**Isotope Hydrogeochemistry of the Nile System in the Eastern Sahara**

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ABSTRACT

Sustainable development in Egypt has to be addressed through integrated water management in the River Nile system and its surrounding deserts, including the available surface water and groundwater resources. Egypt has a high rate of population increase and unique limited river water resources in vast desert under stress and potential menace. The purpose of this work is to use conjugated hydrogeochemical and isotopic data to identify hydrological processes that deem important to improve the national water management.

Environmental isotopes (18O, 2H, 3H, 13C, 14C and 34S), hydrochemical data and modeling were used for studying the prevailing surface water, groundwater recharge and the ionic composition of groundwater extracted from 100 pumping sites, piezometers as well as from surface water bodies in the Nile Delta and Valley.

The collected groundwater samples showed the presences of elder Nile-water in the semi-confined Pleistocene aquifer, downward leakage from the unconfined to the semi-confined aquifer in middle of the Delta and its apex, upward leakage in the northern Delta zone, questionable intrusion of marine groundwater in the coastal reaches (questionable since miscible displacement would rather be the origin of salinity in the northern groundwater masses).

In the Nile valley, upward coning of fossil groundwater from the Nubian sandstone-aquifer was detected (by 18O, 2H and 14C data) only in few cases nearby fracture-aquifer sites. In the western desert skirts of the Nile Delta, and at Wadi-Natron, the origin of isotopically depleted groundwater is attributed to the same phenomenon and/or to presence of elder Nile water storage. The Oxygen-18 and deuterium data showed distinguished signatures of groundwater that was recharged during the pre-and post-High Dam (1970) periods due to evaporation-losses from the huge artificial surface-water storage in Lake Nasser. Thermal-bomb tritium is no longer useful due to 3H short half-life; however there were last-chance cases for natural tritium content applicability in the studied areas that showed active *versus* inactive recharge zones up to the year 2000. Recharge rate estimate of the delta Pleistocene aquifer was attempted; however, it needs further refinement within a comprehensive mass-balance prospect and use of adequate tracers. Carbon-13 data revealed that the low-percent solid-phase carbonates are affected in the heavily cultivated areas by *in situ* biogenic interaction and CO2 degassing. The major biogenic interactions in the sampled Nile delta and Valley aquifer sites are dominated by cultivation and irrigation. Sulfer-34 data was somewhat useful in recognizing aerobic *versus* anaerobic zones and S-containing solid-phase dissolution and precipitation. The rapid circulation of water between intensive irrigation canals, irrigated soils and drainage network needs particular study using the short half-life 35S.

Over-recharge after the complete shift to perennial irrigation regime (that started 140 years ago and completely replaced the ancient flood-irrigation regime by the year 1975 to produce more crops per annum) has resulted in largely reducing the depth to the water-table to <1m instead of >10m in the unconfined Holocene aquifer with subsequent excessive soil water logging that enhances soil salinity build-up. However, the recently stored groundwater can be partially pumped out to tackle potential water shortage and to mitigate soil degradation.

The dominant processes in the Pleistocene aquifer are 1- Leaching by recent and elder Nile water with depleted or enriched isotopic composition, and 2- mixing of recent Nile water (18O of +3%o, 20ppm Cl) with elder Nile (18O of -3%o, 200ppm Cl). The secondary processes are 1- Evaporation 2- Mixing with fossil groundwater, and 3- Mixing with the marine wedge in the coastal zone (controversial issue open to more work using adequate isotope and geochemical data). The approach used in this work is useful for proposing improved groundwater pumping-scheme in the Nile system/its desert-fringes and for the preservation of water quality.

KEYWORDS

Nile water; Isotope hydrology; Geochemistry; Groundwater; Egypt