Water salinity origin at Sousse region (Tunisia). A multi survey approach to the problem.

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ABSTRACT

Water quantity and quality is a major problem ever since at center and south Tunisia. The Oued Laya coastal aquifer system is no exception to this. It's a coastal saline wetland located along the Mediterranean Sea in the Sahel near the seaside resort city of Sousse, 140 km south of Tunis (Eastern Tunisia). This aquifer has a bad groundwater resources quality with a high salinity in comparison with the neighbor's aquifers.

The climate is semi arid and Mediterranean type, Average annual rainfall is about 320 mm/year. Potential evapotranspiration, calculated using the Riou method, exceeds 1750 mm/year. Official annual figures indicate water retrieval of $3{,}3\times10^6$ m^3 for an interannual average groundwater recharge estimated at $2{,}7\times10^6$ m^3.

This work aims to characterize the geometry of the badly known aquifer system and to identify the origin of salty groundwater geochemical processes, according to the degree of salinity, with geochemical, isotope and geophysical techniques. To this purpose, a transient electromagnetic (TDEM) campaign was performed in December 2009 on 29 points in the study area, covering roughly half of it. This work uses also a monitoring network set up in the Sahel of Sousse in the 1980s by the Departmental of water resources of the Ministry of Agriculture, Tunisia.

In the mean while a sampling and measurement campaign was realised on thirty points (dug wells and boreholes). Different methods using geochemistry (ions Na^+, Cl^-, SO_4^{2-}, Ca^{2+}, Mg^{2+}, Br^-) and stable (^{18}O ,^2H) and radioactive isotopes (^3H, ^{14}C) are compared with the hydrodynamic information for identifying the main processes involved in the increase of salinization.

The research area is composed of two aquifers: an unconfined and a deeper confined aquifer in the clay and sandy Mio-Pliocene formations which covers 217 km² and whose thickness varies from 30 to 50 m. This is based at network's data water chemical analyses and hydrostatic level measures, and confirmed from TDEM data. The superficial aquifer as water mean dry residue of 4420 mg/l. The deeper one is even more salty. The confined aquifer of this delta shows high values of electrical conductivity rising from the north (4 mS/cm) to the shoreline (14 mS/cm).

Analyses of cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) were carried out with atomic absorption spectrometry. The anions (Cl^{-}, SO_4^{2-}, Br^{-}, $NO3^{-}$) were analysed by ionic chromatograph. The chloride is strongly correlated to the sodium for the majority of the samples. The predominance of sodium and chloride can be explained by the proximity of the sea, via the spray and/or a progress of seawater intrusion. Even for points far from the sea, the Na^{+}/Cl^{-} molar ratio (meq/l) does not significantly differ from the Mediterranean ratio (0,86). This indicator is then of a limited interest for distinguishing the origins of the mineralization. The Br^{-}/Cl^{-} ratio is often used for identifying a possible seawater intrusion because of its relatively constant value ($1{,}5\times10^{-3}$) in the present sea water. In the Mio-Pliocene confined aquifer, the Br^{-}/Cl^{-} ratio is in general lower than the marine ratio excluding the possibility of sea water intrusion.

This high salinity seems to be not linked with the increasing water well's abstraction, as the major part of coastal aquifers in the Mediterranean area, but seems to be related to the geology of the study area where we observe a deposit of gypsum clay. Also, unconfined aquifer piezometric map and its flow direction don't show any possibility of seawater intrusion. What lithostratigraphic study show is dissolution of the existing evaporates in some geological formations. This hypothesis was checked primarily by the geochemical study which suggests a geological origin of salinity and confirmed by the interpretation of the salinity map and the chemical diagrams as well as the relations between the principal major elements.

Interpreted TDEM data survey, together with previous DC resistivity soundings, does confirm this scenario. Electric conductivity always increases with deep throughout surveyed area, being slightly less conductive at NE sector. The soundings also confirm the clayed layers starting from the surface. Conditions do not allow soundings acquisition near shoreline and localised seawater intrusion were not confirmed.

The return of water irrigation remains to be confirmed by other analytical approaches such as isotopic geochemistry (stable isotope of ^{15}N coupled with the contents nitrates). To face in front of the increase in the salinity of the aquifer, the possibility of carrying out an artificial recharge starting from water of North proves to be a plausible solution.

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