

Isotopic Tools to study Relationship between Surface and Ground Waters under arid Climate: Case of Souss-Massa basin (Morocco)



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INTRODUCTION & SITE DESCRIPTION :

- The Souss-Massa basin situated in the SW of Morocco (Fig. 1), with large surface of 17.000Km²; is defined as one of the most water stressed area in the country;
- The climate is semi-arid to arid, It experiences highly variable rainfall and recurrent droughts;
- The rainfall is ranging from 100 mm/y in the plains to 600 mm/y in the mountains (altitude >700 m a.s.l.);
- Souss and Massa rivers are the major collectors Without permanent flow except within the upstream area of the basin.;
- The shallow aquifer of the plain is the main resource for drinking, irrigation and industrial water in the region (Fig.1);
- The region is an important economic pole for the country focused on: Agriculture, Fishing and Tourism;
- Climate change coupled with increasing water demands are likely to exaggerate water crisis in the region.

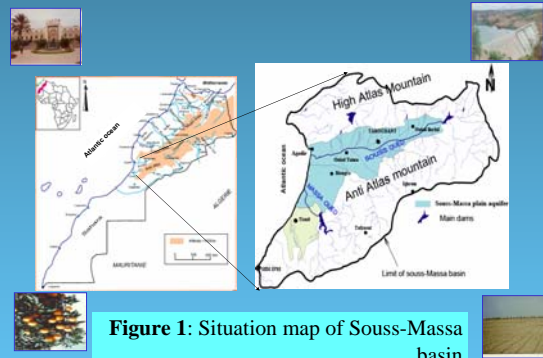


Figure 1: Situation map of Souss-Massa basin

METHOD : In order to improve the management of the water resources in the area, an investigation of the sources and dynamics of groundwater is being conducted with environmental isotopes including ¹⁸O, ²H, ³H and ¹⁴C. The main objectives of this study is:

- Investigation of the mechanisms of recharge to the aquifer and the relationship between surface water and groundwater in semi-arid climate.
- Evaluations of the isotopic techniques in the upstream of the basin (area of the recharge);
- New guidelines for the optimal use of isotope techniques in water management in the context of large hydrologic systems.

RESULTS & INTERPRETATION :

- The stable isotopes contents of waters present a large variation (Fig. 2);
- The upstream of the basin shows more depleted values of ²H and ¹⁸O;
- Compared to GMWL, all Points aligned along GMWL which indicates oceanic origin;
- This finding can be explained by the altitude and the continental effects.
- The slight evaporation recorded by stable isotopes in some samples can be explained by:
 - (i) direct evaporation from dams, rivers, a drier climate;
 - (ii) return irrigation water;
 - (iii) form non deep wells subject to evaporation particularly in the margin of the Anti-Atlas Mountains, which form a barrier against the influence of the Sahara.
- Mixing between surface and GW;

Fig. 2: Relationship Oxygen-18/Deuterium

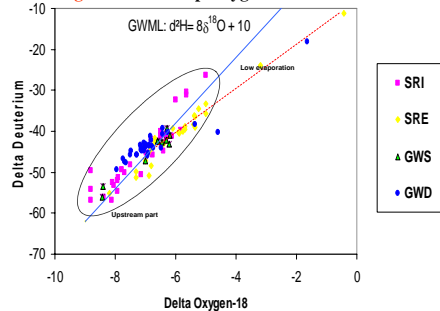


Fig. 3: ¹⁸O, ²H, reveal a significant infiltration of surface water before evaporation,

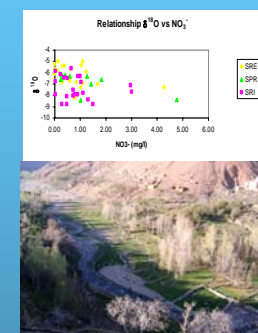
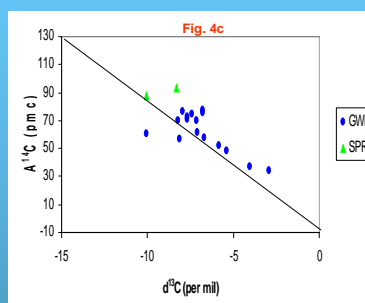
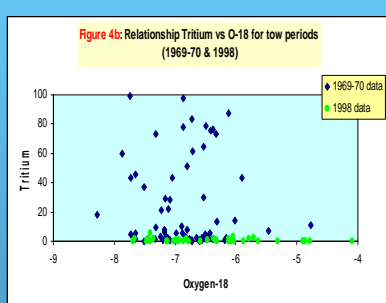
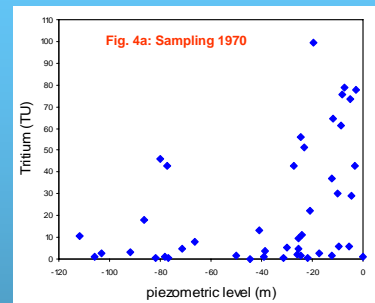


Fig. 5: Surface and GW are vulnerable to contamination. NO3 indicates base flow phenomena form GW to SW.

- ✓ ¹⁸O, ²H, ³H and ¹⁴C values indicate a mixing between recent and old groundwater (Fig.4,a,b,c).
- ✓ The age estimated based on ³H and ¹⁴C data suggested that relatively old GW is practically mined at some wells;
- ✓ The high tritium values in 1970 sampling allow clearly a signature of nuclear bomb effects highlighted between 1960 and 1970 (Fig.4a).
- ✓ The deep groundwater in down-flow parts and in confined aquifer are older and reflect past recharge during the Holocene (humid climatic conditions than that at present).



CONCLUSION: This study shows the interest of isotopic tools in semi-arid climate for water resources management.

- ❖ The recharge of the Souss-Massa GW is mainly coming from High Atlas Mountain which has a relative high rainfall;
- ❖ Two water types were signaled: (i) recent water which follows a superficial flow path, (ii) old water which follows a deep flow path.
- ❖ Stable isotopes signatures reveal a significant infiltration of surface water before evaporation, indicating a recent recharge
- ❖ ³H and ¹⁴C data revealed modern groundwater in the recharge zones of the aquifer;
- ❖ Mixing between surface and Groundwater;
- ❖ Water resources are more vulnerable and very sensitive to climate change and in the studied area;
- ❖ These factors should take into consideration for future water management plans;