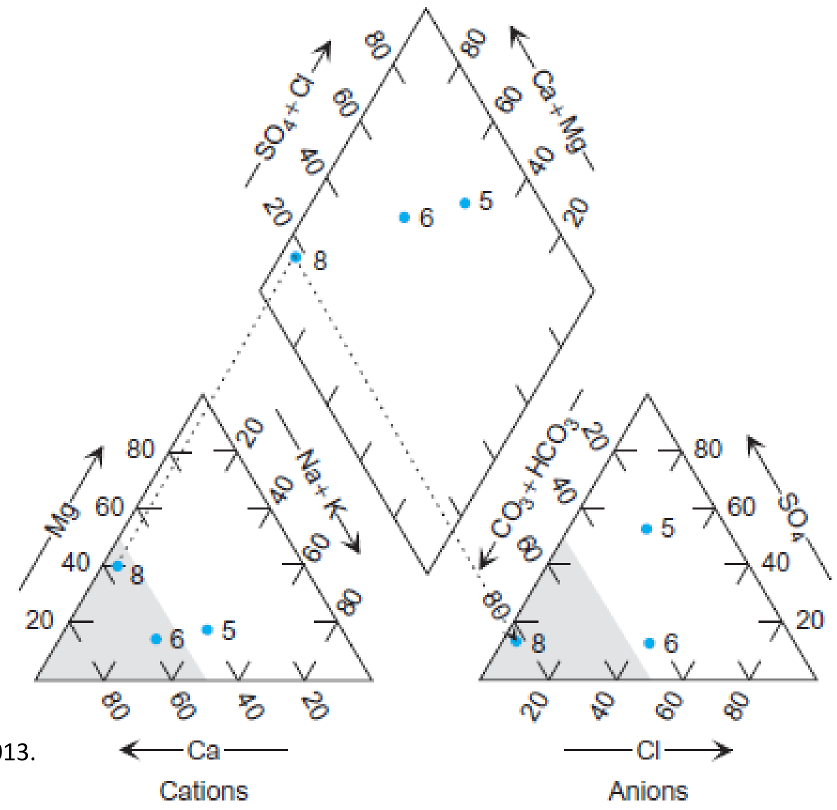
Schoeller-Berkaloff plot; units: meq/L



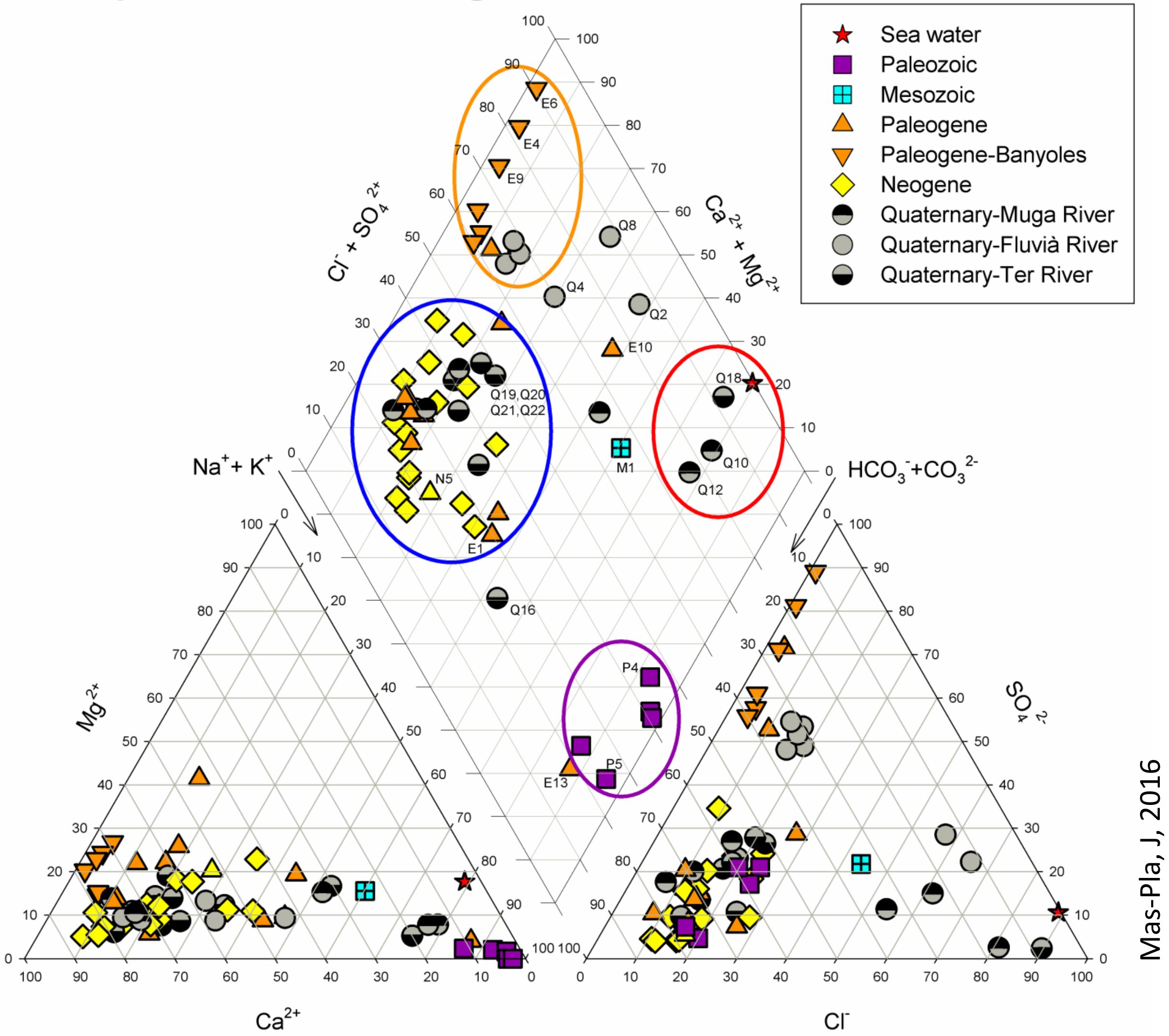
Vílchez Peña, A, 2020, *MSc Thesis*. UdG

4. Data treatment and plotting

Piper-Hill plots; units: meq/L



Fiits, 2013.



Mas-Pla, J, 2016

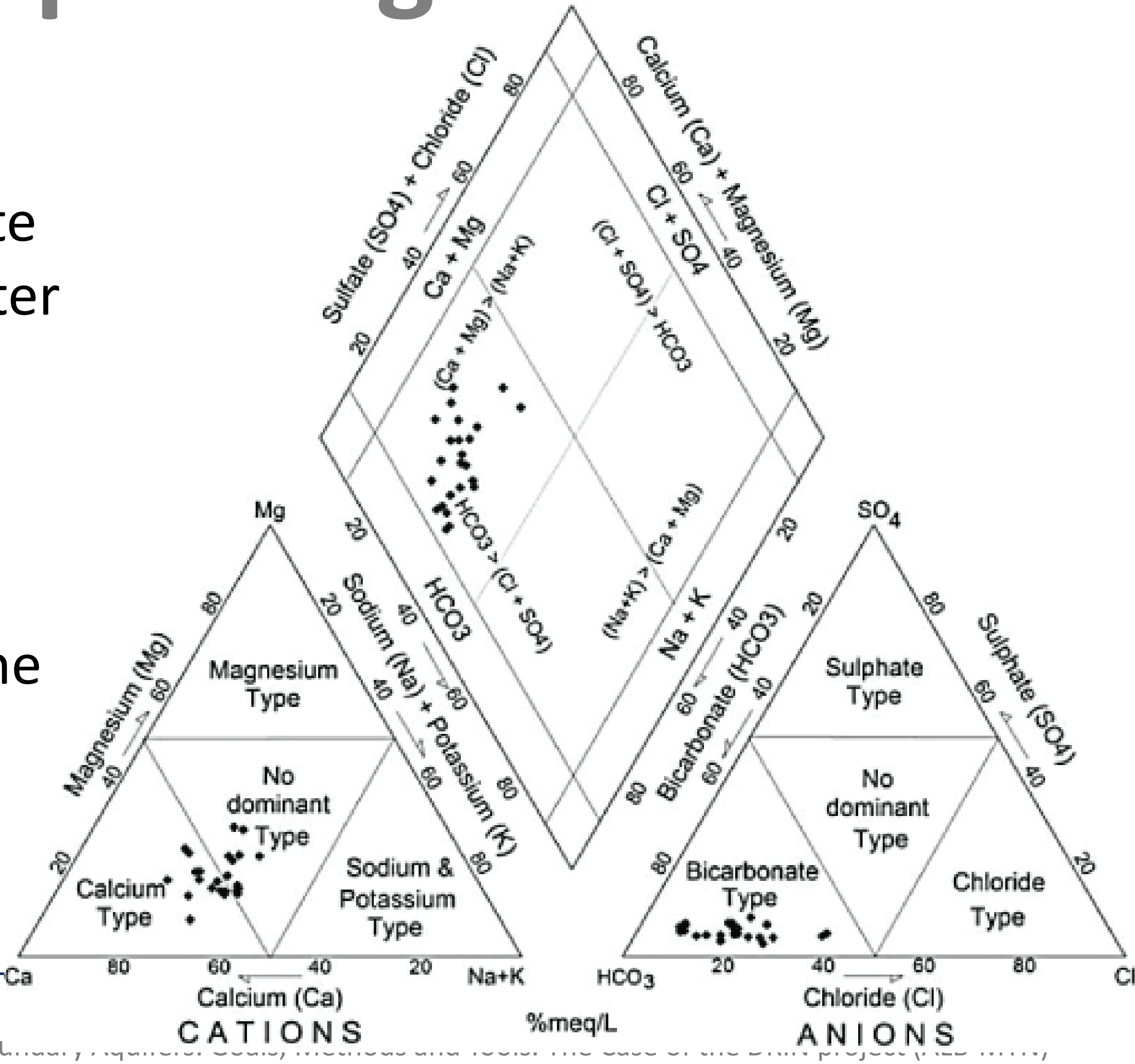
4. Data treatment and plotting

Piper-Hill plots; **Hydrochemical facies**

Hydrochemical facies is a term used to denote the diagnostic chemical aspect of ground-water solutions occurring in hydrologic systems.

The facies reflects **the response of chemical processes operating within the lithological framework,** and also the pattern of flow of the water.

(Back W, 1966, *USGS Professional Paper 498-A*)



Ravikumar, 2015

4. Data treatment and plotting

Piper-Hill "diamond" plot ➡ Hydrochemical facies

Facies:

A - Sulfate-calcium*

B - Chloride-sodium**

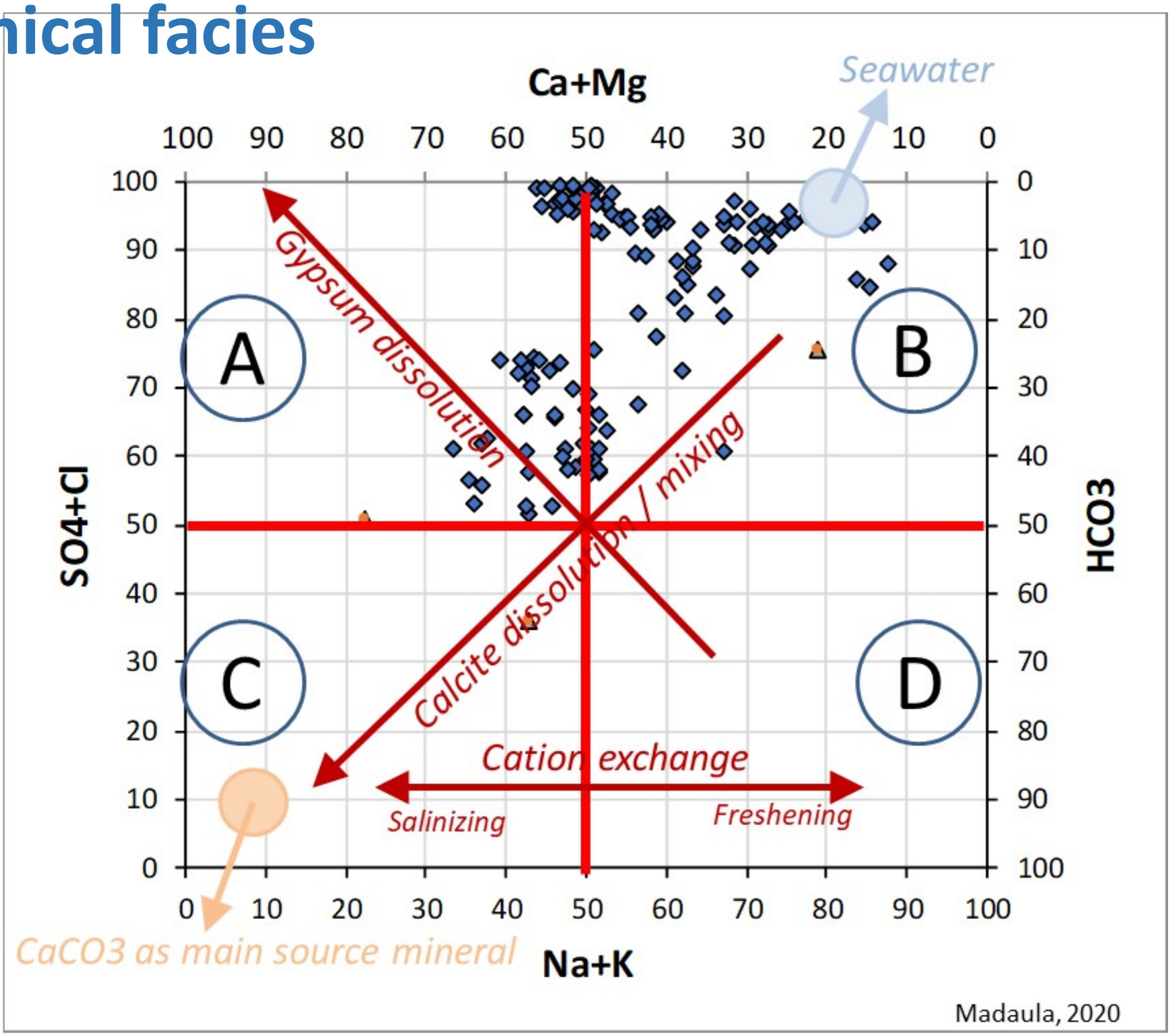
C - Bicarbonate-calcium

D - Bicarbonate sodium***

*.- Mg & K are always low

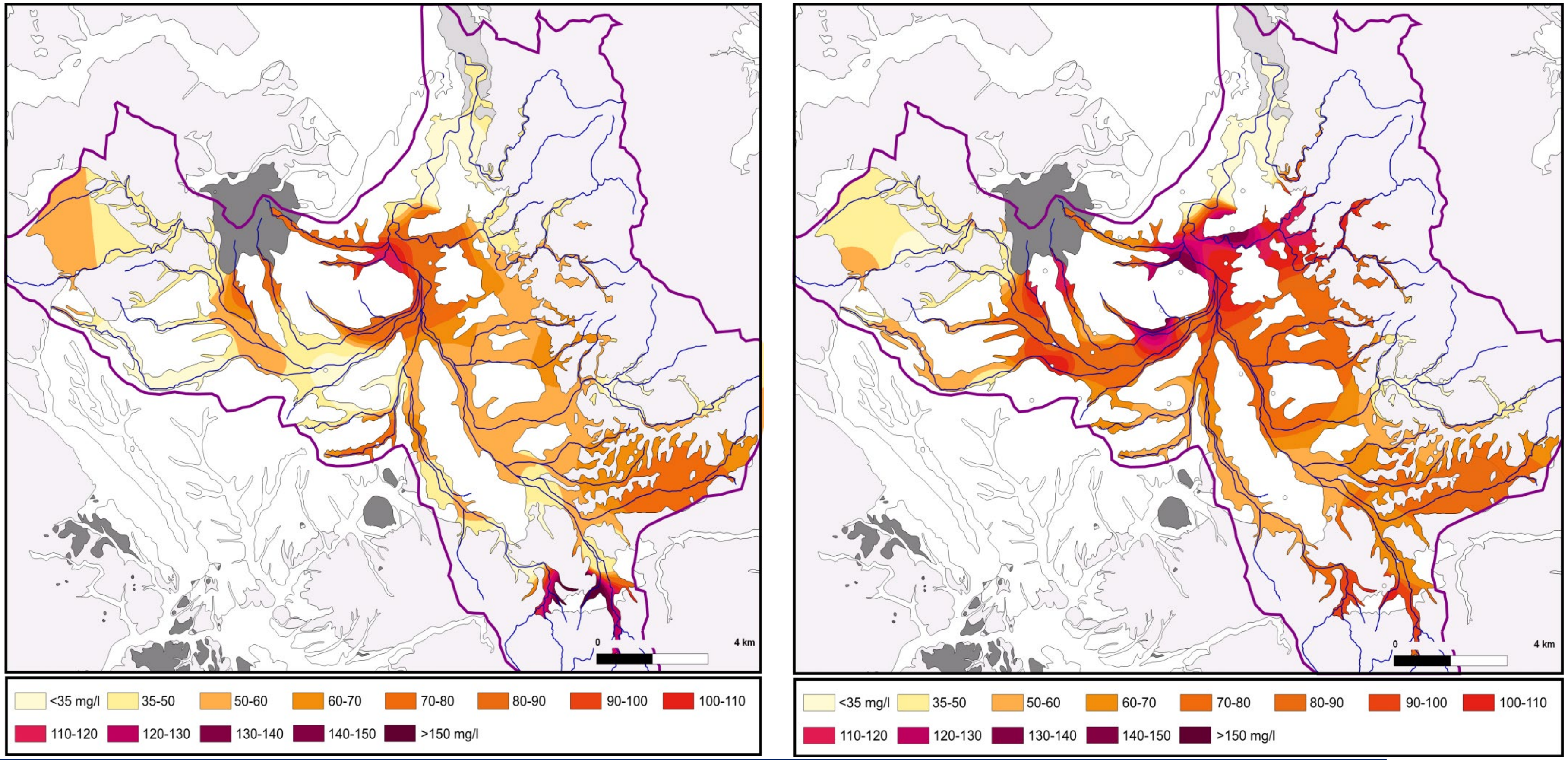
**- SO_4 - Na is rare,

***- HCO3 - Na is common in igneous aqüífers, usually with high pH values.



4. Data treatment and plotting

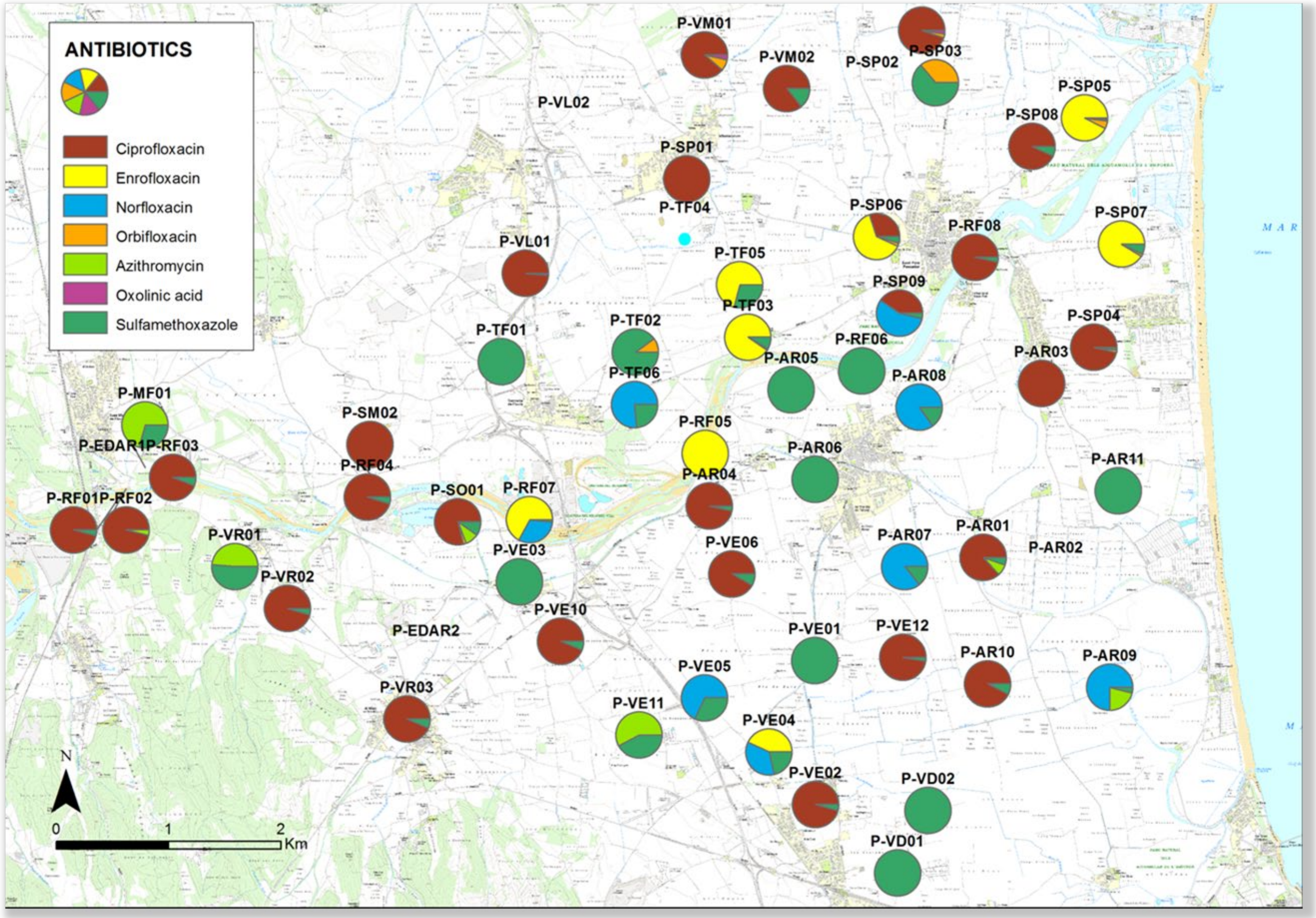
Plotting interpolated data



Menció A, 2010, *PhD Diss*. UdG

4. Data treatment and plotting

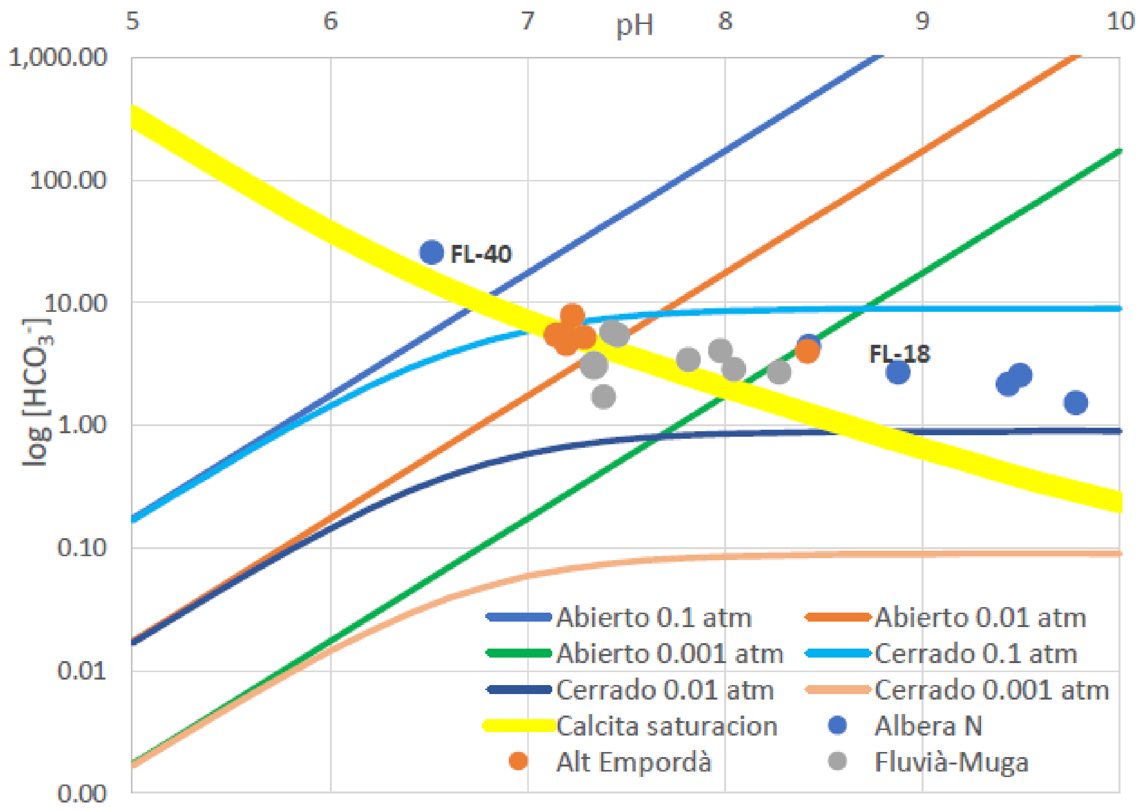
Plotting interpolated data



Boy-Roiura et al. 2018, *Sci. Total Environ.*

5. Data interpretation

Interpreting hydrochemical plots



Vílchez Peña, A, 2020, *MSc Thesis*. UdG

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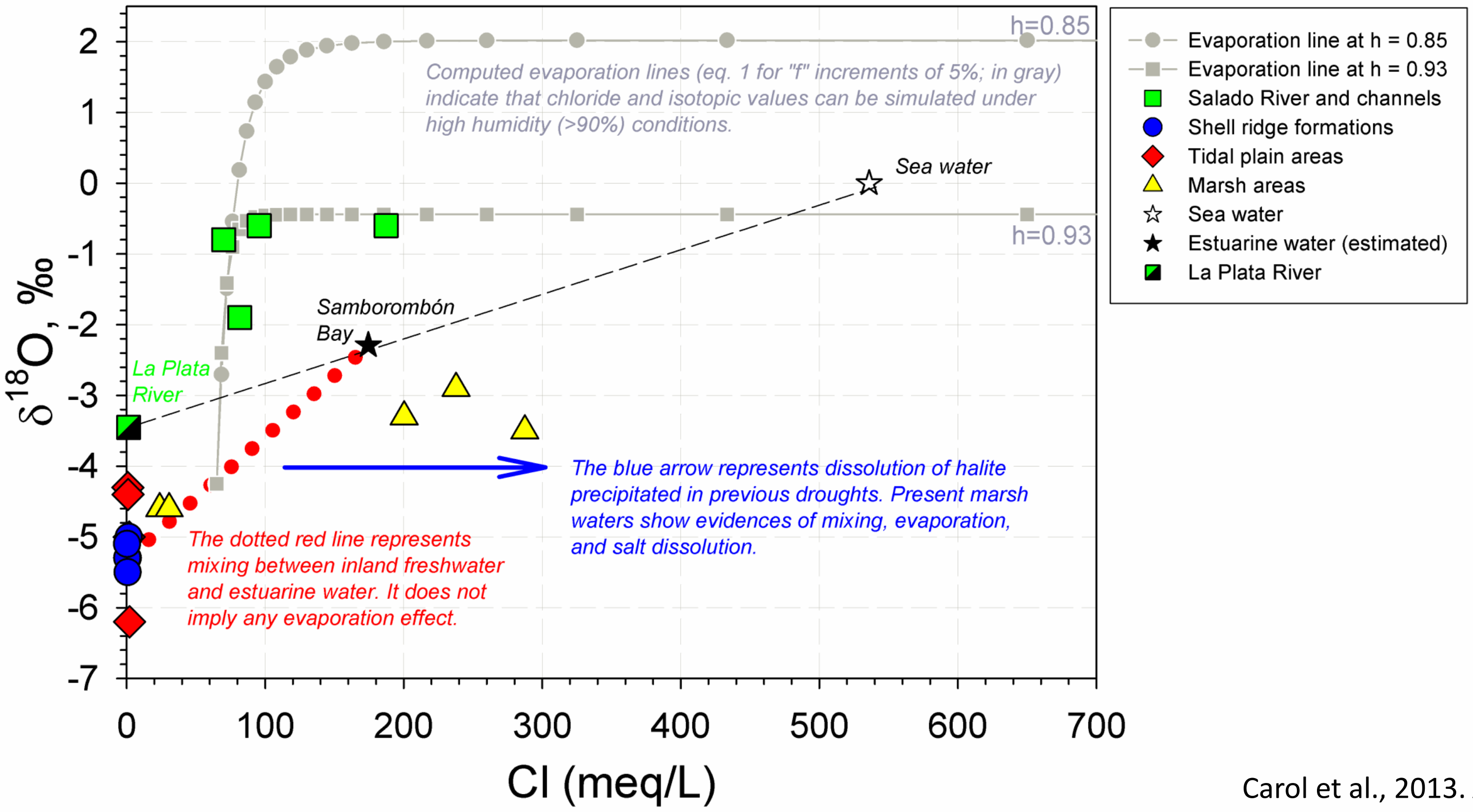
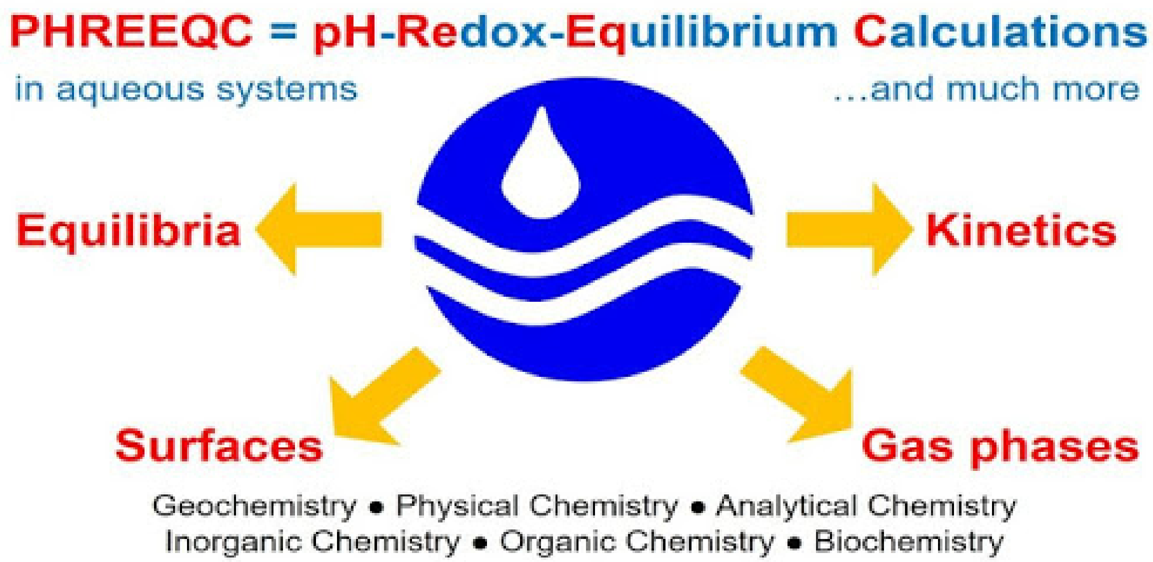
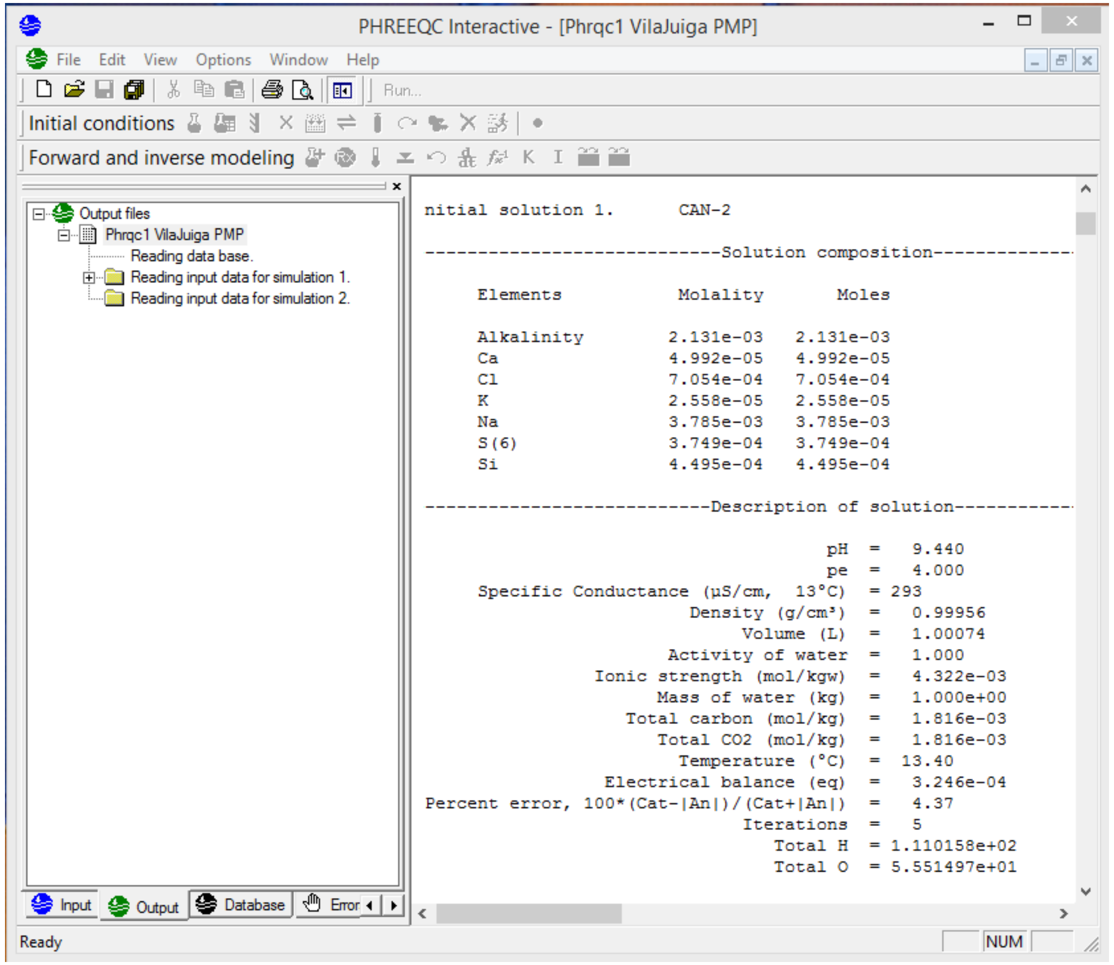


Carol et al., 2013. *Applied Geochemistry*, 34: 152-163

5. Data interpretation

Geochemical modelling

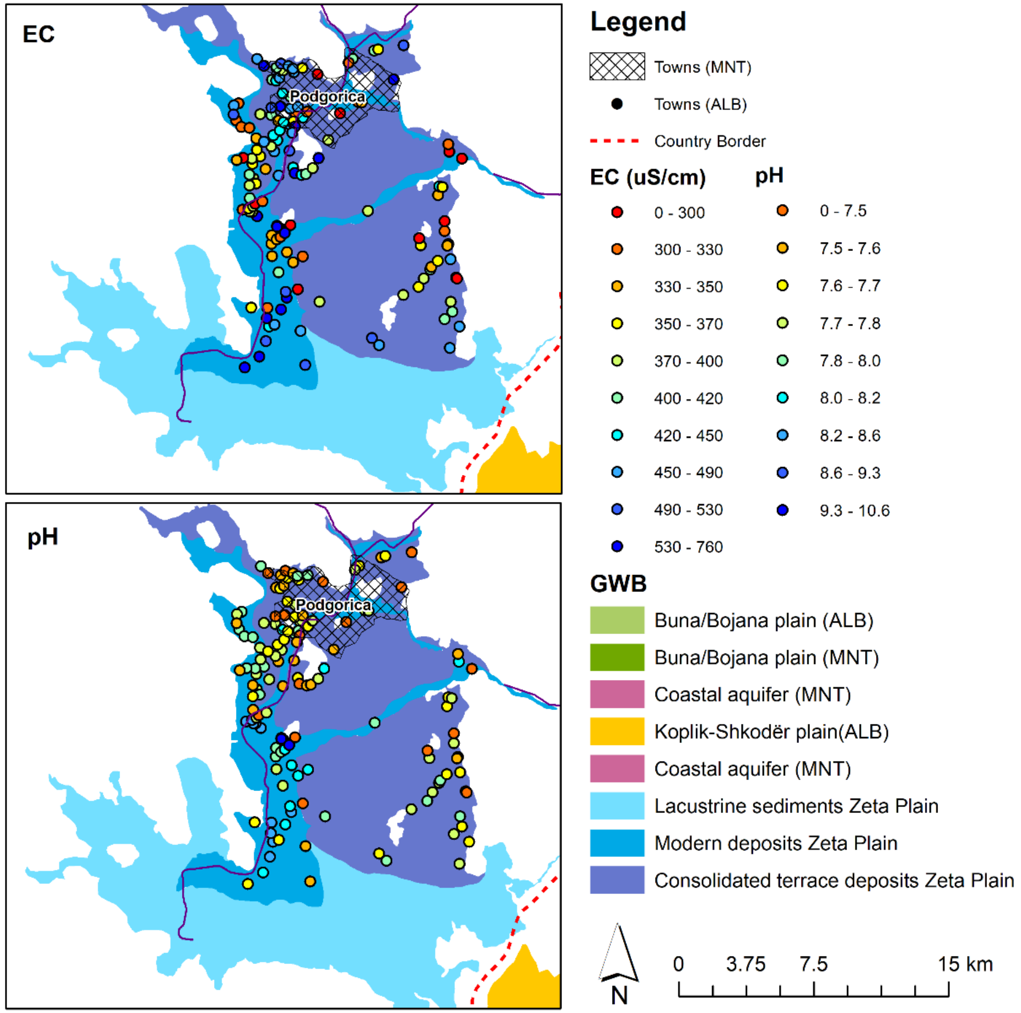


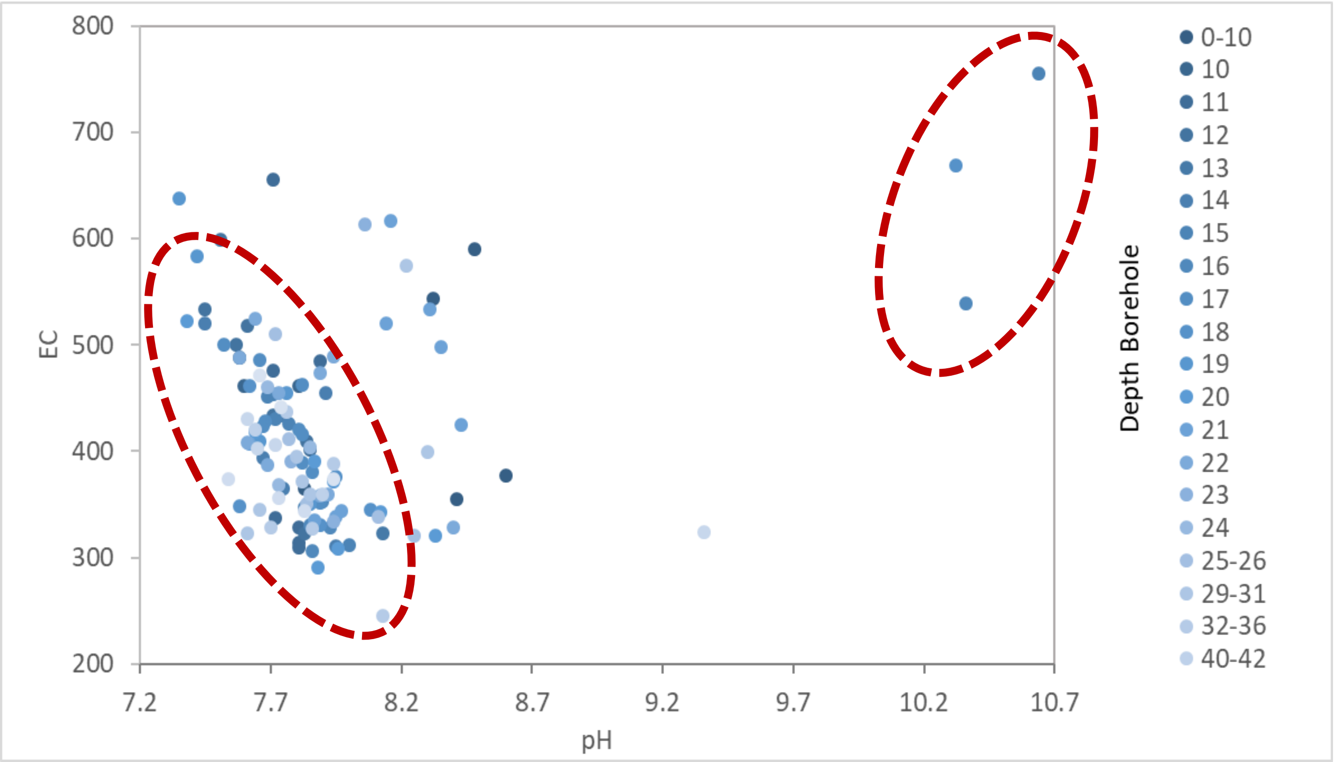


6. Real case

The case of the Skadar/Shkoder - Buna/Bojana transboundary aquifer

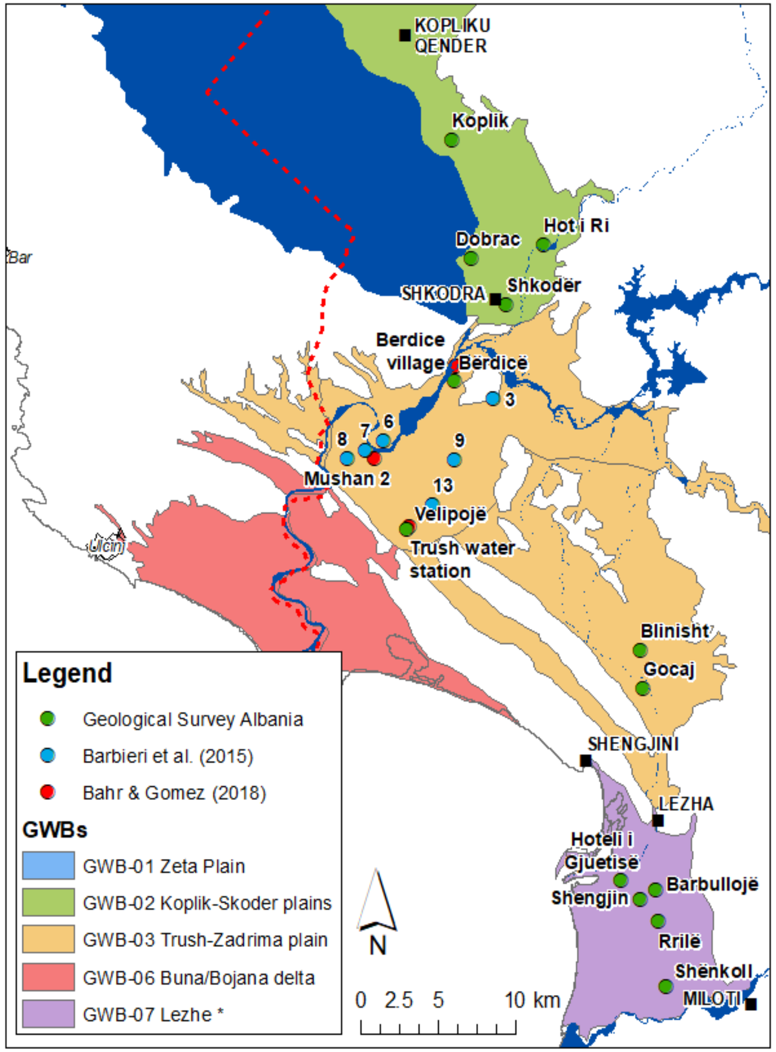
Surveillance monitoring



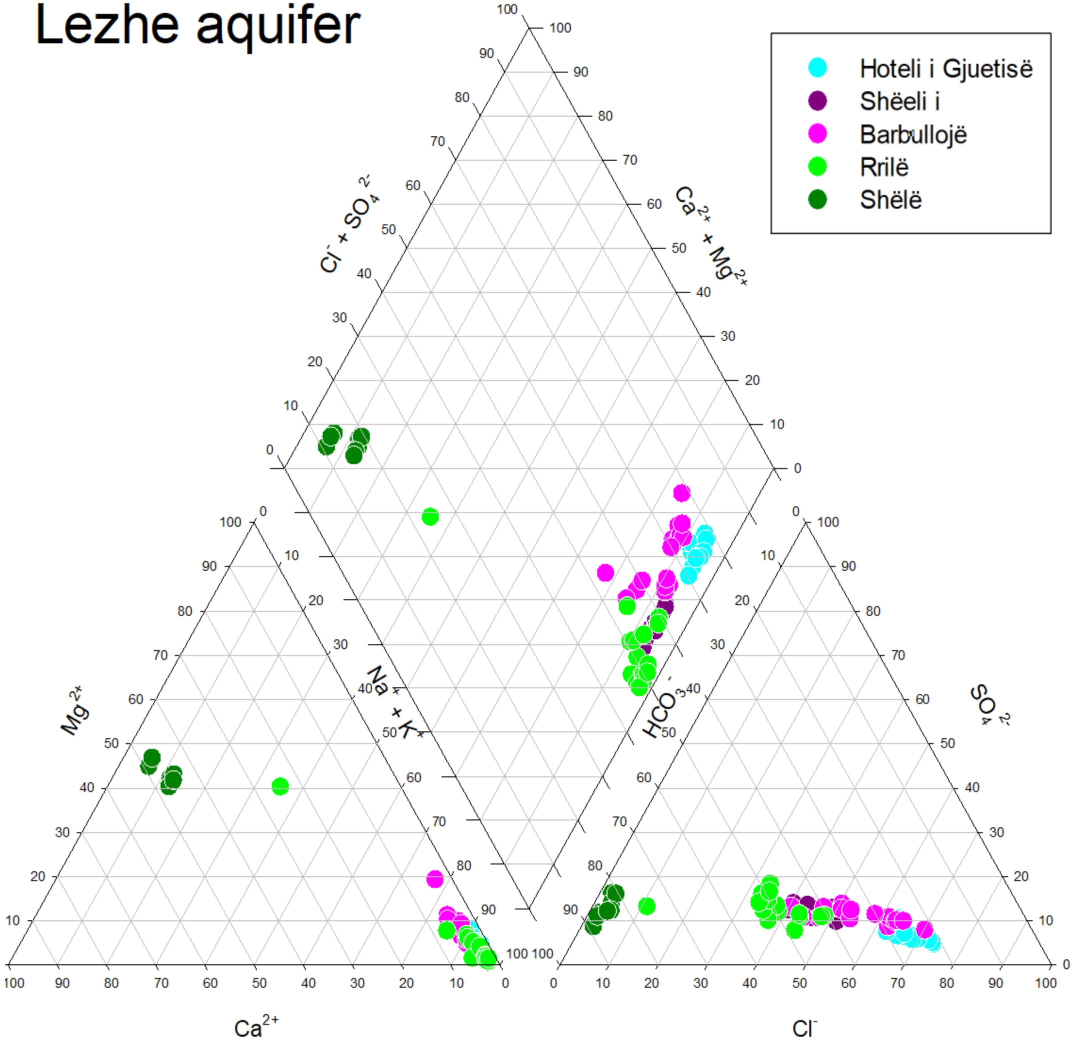


Del Val L, Mas-Pla J 2019. Drin Project. UNESCO
Data from Montenegro Officials

Surveillance monitoring



Lezhe aquifer



Del Val L, Mas-Pla J 2019. Drin Project. UNESCO
Data from Albania Officials

Further reading

- EU-WFD Guidelines Document 26 on "Risk assessment and the use of Conceptual models for Groundwater".
- Enemark, T., Peeters, L.J.M., Mallants, D., Batelaan, O., Hydrogeological conceptual model building and testing: A review, Journal of Hydrology (2018), doi: https://doi.org/10.1016/j.jhydrol. 2018.12.007

Thank you!

Enabling
& Transboundary Cooperation
Integrated Water Resources Management
in the extended DRIN RIVER BASIN

Contact details:

Dr. Josep Mas-Pla
Catalan Institute for Water Research (ICRA) & University of Girona
jmas@icra.cat
Josep.mas@udg.edu