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Commentary Article Open Acces

Commentary: Groundwater and Solute Budget (A case Study from Sabkha Matti, Saudi Arabia)

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Introduction

Sabkhas or salt flats or bodies of saline water are ubiquitous features in arid and semi-arid areas of the earth, especially in the Middle Eastern and North African countries. These systems are important in water resource assessments because they represent the discharge point or base level of local and regional groundwater and surface water flow systems and can affect the groundwater quality in their vicinity. We suggest procedure and methods that can help in understanding the link between hydraulic and hydrochemical processes affecting water and solutes below one of the largest areas of continues inland salt flats in the Arabian Peninsula; that is Sabkha Matti (SM). This sabkha is a wide, north-south trending, salt-covered depression that extends 150 km south from the western Abu Dhabi coastline and across the border between the United Arab Emirates and Saudi Arabia. SM represents a potential discharge zone of the Tertiary mega aquifer system of the Rub' al Khali basin, that is the largest sand desert basin in the world covering an area of about 650,000 km2.

Commentary

The working conceptual model for the origin of solutes in the SM aquifer system is one of ascending brines from underlying formations and concentration increase over time by a combination of evaporation, mineral solution by recharge and density-driven free-convection circulating the solutes. This model was supported through critical hydrogeologic and geochemical parameters. Our approach looked at five separate, yet interconnected conceptual models: (1) the origin of water in the aquifer system; (2) origin of solutes in the aquifer system; (3) the age of deposition of the aquifer skeletal framework; (4) the start of the ground water flow in the aquifer system (the time parameter necessary for steady state solute mass-balance calculations); and (5) the hydrodynamic mechanism that drives the accumulation of solutes over time. We observed that these models have a higher success rate if placed in context of a control volume (representative portion of the aquifer parallel to the groundwater flow direction).

While the above approach is perfectly general, the ease of sampling the SM aquifer and its unusual method of solute concentration is used in the following illustration: Consider first, the mass balance of water. Water may enter an aquifer from adjacent aquifers, from underlying or overlying aquifers, direct precipitation on the aquifer, runon to the aquifer from streams and adjacent highlands. Water may leave the aquifer by discharge to adjacent aquifer to underlying or overlying aquifers discharge to streams and by evapotranspiration. Consider secondly, the mass balance of solutes. Solutes may enter with the ground and surface water transport, from atmospheric precipitation, enter by diffusion, form by reaction of the water with the skeleton framework, enter the system by eolian process and may form by reaction with the gasses. Solute may leave the system as transported with the groundwater or surface flow, leave by diffusion, leave by mineral precipitation, leave by eolian process or leave as a gas phase. Water fluxes multiplied by their solute concentration give the solute fluxes into and out of the system. Consider thirdly, the geological age of the skeletal framework forming the sabkha aquifer. The vast majority of sediments presently in the SM aquifer can be considered Holocene in age, accumulated in a paleo-deltaic depositional environment formed by the ~140 m rise of the Gulf in the last 10,000 years combined with a huge source of continental fluvial sediments derived from the large (>250,000 km2) sabkha Matti drainage basin. Consider fourthly, the current topography and structural history of the area to determine the discharge time of water and solutes from the underlying formation. It is proposed that subsurface deformations (e.g., fractures, faults) associated with the late Pleistocene/Holocene uplift may have enhanced an upward leakage from the deeper confined aquifers to the SM aquifer. This interpretation is supported by outcrop observations of several connected fractures within the shallow geological Formations, which likely serve as preferential fluid migration pathways. Consider fifthly, the hydrodynamic mechanism of solute accumulation in which density-driven free-convection that recycles and thus, concentrates the solutes over time in the sabkha aquifer. The outcome of this study validates the usefulness and universal applicability of the ascending brine model to determine the source of water and solutes in sabkha environments.

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