Ra–Po–Pb isotope systematics in waters of Sambhar Salt Lake, Rajasthan (India): geochemical characterization and particulate reactivity

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Abstract

The Sambhar Salt Lake hydrological system, including river waters, groundwaters, evaporating pans and sub-surface brines, has been analyzed for the salt content (TDS) and naturally occurring radionuclides (210Po, 210Pb and 226,228Ra). The abundance of these radionuclides and their activity ratios show a wide variation in different hydrological regimes, which helps to geochemically characterize the lake system. A significantly lower Ra to total dissolved solids (TDS) ratio in the brines (by two to three orders of magnitude), when compared to the groundwaters and river waters, suggests removal of dissolved Ra by co-precipitation with Ca–Mg minerals at an early stage of the brine evolution. The concentration of Ra in evaporating lake/pan waters saturates at a value of about 35 Bq L−1 over the salinity range of 100–370 g L−1; attributable to its equilibration with the clay minerals. The two distinct regimes, saline lake system (lake water, evaporating pans and sub-surface brines) and groundwaters have been identified based on their differences in the distribution of 226,228Ra isotopes. This observation points to the conclusion that the groundwaters and the lake brines are not intimately coupled in terms of their origin and evolution.

1. Introduction

Studies on the geochemical behaviour of natural radionuclides in surface/sub-surface regimes provide useful information on time scales of various physical, chemical and biological processes. Also, their radiochemical properties in sub-surface medium have direct relevance to the management and storage of nuclear wastes. In this context, the daughter nuclides of the U–Th series offer useful information on their residence times and retardation characteristics in the sub-surface aquifer medium. Because of different geochemical properties and varying half-lives, the nuclides of the U–Th decay series serve as in situ indicators of chemical behaviour of other fission product nuclides injected into the medium. The measurements of Ra, Po and Pb isotopes, reported in this study, in freshwater and brines from the Sambhar Salt Lake provide an ideal opportunity to study their behaviour over wide range of salinities in an environment different from oceanic regions.

There is an extensive body of literature available related to geochemical behaviour of Ra, Po and Pb isotopes in estuaries, coastal and open oceans, lakes, river waters and groundwater system. They deal with mixing of water masses, particle reactivity and removal residence times of particle reactive nuclides (Moore, 1972; Thomson and Turekian, 1976; Tsunogai and Harada, 1980; Krishnaswami et al., 1982, 1991; Bacon et al., 1988; Todd et al., 1986; Glover and Reeburgh, 1987; Dickson and Herczeg, 1992; Sarin et al., 1994). Because of high particle reactivity of 210Po and 210Pb, they are scavenged rapidly from the water medium onto clays and other settling particles and thus, their measurements in the sediment column have relevance to determination of sediment accumulation rate (Krishnaswami and Lal, 1978; Carpenter et al., 1982; Kuehl et al., 1982; Hung and Chung, 1994; Yadav et al., 1992). In the present study, we have attempted to understand various mechanisms responsible for variation in abundances of 226,228Ra, 210Po and 210Pb nuclides in different water bodies of the Sambhar Salt Lake system, including lake water, evaporating pan brines, sub-surface brines and adjacent groundwaters. This study brings out differences in behaviour of radium isotopes in terms of brine evolution from evaporating lake water systems. In addition, relative particle reactivity of 210Po and 210Pb was studied in surface lake...