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title: **Use of multiple isotopic and chemical tools under semi-arid climate: case of recharge residence time of groundwater in the Tadla basin (Morocco)**

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Groundwater resources in Tadla basin are provided by rivers and by different water bodies forming a multilayered aquifer which host one of the most important groundwater reservoirs of Morocco. The hydrodynamic functioning, i.e. the relationship between all regional aquifers, recharge, and the residence time of waters, pose a serious problem for current water management and future exploitation. A combined Hydrogeologic and isotopic investigation using hydrochemical and isotopic tracers such as ^{18}O, ^{2}H, ^{3}H, ^{13}C and ^{14}C, was carried out in order to determine the sources of water recharge to the aquifers, the groundwater flow system, and the residence time of these waters. More than one hundred point measurements distributed throughout the study area in varying surface waters, rivers, wells, boreholes and springs have been accomplishes. The chemical results indicate an important influence of carbonate sediments in the composition of waters from each of the Tadla aquifers. The chemical and stable isotopes results indicate the existence of two groups of groundwater, which can be distinguished by their chemical and isotopic characteristics. The two groups correspond to the unconfined aquifer to the north and the confined aquifer to. Stable isotopes, as well as ^{3}H, and ^{14}C data indicate that the High Atlas mountains in the South and East of the basin, which are characterized by high rainfall and low $\delta^{18}O$ and $\delta^{2}H$ values (–5.5 to –7.5‰ and –30 to –50‰), are currently the major source of recharge to the Tadla aquifers, particularly in the south-east and Tassaout parts for the shallow aquifer. A significant zone of recharge lies in the northern part of the basin where all the aquifers outcrop. However, all isotopes demonstrated that the springs located in the South-West of the basin, which were previously supposed to be the natural outlet of the deep aquifers, are comprised of young waters, with ^{18}O and ^{2}H signatures suggesting a high altitude (Atlasic recharge type). The unconfined parts of the aquifers show enriched values of ^{18}O indicating an evaporation phenomenon which occurs during infiltration or recharge from irrigation. The confined zones show the impoverished values of ^{18}O which corresponds to the signature of Atlas Mountain and/or to paleo-recharge (≥–6.5‰. The mixing process of old and recent waters is confirmed by ^{14}C and ^{3}H. The recent isotopic data indicates probable interaction between the different aquifers. The mixing processes that were hinted at by hydraulic, and supported by hydrochemical and geological data, are defined in great detail when the isotopes data are examined. The data generated in this study will certainly permit the revision as well as improve the mathematical water resources model in the Tadla basin. The results provide the framework for a comprehensive management plan in which water exploitation should shift towards the areas where current recharge occurs where young and high quality groundwater is found.

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