Radium Co-Precipitation in Evaporitic Systems

Yoav O. Rosenberg[1], Volker Metz[2], Yoram Oren[3], Avner Vengosh[4], Y'gal Volkman[3] and Jiwchar Ganor[1]

[1] Department of Geological and Environmental Sciences, Ben-Gurion University of the Negev, Israel.
[2] Institute for Nuclear Waste Disposal, Karlsruhe Institute of Technology, Germany.
[3] Department for Desalination and Water Treatment, the Zuckerberg Institute for Water Research, Ben-Gurion University of the Negev, Israel.
[4] Earth & Ocean Sciences, Duke University, Durham, USA.

Radium is an abundant naturally occurring radioactive material (NORM) in groundwater, lakes and ocean. Its concentration is often technologically enhanced when these water resources are utilized in the industry (TENORM). The concern regarding the fate of Ra TENORMs in high ionic strength environments in general and evaporitic system in particular was expressed in two recent technical reports of the EPA [1] and the IAEA [2].

The present study aims to examine the fate of Ra in evaporitic systems. For this purpose, three such systems are investigated both in laboratory experiments and field: 1. brine of a desalinization plant; 2. evaporated seawater; and 3. evaporated Dead Sea brine. These systems altogether provide a wide range of ionic strength (from 0.7m to ~16.5m) and variable chemical compositions. While the adsorption of Ra from seawater and brine of a desalinization plant onto MnOx fibers was almost complete (>95%), the adsorption of Ra from the Dead Sea brine was very low. Similar observations were made by Y. Kiro and Y. Weinstein (personal communication). Interestingly, dilution of the brine to sea water ionic strength did not lead to complete adsorption. Preliminary results suggest that extensive dilution by a factor of 25 is required to achieve similar Ra retention. These observations indicate that a simple competition mechanism over adsorption sites cannot explain this behavior.

Evaporation batch experiments of the desalinization concentrate indicated that Ra and Ba co-precipitate into barite. Although gypsum is the major mineral to precipitate in this system (gypsum/barite=105), it has no significant role in determining Ra fate. The value of the apparent partition coefficient in these experiments was calculated to be $K'D,barite=1.0\pm0.1$. This value of K'D is significantly lower than the accepted value for relatively dilute solutions (1.8 ± 0.1). By numerically modelling these experiments, we suggest that the decrease in K'D is a result of both kinetic and ionic strength effects. Thus, Ra removal from brine is reduced compared to low ionic strength conditions. Generalization of this observation to other systems is currently being examined using evaporated seawater and Dead Sea brine.

Bibliography: [1] EPA, 2008, Technical Report 402-R-08-005. [2] IAEA, 2003, Technical Reports Series No. 419.