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Identifying modern recharge in the arid region of Northern Chad: an hydrochemical baseline study of the Nubian Sandstone Aquifer System

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The Nubian Sandstone Aquifer System (NSAS) is located in the north-east Sahara, transboundary between the countries of Libya, Egypt, Sudan and Chad. It is characterized by its large extension and is unconfined in its southern borders and confined north of 25°N. The role of modern recharge dynamics in the unconfined part of the aquifer has been under debate by several groups of researchers; however, there has not yet been any detailed study on the zone of potential recharge located in Northern Chad (Ennedi, Tibesti). This study focuses on the Chadian extent of the NSAS.

When investigating very large aquifer systems, particularly in arid zones, stable isotopes have been successfully used to locate where modern recharge is occurring. Field-based assessment and hydrochemical sampling of 152 water points (total geographical area covered 88'000 km2), analyzed for their major ionic content and their stable isotopic ratio (δ18O and δ2H), provide a comprehensive picture of the groundwater flow paths organization in this section of the NSAS. Groundwater recharged by recent precipitation have stable isotopic values close to contemporary precipitation over North and Central Africa (δ18O -6 to +6‰ and δ2H -40 to -2‰ and a characteristic Ca-Mg-(Na)-HCO_3 signature. The geographical distribution of this compositional group closely correlates to the distribution of higher precipitations over the Ennedi and Tibesti mountains (FEWS-NET rainfall estimates RFE2). Progressive changes in the water's ionic and stable isotopic composition are found along flow lines, mainly expressed by an enrichment of Na-SO4-Cl over Ca-Mg and stable isotopic ratio becoming increasingly depleted. Similar to the Kufra oases in Libya, groundwater at the discharge point of the Ounianga Lakes has an isotopic signature compatible with Pleistocene-Holocene groundwater (δ18O -9 to -12‰ and δ2H -70 to -90‰ and a chemical composition Na–Cl–SO4–(HCO_3).

Several countries facing similar climatic and water-scarcity conditions are planning for an increase of exploitation of groundwater. This study is an example of minimum data field requirements (groundwater elevation, chemical and stable isotopic signatures) to assess the renewability of the resource, a fundamental characterization for a planned socially-sustainable utilization of groundwater . In Northern Chad, the mountains of the Ennedi are conclusively a zone where contemporary recharge is occurring, and this conclusion has important implications for the potential socio-economic development of the region.