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Study of interactions between a freshwater lake and groundwater in a Mediterranean coastal area by means of hydrochemical indicators

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INTERACTIONS BETWEEN GROUNDWATER AND SURFACE WATER IN A COASTAL AREA

A freshwater lake fed by the underlying aquifer is a valuable drinking water resource in a coastal semi-arid area.

The aim is to assess the correlation between groundwater and lake water chemistry by understanding:

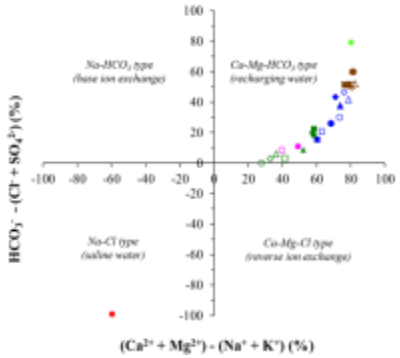
- the origin of dissolved chemical species;
- the variations of water quality over time;
- the potential influence of seawater intrusion.

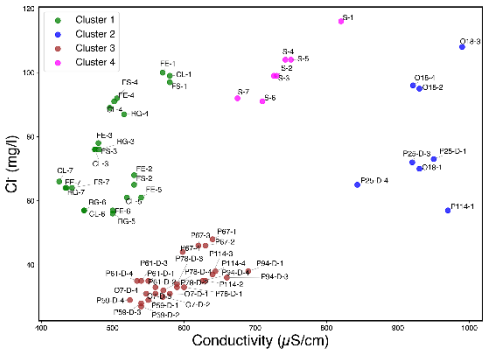
Presentation Outline

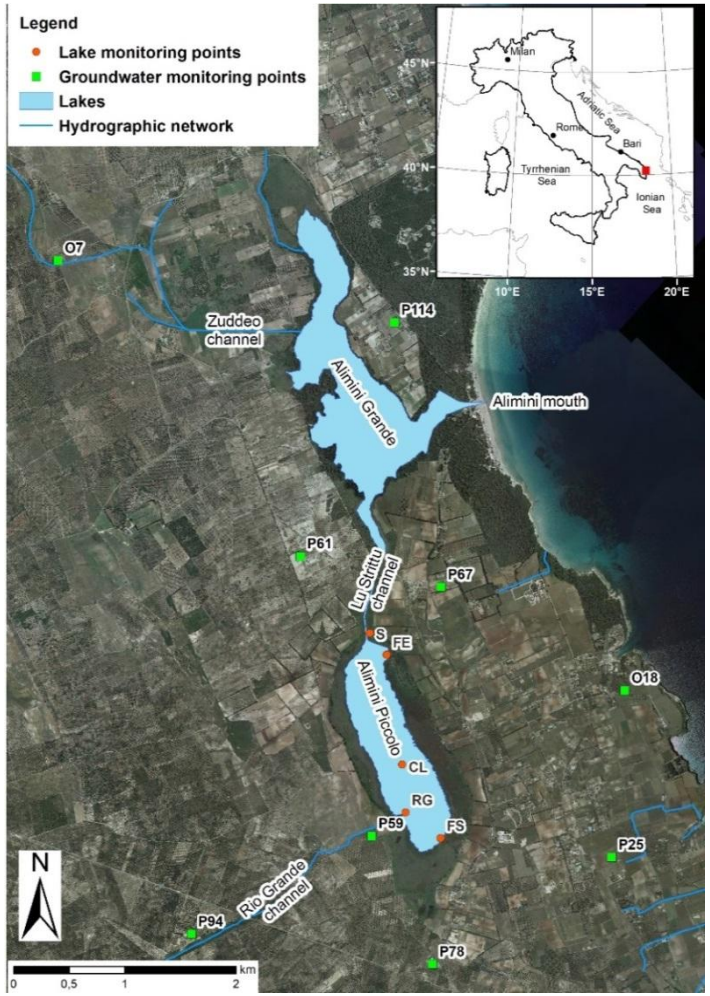
1. Study area and data collection

2. Methodology

3. Results







STUDY AREA AND DATA COLLECTION

THE *ALIMINI* WATER SYSTEM

Location: Salento Peninsula, South-Eastern Italy

Two shallow lakes lying above a carbonate aquifer:

- *Alimini Grande* (area = 1.37 km^2): brackish water
- *Alimini Piccolo* (area = 0.8 km^2): freshwater

Water can flow only in one direction through the connecting channel.





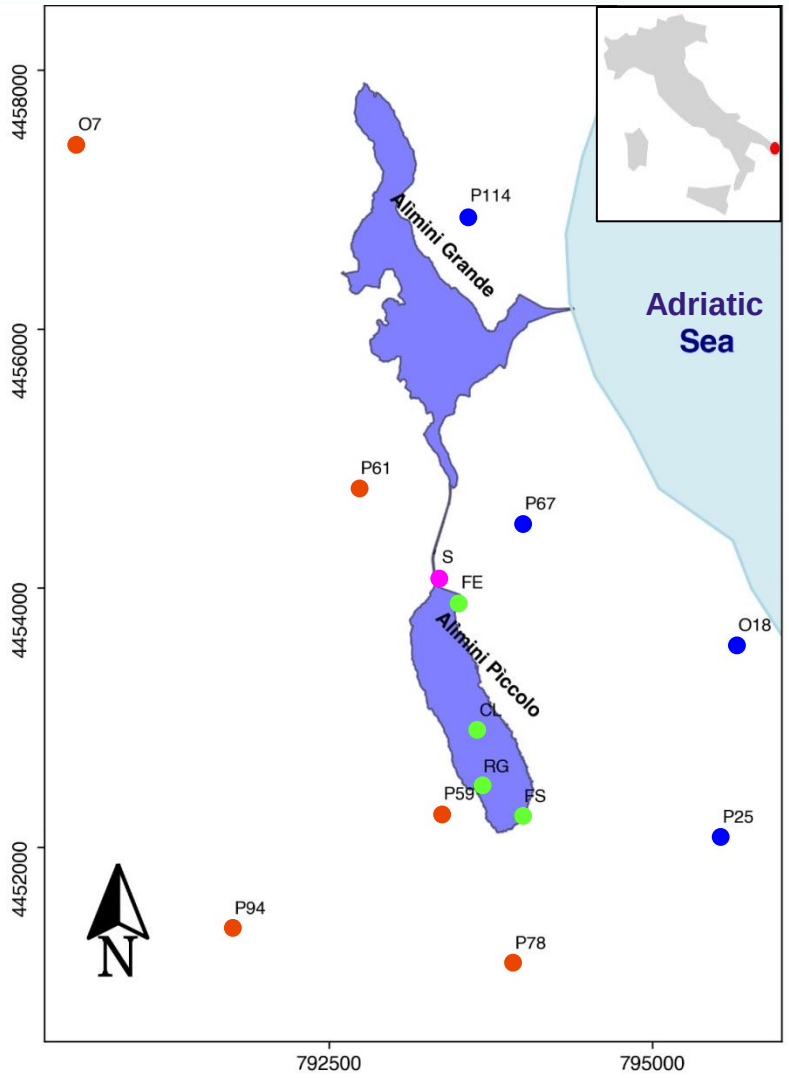
FIELD DATA COLLECTION

Groundwater monitoring

- Water level measurements in 52 wells
- Sampling for chemical analysis in 9 wells

Alimini Piccolo lake water monitoring

- Water level measurements in one point
- Sampling for chemical analysis in 5 points



WATER SAMPLING PLAN

Monitoring over one hydrological year (Sep. 2013 – Sep. 2014) in both the dry (D) and the wet (W) season

Four groundwater sampling campaigns

- 4 coastal wells (blue)
- 5 inland wells (brown)

Seven *Alimini Piccolo* sampling campaigns

- 4 sampling points in the lake (green)
- 1 sampling point at the main spring (pink)

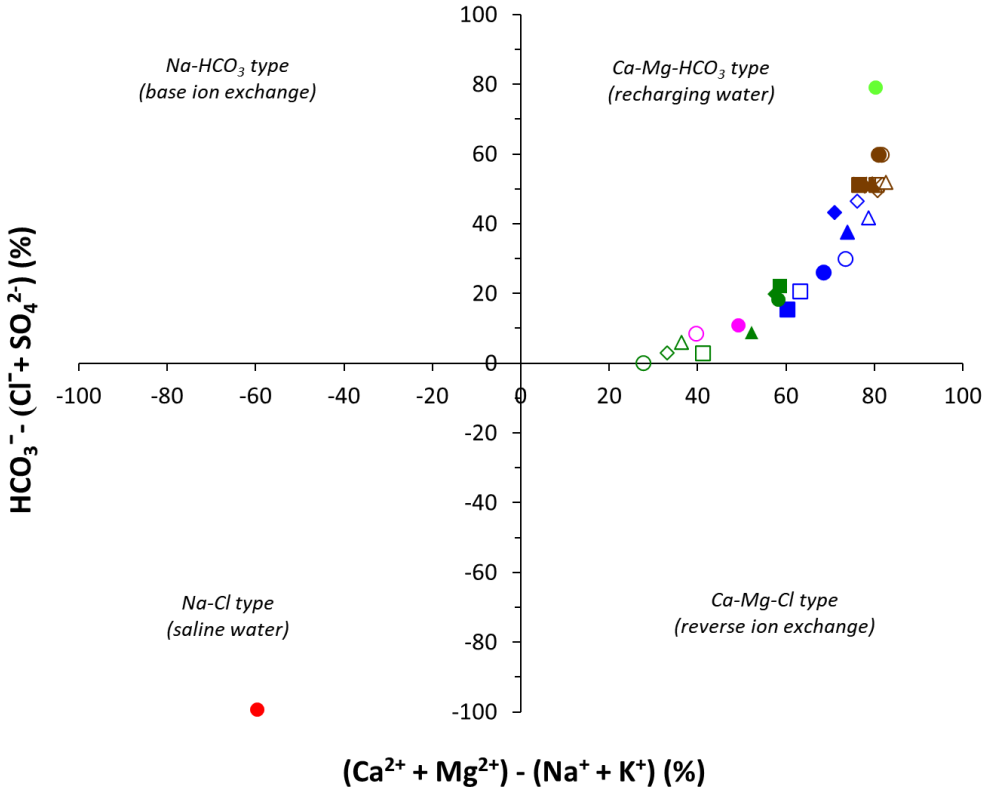
GEOCHEMICAL INTERPRETATION OF WATER QUALITY DATA

Analysis of hydrochemical indicators (mean values calculated over both the dry and the wet season)

Correlations involving major cations (Na^+, Ca^{2+}, Mg^{2+}) and major anions (HCO_3^-, Cl^-, SO_4^{2-})	Origin of dissolved ions and mechanisms affecting groundwater composition
Correlations involving Cl^-	Occurrence of seawater intrusion
Comparison between groundwater and lake water indicators	Understanding the relationship between lake water and the feeding groundwater
Raw chemical data processing through a K-means clustering algorithm	Comparing the grouping patterns of data with the outcomes of hydrochemical analysis

CHADHA PLOT

Identification of groundwater types (hydrochemical facies) and specific hydrochemical processes



- Groundwater chemistry is dominated by carbonate minerals dissolution.
- Composition can be related to the well distance from the coast.
- Lake data points reveal higher salinity than groundwater and the influence of seasonality.

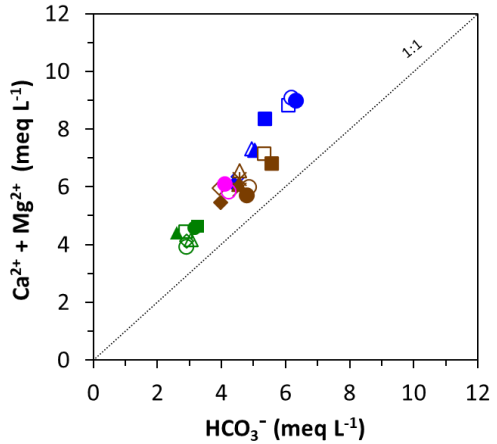
LEGEND

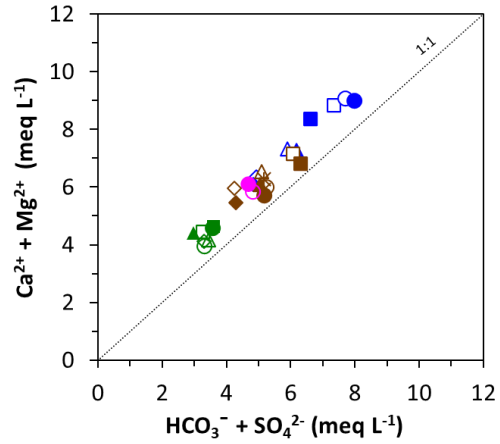
Groundwater		Lake	
P67-D	P67-W	LC-D	LC-W
O18-D	O18-W	RG-D	RG-W
P114-D	P114-W	FS-D	FS-W
P25-D	P25-W	FE-D	FE-W
P61-D	P61-W	S-D	S-W
P59-D	P59-W		
P94-D	P94-W	End-members	
P78-D	P78-W	SW	FW
O7-D	O7-W		

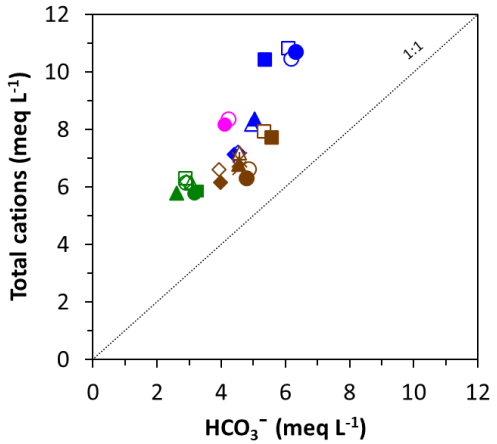
D = dry season W = wet season

CHECKING THE INFLUENCE OF PROCESSES OTHER THAN MINERAL DISSOLUTION

- Deviation from the linear 1:1 trend of bicarbonate vs. cations may be an index of ion exchange.
- The contribution of sulphate to ion balance should be ascribed to the intake of sea salts.
- Lake water shows the lowest concentrations of bicarbonate.
- At the main spring sampling point lake water quality resembles that of the feeding groundwater.





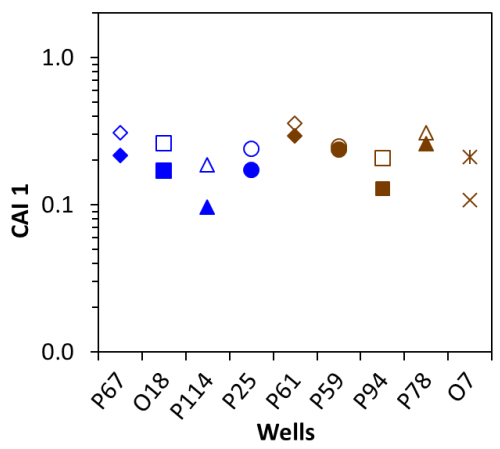


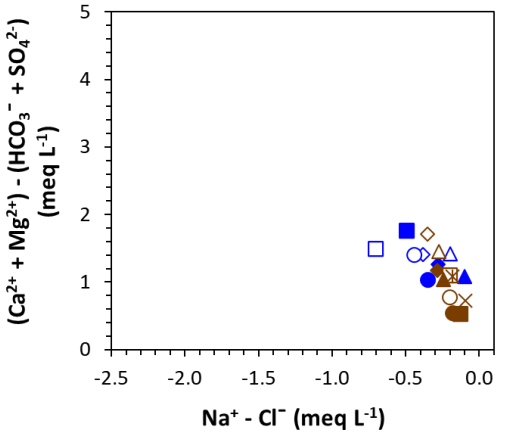
LEGEND

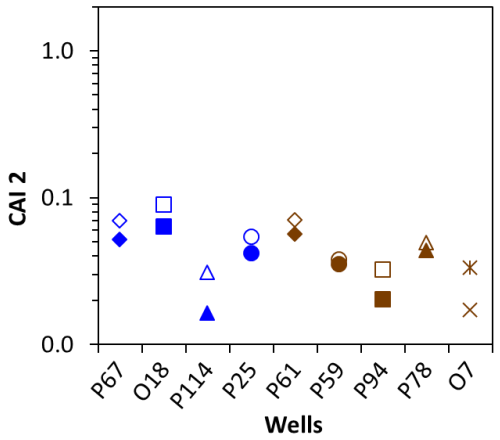
Groundwater		*Lake*	
P67-D	P67-W	LC-D	LC-W
O18-D	O18-W	RG-D	RG-W
P114-D	P114-W	FS-D	FS-W
P25-D	P25-W	FE-D	FE-W
P61-D	P61-W	S-D	S-W
P59-D	P59-W		
P94-D	P94-W		
P78-D	P78-W		
O7-D	O7-W		

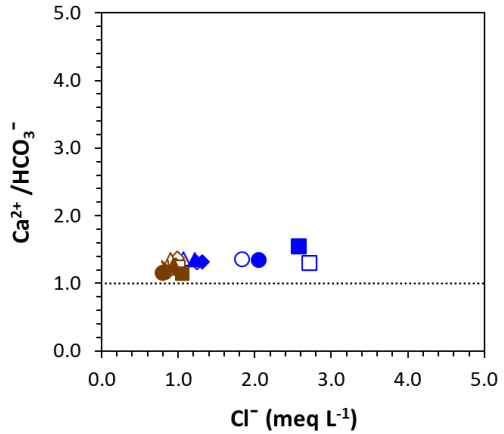
D = dry season
W = wet season

CHECKING THE INFLUENCE OF CATION EXCHANGE









LEGEND

Groundwater

P67-D	P67-W
O18-D	O18-W
P114-D	P114-W
P25-D	P25-W
P61-D	P61-W
P59-D	P59-W
P94-D	P94-W
P78-D	P78-W
O7-D	O7-W

D = dry season
W = wet season

CAI = Chloro-alkali indices

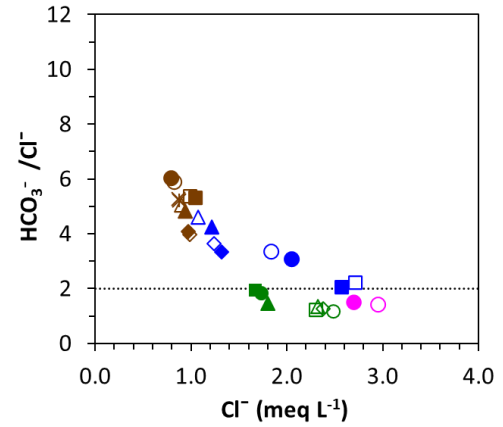
$$CAI\ I = \frac{Cl^- - (Na^+ + K^+)}{Cl^-}$$

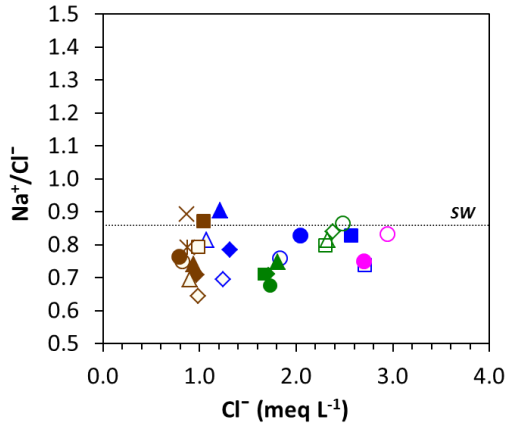
$$CAI\ II = \frac{Cl^- - (Na^+ + K^+)}{SO_4^{2-} + HCO_3^- + CO_3^{2-} + NO_3^-}$$

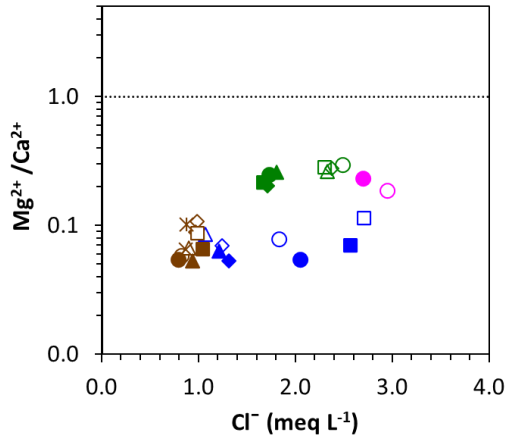
CAIs and other correlations involving major ions confirm that the role of ion exchange is negligible in our system.

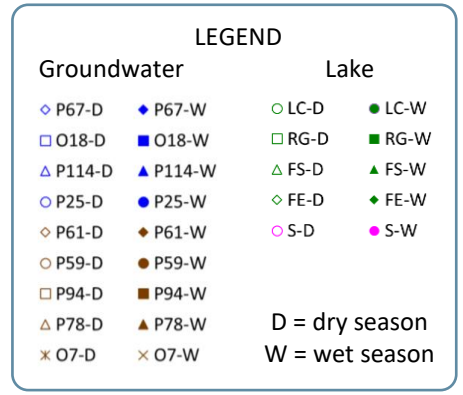
CHECKING THE OCCURRENCE OF SEAWATER INTRUSION

- HCO_3^-/Cl^- and Mg^{2+}/Ca^{2+} values do not suggest the occurrence of seawater intrusion.
- A minor seawater contamination may explain the Na^+/Cl^- values slightly lower than the typical value of seawater.
- The direct input of sea salts affects chloride concentration in lake water.
- Chloride increases in the lake during the dry season due to the effect of evaporation.

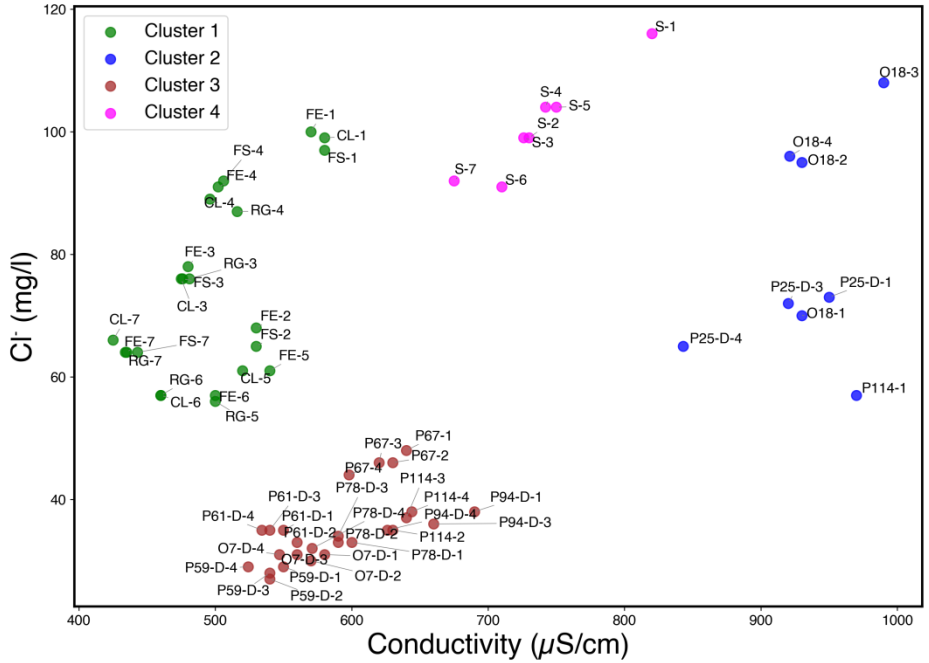


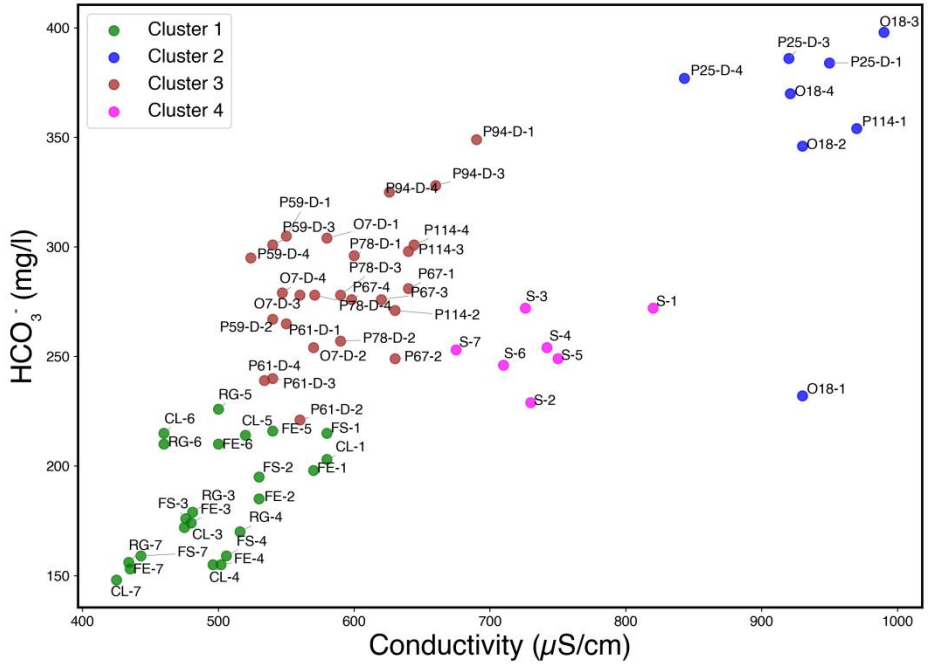






ANALYSING THE GROUPING PATTERNS WITHIN THE CHEMICAL DATA SET





- Clusters were consistent with the sample points location
- Within the “lake” cluster, sub-groups identifying sampling campaigns confirmed the seasonal change of composition

CONCLUSIONS

RESULTS

- Lake water quality closely resembled that of groundwater, except for the higher chloride content and the detectable seasonal variations.
- Raw chemical data clustering was consistent with hydrochemical analysis

IMPLICATIONS

This work provides a combined approach to the understanding of groundwater-surface water interactions in a coastal hydrogeological system

Thank you for your attention!

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