Radium behavior in the variable-density flow field of the Dead Sea aquifer

Yael Kiro[1,2], **Yoseph Yechieli**[2], Yishai Weinstein[3], Abraham Starinsky[1] and Clifford I. Voss[4]

[1] Geological Survey of Israel, 30 Malkhe Israel St., Jerusalem, 95501
[2] Institute of Earth Sciences, Hebrew University of Jerusalem, Givat Ram, Jerusalem, 91904
[3] Bar-Ilan University, Department of Geography, Ramat-Gan 52900
[4] US Geological Survey, 12201 Sunrise Valley Drive, Reston, VA, 20192 USA

ABSTRACT

The continuous lake level drop of the Dead Sea provides a unique opportunity to study the interaction between hypersaline brines and the aquifer in this extremely dynamic system. We studied the behavior of radon and radium isotopes in groundwater whose salinity ranges between fresh water and the Dead Sea salinity.

Radium and radon isotopes are commonly used as tracers for submarine groundwater discharge and for estimating adsorption distribution coefficients. The possibility to study the Dead Sea water after it enters the aquifer and mixes with fresh groundwater offers a natural case, which demonstrates the effect of salinity on the activity of radium.

The Dead Sea lake water is enriched in ^{226}Ra with an activity of 140 dpm/L. Radium is removed from the Dead Sea water as it enters the aquifer, resulting in a reduced ^{226}Ra activity of 60 dpm/L in groundwater with Dead Sea salinity. The relation between the salinity and the ^{226}Ra activity shows a mixing process with fresh groundwater.

Unlike the ^{226}Ra, the short-lived radium isotopes are produced from the aquifer sediments and are almost absent from the Dead Sea lake water. The activities of the short-lived radium isotopes increase with salinity in a nonlinear relation.

Considering the dynamic conditions of the Dead Sea level drop, an approach of studying radium isotopes in a dynamic flow field was taken. Analysis and simulations with SUTRA-MS were performed in order to describe the processes controlling radium and radon distribution in the Dead Sea aquifer.

The large decrease of ^{226}Ra on entering the aquifer cannot be explained by adsorption because of the high salinity of the water where adsorption is expected to be very low. This is also supported by the simulations. Therefore, we suggest removal of radium via the precipitation of barite. This is supported by the reduced concentrations of barium in this groundwater compared with the Dead Sea water.

According to the simulations, the relation between ^{226}Ra activity and salinity over time changes during the lake level drop. On the other hand, the relation between the salinity and the activity of short-lived radium isotopes is constant in time and is not affected by the Dead Sea level drop. The simulations show a relatively good fit with field data and may allow a good estimation of the radium adsorption distribution coefficient.