SUBMARINE GROUNDWATER DISCHARGE IN A MINORCA KARSTIC COVE USING RA ISOTOPES AND ^{222}RN

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Abstract

Excesses of radium and ^{222}Rn have been found in cove waters of a karstic area in Minorca (Balearic Islands) pointing out the existence of submarine groundwater discharge. Visible springs actually supply enriched groundwater while sediment does not seem to contribute to the Ra balance. The SGD flux has been estimated to be around 5 cm/d by applying a two endmember mixing model.

Keywords : Coastal Waters, Radionuclides, Geochemistry, Western Mediterranean, Coastal Management.

Minorca (Balearic Islands), as most of the Mediterranean islands, has limited water reserves that are intensively exploited for the demographic pressure. Minorca is divided in two geological settings: an impermeable area in the north and a permeable band constituting the most important aquifer in the south. This area is characterized by an inclined plain towards the sea, crossed by deep precipices that end into small and narrow coves. This aquifer is composed of miocenic materials highly degraded by erosion and karstification processes. The aquifer supplies up to 90% of the extracted water and from the hydrological balance the submarine groundwater discharge (SGD) is estimated to be up to 38 hm^3/yr [1]. This may stand for an input of nutrients to the sea that, in certain circumstances, can induce the proliferation of algae. The present study has been carried out in the Alcalfar cove with an extension of 1.74 Ha.

The Ra quartet (^{223,224,226,228}Ra) has been proposed as a useful tool to estimate SGD in several environments [2; 3; 4]. The strategy for using Ra isotopes in SGD studies is based on the fact that Ra is greatly enriched in groundwater relative to coastal waters (1-2 orders of magnitude) [5]. It is largely particle-bound in fresh water but desorbs from particles in contact with salty water, so adopting a conservative behavior once released in sea water. In order to determine the SGD, a total of 36 samples were collected from seawater, submarine springs, wells and drive points. The short-lived isotopes, ^{223}Ra and ^{224}Ra, where measured with alpha delayed coincidence counting [6], while concentrations of ^{226}Ra and ^{228}Ra were determined by gamma spectrometry. In order to complete the series of data, ^{222}Rn was measured in some samples using a commercial RAD 7 detector.

Groundwater discharges from several visible points along the cove and forms a several mm film above surficial seawater. Concentrations of Ra isotopes in spring samples showed an enrichment in comparison with seawater samples (two orders of maginitud for the ^{224}Ra). The radiumactivities in cove surficial waters versus salinity pointed out a Ra dilution process taking place when mixing with seawater. On the other hand, cove water samples collected at 10 cm above the sediment presented salinities comparable to the open sea stations and ^{222}Rn at bottom waters showed lower concentrations, indicating no detectable groundwater is flowing out through the sediment and thus supporting the idea of the submarine karstic springs as the sole groundwater inputs. A two endmember mixing model between spring and open sea waters has been built to estimate the groundwater fraction in cove waters. An average groundwater fraction of about 30% is obtained when using the radium isotopes distribution. This is translated in an approximate SGD flux of 5 cm/d when considering the width of the cove water's fresh layer and the residence time of the water as obtained from the short-lived Ra isotopes distribution.

References

1 - Estradé S, 2005. *Aportacions al coneixement del balanç hídric de l'aqüífer de migjorn de Menorca*. OBSAM internal report.
2 - Moore, W.S., 1999. The subterranean estuary: a reaction zone of ground water and sea water. *Mar. Chem.,* 65, 111-126.
3 - Charette, M.A., Buesseler, K.O., Andrews, J.E., 2001. Utility of radium isotopes for evaluating the input and transport of groundwater-derived nitrogen to a Cape Cod estuary. *Limnol. Oceanogr.,* 46, 465-470.
4 - Hwang, D.W., Kim, G., Lee, Y.W., and Yang, H.S., 2005b. Estimating submarine inputs of groundwater and nutrients to a coastal bay using radium isotopes. *Mar. Chem.,* 96, 61-71.
5 - Moore, W.S., 1996. Large groundwater inputs to coastal waters revealed by ^{226}Ra enrichments. *Nature* 380, 612-614.
6 - Moore, W.S. and Arnold, R., 1996. Measurement of ^{223}Ra and ^{224}Ra in coastal waters using a delayed coincidence counter. *J. Geophys. Res.,* 101, 1321-1329.