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Salinity problem of groundwater in the Wadi Tharad Basin, Saudi Arabia

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Abstract

In Wadi Tharad the groundwater has been subjected to hydrochemical study to identify the process (s) that led to the formation of relatively highly saline water in shallow alluvial aquifer. The chemical analyses results show that the groundwater salinity was highly variable and randomly distributed along the wadi course. This variation could be attributed to intensive evaporation on effluent prone surface irrigation water that led to precipitation of evaporates (e.g., calcite, dolomite, gypsum and probably halite). The intensive irrigation practice through mineral dissolution recharged the groundwater with a marked increase in the salinity. The local hydrogeological condition is also involved in determining the risk of the groundwater salinity as a consequence of irrigation practice.

Introduction

The Hijaz highlands are considered to be the most important recharge zone for the alluvial aquifers in the western province of Saudi Arabia. They are traversed by a number of wadis, which are ephemeral in nature and carry water only in direct response to torrential rainfall. On the other hand, streams are often occupied in the form of a lateral flow and part of the surface horizons are dry or weakly humiferous. Wadi Ranyah Basin, which is one of these wadis might be considered one of the major drainages located in the Hijaz highlands. Within the wadi, the groundwater chemistry evolves rapidly and the salinity goes up considerably, leading to a restriction of its utilization. At the same time the wadi drainage receives a considerable amount of rainfall throughout the year. The existing salinity problem seems to be localized and there is no doubt that a relatively strong potential exists for groundwater salinity development.

In this paper, Wadi Tharad which is the most important tributary of the Wadi Ranyah Basin was selected as a pilot area for the present work. An attempt was made to identify factor(s) responsible for the groundwater salinity problem in the shallow alluvial aquifer.

Topography, climate and geology

The investigated area lies between latitudes 20°15′ and 20°20′ N and longitudes 41°50′ and 42°00′ E. Wadi Tharad originates in the flat highland plateau and drains in a northeasterly direction (Figure 1). Generally, the ground elevation decreases in a northeasterly trend from in excess of 2500 m.a.s.l in the southwestern part to about 1360 m.a.s.l at the study area. Along the wadi system the alluvium deposits have been structurally disturbed by faults filling-dike and shallow bedrock surface. As often in such a system, groundwater flow is likely to be affected and consequently, it appears at the surface forming a semi-permanent stream that disappears some tens meters downward of these barriers before it soaks back into the ground.

The uppermost area of wadi catchment receives a considerably larger amount of rainfall, on the average 400 mm yr^{-1} (Biljurashy station), than the lower part (110 mm yr^{-1}). The average monthly rainfall at the recharging area is illustrated in Figure 1. The rainfall distribution is generally heaviest from December to April. Flash floods, which are the major recharge source, frequently take place due to heavy and intensive rainfall, but high flows are of short duration. The magnitude of annual evaporation is far in excess of the annual rainfall. At the same station, the annual evaporation was estimated to be more than 900 mm $yr^{-}1$ (Al-Jurash, 1986). Higher values are expected in the lower part of the basin, where temperature tends to increase rapidly toward the lowest altitude. The maximum recorded temperature in the study area is about 35 °C in July, thus giving rise to considerable losses of water by intensive evaporation processes.

Several investigators have discussed various aspects concerning the geology of the region (e.g., Brown and Jackson, 1960; Zakir, 1972; Greenwood, 1975 and Hadley and Fleck, 1980). However, the geological features discussed below are based on the recent work carried out by Cater and Johnson (1987).

The five principal units of Precambrian layered rocks outcropping in Jabal Ibrahim quadrangle are defined in Figure 2. From the oldest to the youngest they include: (1) Jof Formation of the Baish group, which consists of volcaniclastic rocks, together with abundant mafic and felsic sills and dikes; (2) Ras Formation of the Bahah group, which comprises mainly of metamorphosed sandstone, siltstone, shale