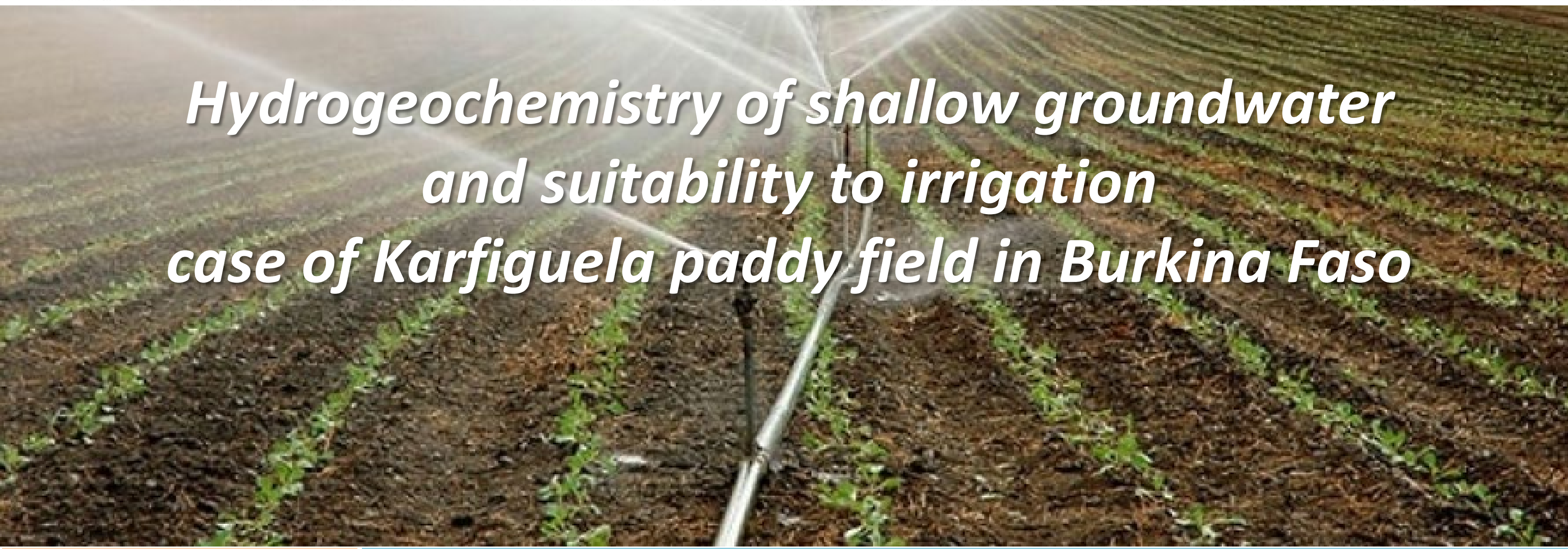
INTERNATIONAL CONFERENCE

GROUNDWATER, KEY TO THE SUSTAINABLE DEVELOPMENT GOALS

PARIS - May 18 -20, 2022

ORGANIZED BY IAH-CFH, UNESCO-IHP, THE FRENCH WATER PARTNERSHIP, UNDER THE PATRONAGE OF THE FRENCH NATIONAL COMMISSION FOR UNESCO AND WITH THE SUPPORT OF THE MINISTRY FOR ENVIRONMENT, SEINE-NORMANDY WATER AGENCY, AND SORBONNE UNIVERSITY



Hydrogeochemistry of shallow groundwater and suitability to irrigation case of Karfiguela paddy field in Burkina Faso

Speaker: Dr. SAURET Elie Serge Gaëtan
Institute for the Environment and Agricultural Research [INERA-CNRST], Burkina Faso

16/05/2022

PLAN

1. INTRODUCTION
2. STUDY AREA PRESENTATION
3. MATERIAL AND METHODS
4. RESULTS AND DISCUSSION
    1. GROUNDWATER HYDROGEOCHEMISTRY
    2. GROUNDWATER SUITABILITY FOR IRRIGATION
5. CONCLUSION

1. INTRODUCTION

- Groundwater is an important and essential resource for survival and socio-economic development worldwide

- Shallow groundwater, neglected and underestimated are generally porous, unconsolidated and full of significant potential that can be used for various uses, including irrigation.

- Assessing the capacity of a resource to meet a need necessarily requires to assess its quantity and its quality.

- characterization of processes that control aquifer chemistry and identification of probable sources of ions and pollution are important for groundwater resources sustainable management.

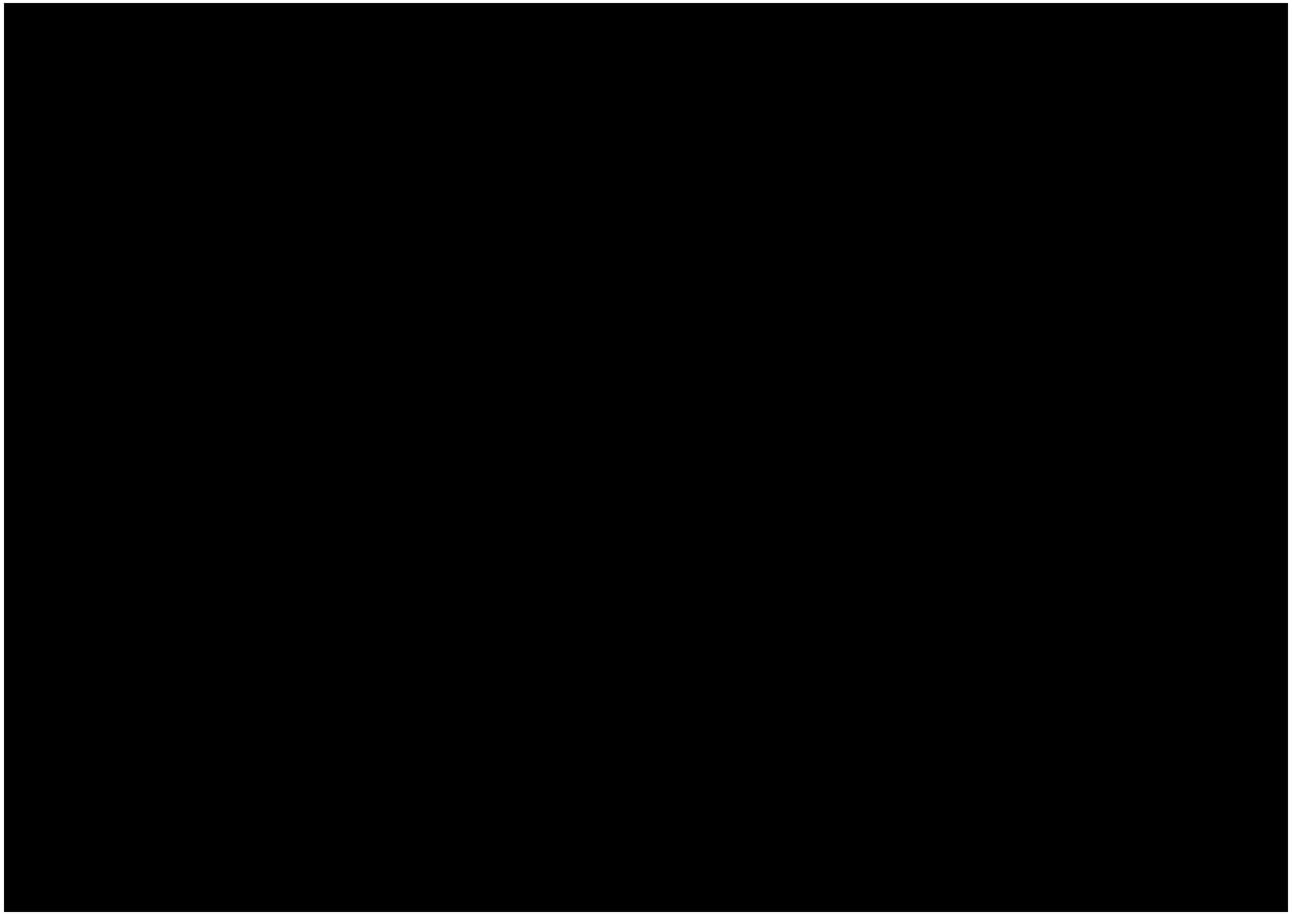
Thus, the aim of this study is to:

- identify and assess processes that control the shallow groundwater chemistry in an agricultural context and
- assess the suitability of these waters for agricultural use.

2. STUDY AREA PRESENTATION

The study was conducted in the **Karfiguéla paddy field**

Located: Burkina Faso (10° 38′N, 4° 50′W) to (10° 42′N, 4° 48′W)



- **Climate**: southern Sudanese P= 1040 mm, T= 17 °C to 36 °C
- **Shallow aquifer:** alluvial, sandy, gravelly and clayey materials
- **Transmissivity** in order of 10^{-3} m^2/s
- **Storage coefficients** in order of 10^{-1}
- **Average specific flow** 17 m^3/h

3.1. GROUNDWATER HYDROGEOCHEMISTRY

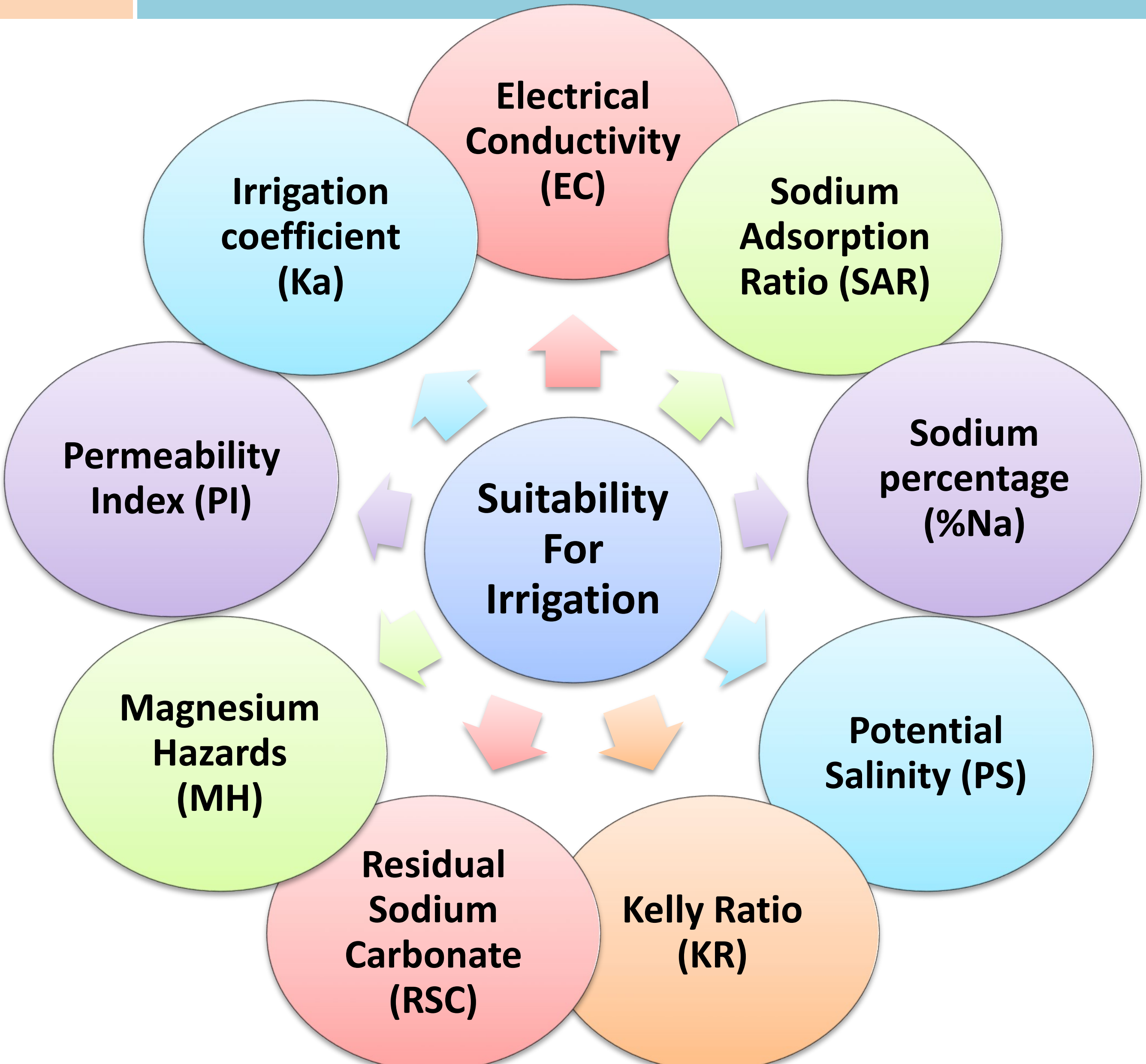
pH, TDS and EC were measured in situ using AQUAREAD AP-2000 material. Major ions, minor ions and metallic trace elements analyzed by EDTA titration, atomic absorption, photometry and spectrometry.

Results interpretation Piper (Piper, 1944), Stiff (Stiff, 1951) and Gibbs (Gibbs, 1970) diagrams were used for the determination of water type and hydrogeochemical processes

Processes controlling the chemistry: factor analyses and bivariate plots

Spatial distribution: IDW interpolation method

3.2. GROUNDWATER SUITABILITY FOR IRRIGATION



4. RESULTS AND DISCUSSION

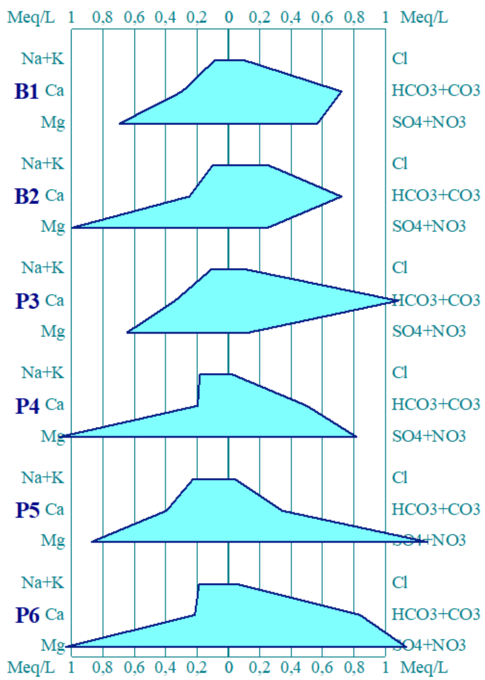
4.1. GROUNDWATER HYDROGEOCHEMISTRY (1/5)

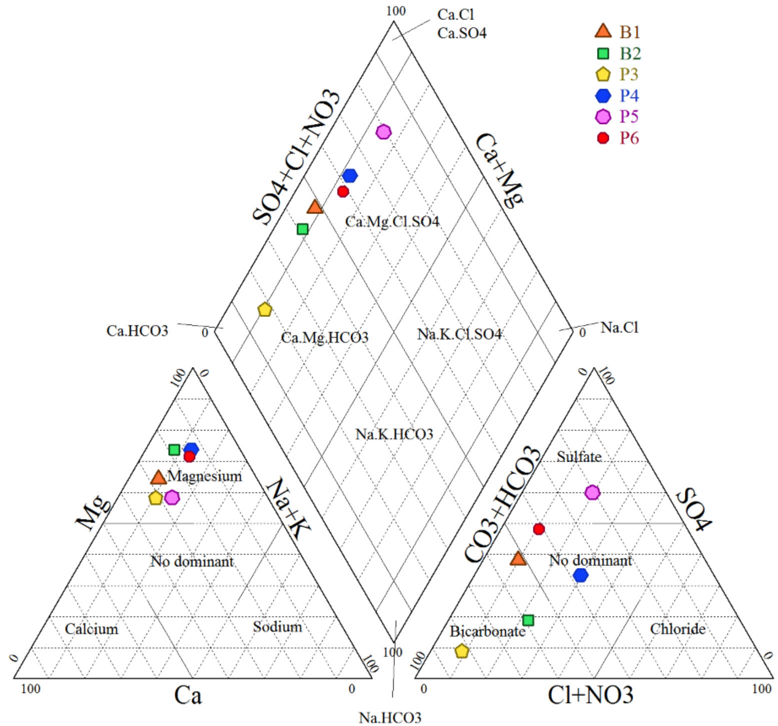
[redacted]

- low mineralization of the groundwater but a relative high variation and the large spatial variability of the physicochemical parameters.
- Concentrations respect FAO standards concerning irrigation water quality excepting nitrate (R.S. and Westcot, 1985).

4. RESULTS AND DISCUSSION

4.1. GROUNDWATER HYDROGEOCHEMISTRY (2/5)





50% Ca-Mg-HCO_3 — the most encountered in the tabular Infracambrian groundwater of Burkina Faso

50% Ca-Mg-Cl-SO_4 — the most important in the study area and. Chloride presence would be the result of water contaminated by anthropogenic chlorides infiltration (Huneau et al., 2011; Kouanda, 2019)

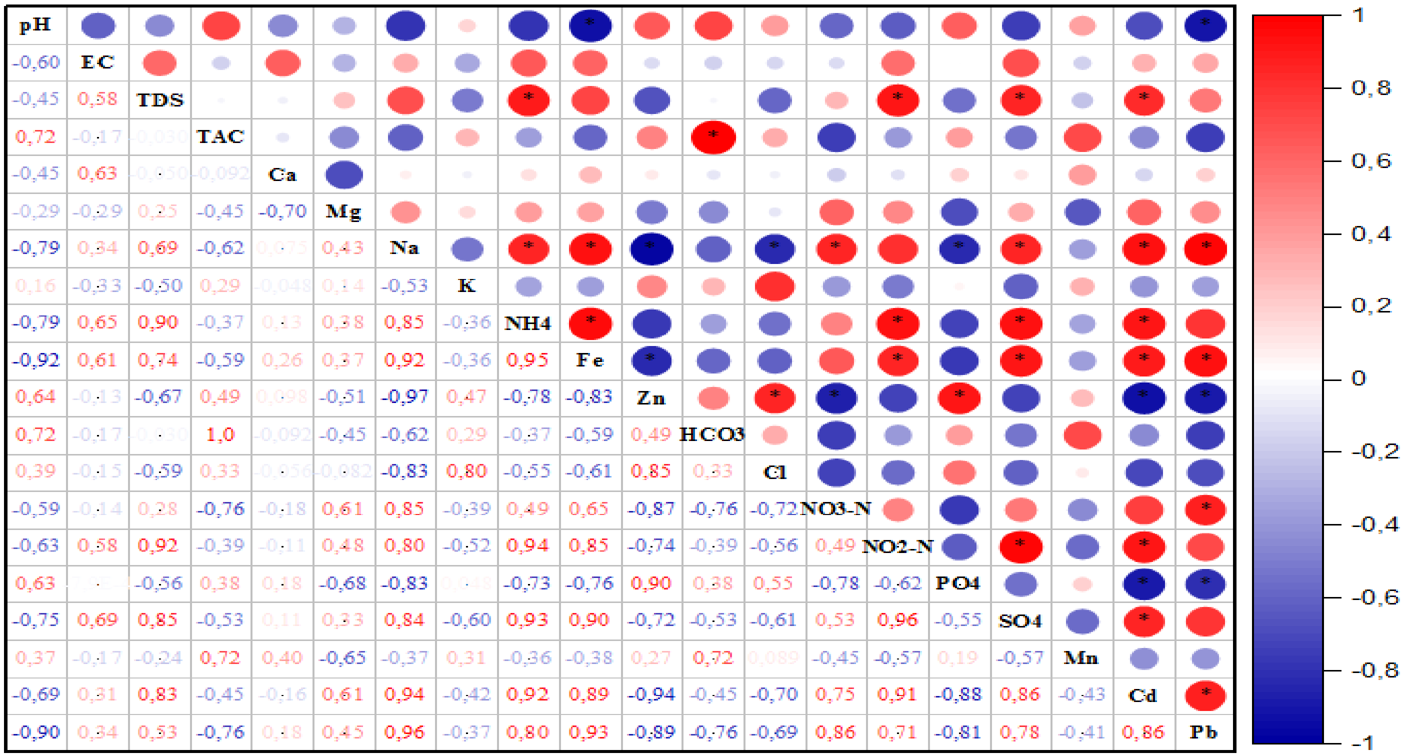
4.1. GROUNDWATER HYDROGEOCHEMISTRY (3/5)

Attribute	PC1	PC2	PC3
Na	**0.977**	0.018	0.025
Cd	**0.964**	0.123	-0.185
Fe	**0.956**	-0.201	0.143
Pb	**0.940**	0.032	0.291
SO4	**0.921**	-0.245	-0.099
Zn	**-0.920**	-0.183	0.117
NH4	**0.918**	-0.230	-0.121
NO2-N	**0.899**	-0.101	-0.275
pH	**-0.814**	0.233	**-0.502**
PO4	**-0.804**	-0.341	0.015
NO3-N	**0.783**	0.450	0.206
TDS	**0.764**	-0.267	**-0.540**
Cl	**-0.732**	0.062	0.278
HCO3	**-0.624**	-0.216	**-0.643**
K	**-0.505**	0.253	0.357
Mg	**0.504**	**0.777**	0.019
Ca	0.025	**-0.836**	0.477
EC	0.439	**-0.817**	0.066
Mn	-0.499	-0.354	-0.171
Eigen value	***11.41***	***2.87***	***1.72***
Var. Expl.	***60.05 % (60 %)***	***15.10 % (75 %)***	***9.05 % (84 %)***

PCA result shows 3 process or a group of processes that explain the chemistry of the groundwater with respective variances of 60%, 15% and 9%, explaining 84% of the total variance

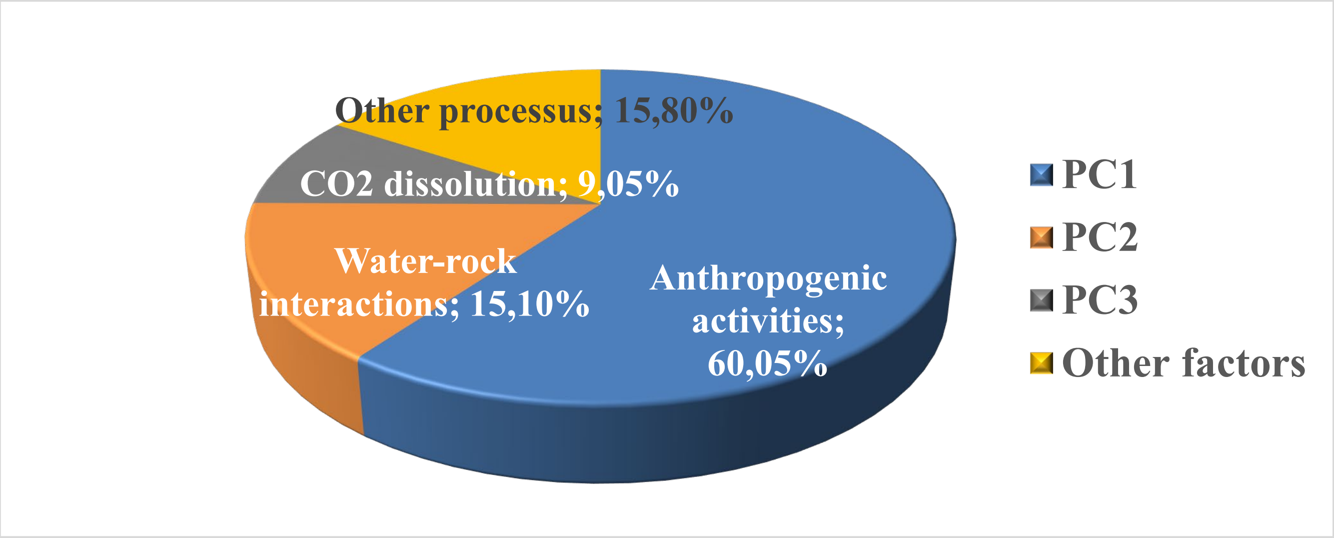
4. RESULTS AND DISCUSSION

4.1. GROUNDWATER HYDROGEOCHEMISTRY (4/5)



- **PC1:** Positive and strong correlations between Na^{+}, Cd, Fe, Pb, SO_4^{2-}, $NH4^{+}$, NO_2^{-}, NO_3^{-} and TDS is an indicator of their common sources
- **PC2** strong positive correlation with Mg^{2+} and negative with Ca^{2+} and EC, showing that they do not have the same source.
- **PC3** is strongly correlated with pH, TDS and $HCO3^{-}$ and pH and $HCO3^{-}$ Tare also positively correlated

4.1. GROUNDWATER HYDROGEOCHEMISTRY (5/5)



- **Anthropogenic activities** represent the main source of groundwater mineralization. Positive and strong correlations between Na^+, Cd, Fe, Pb, SO_4^{2-}, $NH4^+$, NO_2^-, NO_3^- and TDS is an indicator of their common sources: agricultural (Sako et al., 2020) activities occurred in the paddy field.

- **Water-rock interaction: (**PC2) Ca^{2+} could therefore come from calcite or aragonite ($CaCO_3$) and Mg^{2+} from magnesite ($MgCO_3$) dissolution.

- **CO_2 dissolution:** This axis represents CO_2 dissolution process in water depending on the pH. The CO_2 comes from organic matter decomposition (Dakoure, 2003).

4.2. GROUNDWATER SUITABILITY FOR AGRICULTURE

- **EC, SAR, %Na, PS, KR, RSC, MH, and Ka:** 100% good for irrigation
- **NO_3^{-}-N** and **PI** indicated that it is permissible
- **MH:** 100% unsuitable for irrigation and could lead to soil alkalinity

	Units	Values	Suitability
EC	[dS/m]	58.7 ± 16.01	100% Excellent
SAR	—	0.16 ± 0.07	100% Excellent
NO_3^-–N	[mg/L]	9.01 ± 9.51	50% Good 50% Permissible
%Na	[%]	11.30% ± 2.87%	100% Excellent to Good
PS	[meq/L]	0.37 ± 0.15	100% Excellent to Good
KR	—	0.10 ± 0.04	100% Excellent
RSC	[meq/L]	-0.48 ± 0.36	100% Excellent
MH	[%]	75.10% ± 8.16%	100% Unsuitable
IP	[%]	73.10% ± 17.57%	50 % Suitable 50% marginally suitable
Ka	—	651.74 ± 278.11	100% Suitable

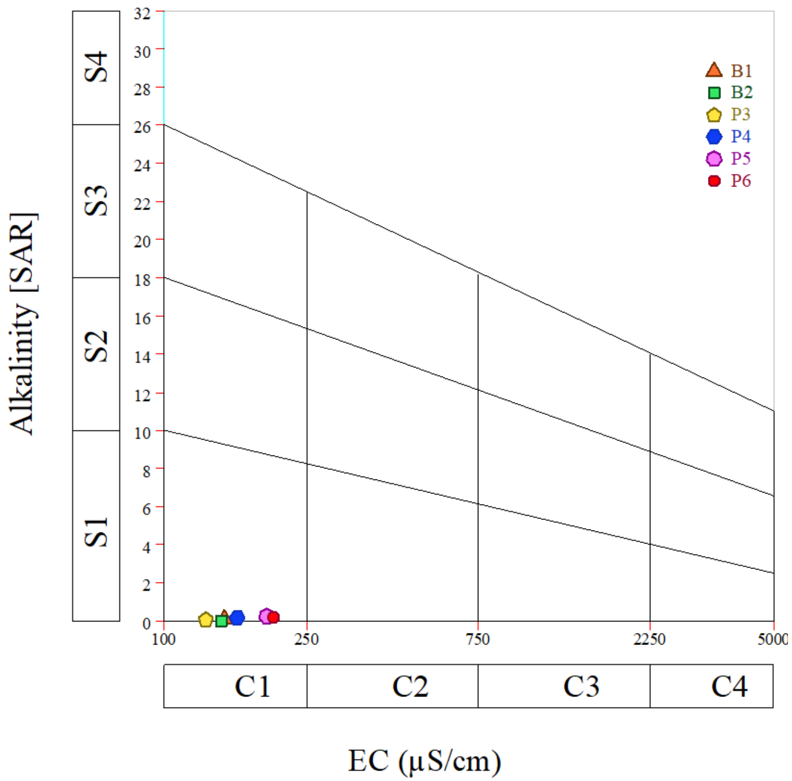
4.2. GROUNDWATER SUITABILITY FOR AGRICULTURE

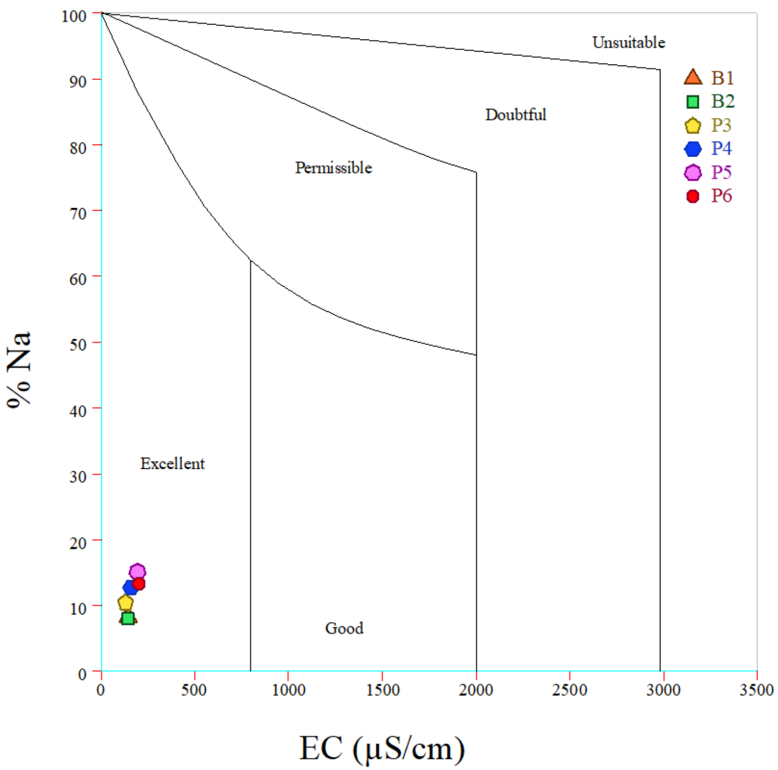
Wilcox diagram: C1S1 type

good quality water for irrigation.

USSL diagram (US Salinity Lab):

Excellent water





4.2. GROUNDWATER SUITABILITY FOR AGRICULTURE

	Units	B1	B2	P3	P4	P5	P6	Recommended Maximum concentration (FAO)
Cu	$mg.L^{-1}$	0.00	0.00	0.00	0.00	0.00	0.00	0.2
Ni	$mg.L^{-1}$	0.00	0.00	0.00	0.00	0.00	0.00	0.2
Cr	$mg.L^{-1}$	0.00	0.00	0.00	0.00	0.00	0.00	0.1
Mn	$mg.L^{-1}$	0.00	0.00	0.01	0.00	0.00	0.00	0.2
Cd	$mg.L^{-1}$	0.00	0.00	0.00	**0.03**	**0.04**	**0.05**	**0.01**
Pb	$mg.L^{-1}$	0.00	0.00	0.00	0.07	0.12	0.06	5
Al	$mg.L^{-1}$	0.00	0.00	0.00	0.00	0.00	0.00	5
Zn	$mg.L^{-1}$	0.04	0.05	0.03	0.00	0.00	0.00	2

Toxicity and Trace Elements: Ni, Mn, Zn and Pb within FAO standard for irrigation water but Cd concentrations four times higher than the standard.

Karfiguéla Shallow Groundwater can be used without precautions on soil and crops that are not sensitive to sodium and with some precautions about nitrate, magnesium and cadmium toxicity.

5. CONCLUSION

Anthropogenic activities, water-rock interaction and dissolution of CO_2 were the major processes controlling groundwater chemistry

Karfiguéla shallow groundwater can be considered suitable for irrigation but the water quality should be monitored

Karfiguéla shallow groundwater is a way to increase the paddy field productivity.

MERCI POUR VOTRE AIMABLE ATTENTION