Strategic Partnership for the Mediterranean Sea Large Marine Ecosystem
MedPartnership
Together for the Mediterranean Sea
GEF UNEP

Experience Note

Identification of the effects of human pressure on groundwater quality to support water management strategies in coastal regions: a multi-tracer hydrogeochemical approach in the region of Nador - Morocco

AT A GLANCE

The Strategic Partnership for the Mediterranean Sea Large Marine Ecosystem (MedPartnership) is a collective effort of leading environmental institutions and organizations together with countries sharing the Mediterranean Sea to address environmental challenges that Mediterranean marine and coastal ecosystems face. The project's 78 demonstration and the promotion and replication of good practices will maximize impact and ensure the sustainability of the project beyond its lifespan.

Total budget: 48 millions USD.
13 million USD: Global Environment Facility
35 million USD: Participating countries, executing agencies, and donors.

ABSTRACT

Groundwater pollution from anthropogenic sources is a serious concern affecting several coastal aquifers in the Mediterranean Basin. In this region adequate science-based management strategies to protect groundwater from contamination and overexploitation are of paramount importance. In particular special attention has to be paid to coastal aquifers in arid and semi-arid regions, often representing the main freshwater resource to sustain human needs, as in the case of the Bou-Areg Aquifer (Nador Region, Morocco). A complete assessment of human impacts on groundwater quality determined that the Bou-Areg aquifer is characterized by a high natural salinity, increased by the effects of agricultural activities through irrigation return flows. The coupled multi-tracer and statistical analysis confirmed the strong dependency on irrigation activities and favoured the identification of the processes governing the aquifer's hydrochemistry in the different seasons. This study represents a reproducible example of the application of hydrogeochemistry as a tool for groundwater management in rural coastal areas.

UNESCO
Organisation des Nations Unies pour l'éducation, la science et la culture
Programme Hydrologique International

ACTIVITY DESCRIPTION

Between September 2009 and September 2012 a hydrogeochemical investigation was performed in the region of Nador (Morocco) with the overall objective of supporting new water management plans in the Bou-Areg aquifer and the nearby lagoon of Nador. In particular the study addressed (i) the identification of aquifer recharge processes in the different seasons, (ii) the evaluation of the impact of human activities on groundwater quality, and (iii) the assessment of aquifer/ lagoon interactions.

THE EXPERIENCE

Coastal aquifers often represent an important source of renewable freshwater exploited to sustain human activities worldwide. Those areas are also among the most inhabited zones, especially in arid and semi-arid regions, hence greatly exposed to all the negative externalities associated to human activities (e.g. excessive abstraction and contaminant loads).

Methodology

Preserving natural groundwater quality of coastal aquifers is of paramount importance, especially in zones where renewable resources are unevenly distributed, or scarce, and average rainfall is low, as in the case of the region of Nador (North Morocco). In this area, the Bou-Areg Aquifer (119 Km^2) is a perfect example of a coastal aquifer constantly exposed to all the negative externalities associated with groundwater use for agricultural and domestic purposes, which lead to a general increase in aquifer salinization. In addition, the aquifer borders with a coastal shallow lagoon, the Lagoon of Nador, hence the aquifer-lagoon water interaction needs to be studied to verify the occurrence of saline water intrusion and/or lagoon contamination due to aquifer discharge.

Dr. Elisa Sacchi and Dr. Viviana Re performing in situ measurements in Nador suburbs (© Tomas Lovato 2011)

In order to assess the impact of human activities on both groundwater and lagoon waters in the region of Nador, and to support new science-based water management practices, an integrated hydrogeochemical investigation was conducted between September 2009 and September 2012. The investigation was carried out by researchers from the Ca' Foscari University of Venice (Italy), in collaboration with local colleagues from the University of Oujda (Morocco) and the University Hassan I of Settat (Morocco) with the support of the Italian Ministry for Environment, Land and Sea and UNESCO-IHP.
The hydrogeological investigation, geochemical analysis of major and trace element, Isotope geochemistry ($\delta^{18}O$, $\delta^{2}H$, $\delta^{18}O_{NO3}$,$\delta^{15}N_{NO3}$, $\delta^{13}C_{DIC}$, $\delta^{11}B$) on more than 100 groundwater and lagoon water samples, together with subsequent statistical data treatment enables researchers to assess the baseline aquifer conditions, the impact of human activities on natural water quality and aquifer-lagoon interactions.

RESULTS

Results show that groundwater is mainly characterized by sodium-chloride hydrochemical facies and by a high natural salinity, primarily due to water-rock interaction processes (dissolution of evaporative rocks and carbonates). Agricultural return flow has been recognized to be the main contribution to anthropogenic groundwater salinization especially in the central part of the aquifer .

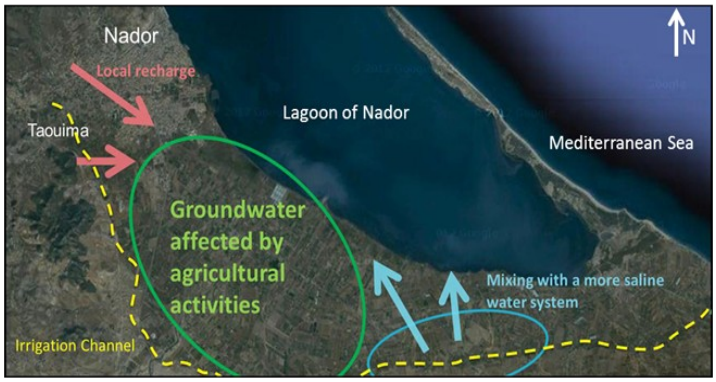


Figure 1 Schematic representation of salinization processes in the Bou-Areg coastal aquifer (Re, 2011)

On the other hand, saline water intrusion from the lagoon in the shallow aquifer can be considered as negligible, while discharge of polluted groundwater into the lagoon has been found to partially alter its quality.
Most of the sampled sites show high NO_3^- concentrations often exceeding the WHO statutory limits for drinking water (WHO, 2011). Analysis of $\delta^{18}O_{NO3}$,$\delta^{15}N_{NO3}$ permitted to associate nitrate pollution in groundwater to two main drivers, namely manure and septic effluents (especially in the urban and sub-urban areas) and synthetic fertilizers (in the agricultural zones; Figure 1).

However, despite the high vulnerability to agricultural (and urban) pollution the Bou-Areg coastal aquifer has shown a good resilience to intense agricultural activities as proven by the strong seasonal hydrochemical variations (i.e. difference with irrigation and no irrigation; Figure 2).

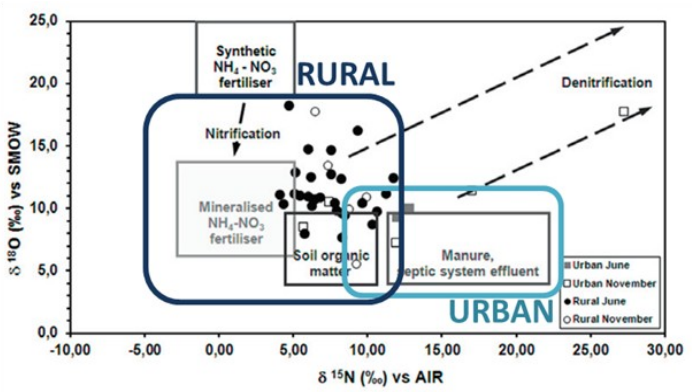


Figure 2 Isotopic composition of dissolved nitrates (‰) for groundwater samples in the Bou-Areg aquifer (Re, 2011)

LESSONS LEARNED

The investigations performed in the framework of MedPartnership were focused on the study of seasonal variations (low irrigation - recharge from precipitation and low use of groundwater from October to April, and high irrigation - no recharge from precipitation and high use of groundwater for irrigation from May to October) to assess aquifer vulnerability, with special attention on the agricultural and sub-urban parts of the Bou-Areg coastal aquifer.

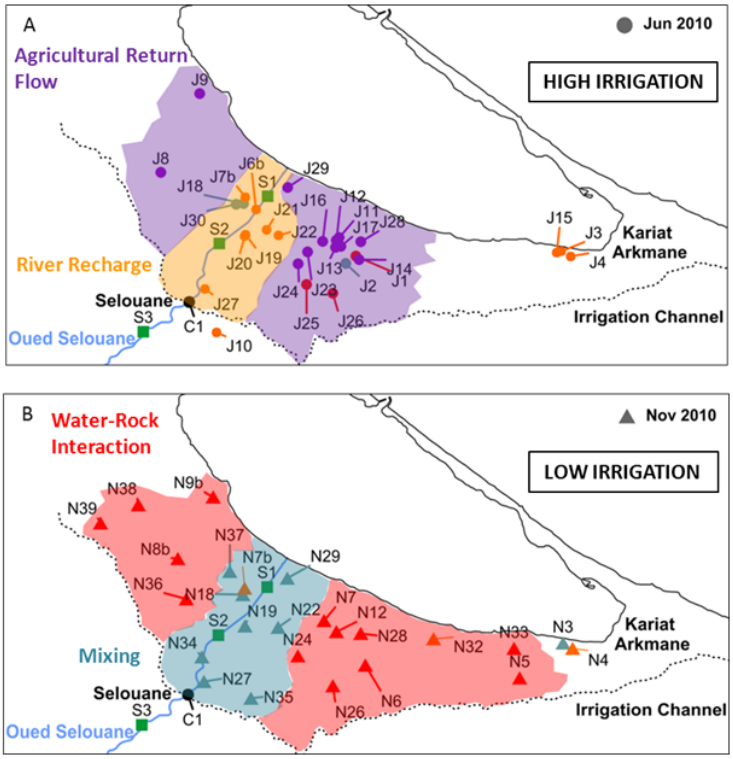
The proposed integrated approach proved to be effective in identifying the drivers of pollution and salinization in the aquifer and in providing inputs for the development of new groundwater management strategies. In order to make this process even more effective, stakeholder engagement and public participation (especially of local farmers and civil society) could foster the identification of alternative strategies for pollution reduction and the proposition of shared decisions in the water sector.

To ensure the sustainability of the project a long term monitoring strategy should be implemented order to control the variation of both groundwater quality and quantity, also in view of the current tourist development plan of the region of Nador (e.g.,. Marchica Med project).

Hydrogeochemistry has proven to be a useful tool for coastal aquifers management, as the understanding the hydrogeology system and of the associated contaminants' behaviour is not only a necessary step in groundwater vulnerability assessment but also the base for the promotion of more sustainable water management practices.

IMPACTS

The results obtained with the project have important management implications and must be taken into account for future agricultural development plans of the region. In fact, the high aquifer vulnerability implies the need to better control both the quantity and the quality of irrigation waters. Managing the impacts of agricultural return flow and urban inputs will enhance groundwater quality with relevant positive effects on crop efficiency, soil salinization, and environmental issues. Conversely, results highlight the need for a more efficient use of available water resources coupled with the identification of alternative irrigation sources, and the implementation of more efficient agricultural practices. Indeed the promotion of stakeholder engagement together with the development of participatory monitoring assessment would favour the implementation of new water management plans tailored on the real needs of local population.



Seasonal variations in the Bou-Areg aquifer and impacts of agricultural activities in (A) High Irrigation season (June 2010) and (B) Low Irrigation season (November 2010) (Re et al., 2014)

REFERENCES

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KEYWORDS

Bou Areg, Water Basin, Groundwater, Hydrogeochemistry, Water Management

EXECUTING PARTNER

UNESCO-IHP, the International Hydrological Programme (IHP) is the only intergovernmental programme of the UN system devoted to water research, water resources management, and education and capacity building. Since its inception in 1975, IHP has evolved from an internationally coordinated hydrological research programme into an encompassing, holistic programme to facilitate education and capacity building, and enhance water resources management and governance.

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Executing partners: FAO, UNESCO/IHP, UNIDO, GWP-Med, MIO-ECSDE, WWF MedPO, UNEP/MAP's MEDPOL programme and regional activity centres (SCP/RAC, SPA/RAC and PAP/RAC).

Participating countries: Albania, Algeria, Bosnia and Herzegovina, Croatia, Egypt, Lebanon, Libya, Morocco, Montenegro, Palestine, Syria, Tunisia and Turkey.