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Water Rock Interaction [WRI 14]

Groundwater contamination and water-rock interaction during leakage of industrial waste water into a carbonate aquifer in an arid zone, Israel

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Abstract

Leakage of contaminated, acidic, and salty waste water from a chemical industrial complex in the Negev desert, Israel, resulted in increased salinity of the water in the regional carbonate aquifer. Changes in concentrations of the major elements and some ionic ratios enabled delineating the mixing process of the waste water in the aquifer. Although the waste water is enriched in trace elements, no noticeable change in their concentrations was detected in the contaminated aquifer. The removal of the trace elements is attributed to adsorption that was enabled by a rise in the pH of the contaminated water as it comes in contact with the carbonate host rock.

Keywords: contamination, salinization, Judea Group, carbonate aquifer, acidity, trace elements.

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1. Introduction

Contaminated water from a chemical industrial complex in the northern Negev desert, southern Israel (Fig. 1), was allowed to infiltrate into the subsurface for several decades, until the mid 1990s. The infiltrating water differs significantly from the natural groundwater of the regional aquifer in both the salinity and trace elements content. The interaction between the industrial waste water and the host rock in the unsaturated zone as well as between the rock and the mixed water in the aquifer itself resulted in a sharp change in the composition of the groundwater. Here we describe the changes and processes that occurred over the years in the subsurface that are due mainly to water rock interactions and basic chemical processes.

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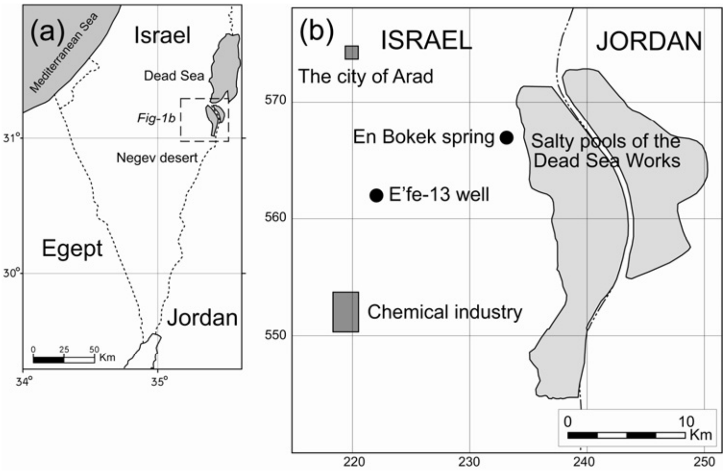

Fig.1. Northern Negev location map. The industrial complex is located south of the city of Arad. Ef'e-13 well and En Bokek spring are located downstream from the complex at a distance of 9 and 15 Km, respectively.

2. Contamination of the Judea Group regional aquifer in the northern Negev desert

The Judea Group aquifer in the northern Negev is a 500 m thick sequence of karstic limestones and dolomites interbedded with some marly layers. The salinity of the aquifer, as established in the 1980s, was 500-550 mgCl/L. The natural flow is north-eastwards, towards En Bokek spring which is the only outlet of the aquifer (0.43 10^6 m^3/year on the average). This spring is located in the Dead Sea rift Valley, close to the artificial evaporation ponds of the Dead Sea Works Ltd. (Figure 1). Until the mid 90's the salinity of the spring was stable at 500-520 mg Cl/L, similar to the salinity of the aquifer upstream. Below the industrial complex the top 350 m are unsaturated. The carbonate sequence dips here northward towards a local synclinal, where a well (Ef'e-13, 460 m deep) was drilled in 1994 to the aquifer. The contaminating water flowed northward in the unsaturated zone along the geological structure until reaching the water table of the regional carbonate aquifer, where mixing occurred.

The industrial complex produced waste water at annual volumes and composition which are not fully known. The water was discharged into nearby evaporation ponds, from which it leaked continuously, as well as directly infiltrated into a karstic swallow-hole. Based on some scarce data, Burg and Naor [1] evaluated that approximately 2 10^6 m^3 of water leaked and discharged every year into the subsurface, amounting to a total volume of ~75 10^6 m^3 since the beginning of the industrial activities. The waste water originated from different industrial sources and thus included dissimilar types of contaminants, each source characterized by its own composition (Arad and Halicz [2]; Burg and Naor [1]). Generally, the contaminating waste water was highly saline, particularly enriched with Ca and Cl and often very acidic (pH of 1-2.5). The acidic waters were also characterized by high concentrations of trace elements, including Al, Cd, Zn, Pb, Cu, Cr, As, B, Mo, Ni, Mn, Fe, and PO_4. The high salinity and chemical composition of the contaminating water can be appreciated from the composition of the water encountered in a shallow well that was drilled to a small and restricted shallow perched aquifer adjacent to the evaporation ponds (Table 1).