Estimating submarine groundwater discharge into the Ria Formosa lagoon, Portugal: Uncertainties in the lagoon-open ocean radium exchange

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Abstract

The Ria Formosa lagoon is the most important resource for the fishing, aquaculture and tourism industries of southern Portugal. The lagoon expands across an area of approximately 100 km² and about half of its area is intertidal, covered with muddy sand and saltmarshes. The lagoon is shallow (2 m average depth) with semidiurnal tides at amplitudes between 1.3 m and 3 m (during neap and spring tides respectively) causing a relatively rapid renewal of water through three inlets at time scales shorter than 5 days. The hinterland is characterized by intensive agriculture leading to elevated nitrate concentrations in coastal groundwaters. To quantify the amount of submarine groundwater discharge (SGD) and possible associated nutrient fluxes to the lagoon radium concentrations (^{223}Ra, ^{224}Ra, ^{228}Ra, ^{226}Ra) were measured during low and high spring tides in December 2009 and May 2010 using standard techniques (delayed coincidence counting, gamma spectrometry). A radium mass balance model accounting for all major sources and sinks of radium was employed to derive quantitative estimates of SGD. In order to avoid biases due to non-representative sampling, areal average radium concentrations were generated using the ArcGIS spatial analyst interpolation scheme. Radium exchange with the open ocean was the most significant parameter in the mass balance calculations. Three independent models were used to calculate this exchange flux: i) a tidal prism model using radium to calculate the return flow factor, ii) a hydrographic model providing outflow and inflow water fluxes for the Ria Formosa lagoon; and by combining these fluxes with the average concentrations measured at the inlet; iii) a model which estimates the exchange with the ocean based on the radium residence time calculated from the water exposure time in the lagoon. For each of these models we calculated SGD based on ^{223}Ra, ^{224}Ra and ^{226}Ra mass balances the differences being at a maximum no greater than 35 %. However, the results from the models differed up to a factor of 2 with the tidal prism model producing the highest estimate and the residence time model the lowest estimates. We will discuss possible causes for the differences in the model results.

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4th International Ra-Rn Workshop: Detailed Program

Sunday (6/3)	All day	Arrival& Hotel Check-In
	18:00-19:30	**Registration & Welcome Reception (The Village Inn)**
Monday (6/4)	08:30-08:55	Welcome

Session: Ra isotopes as tracers of mixing processes. Leader: Aaron Beck

08:55-09:20 C. A. Waters and H. Dulaiova: Comparison of apparent radium ages determined using short-lived radium isotopes using different approaches

09:20-09:45 C. Rocha, J. Scholten, Jean Wilson, C. Veiga-Pires: Using Radium isotopes to evaluate the mixing timeline and relative age of waters in a leaky coastal lagoon

09:45-10:10 W. Burt, H. Thomas, E. Horne: Enhanced pore-water diffusive fluxes of ^{224}Ra, CO_2 and nutrients related to a deep-water renewal event

10:10-10:40 Break

10:40-11:05 P.J. Morris, M.A. Charette, W.J. Jenkins, P.B. Henderson, W.S. Moore: Radium-derived mixing rates in the North Atlantic

11:05-11:30 H. Dulaiova: Radium isotopes as tracers of lateral fluxes off the continental margin of northwest Africa

11:30-11:55 B. Lansard, V. Sanial, P. Van Beek, M. Souhaut and F. D'Ovidio: What do we learn from radium isotopes about natural iron fertilization off Crozet and Kerguelen Islands, Southern Ocean?

12:00-13:30 Lunch at Village Inn

Session: Ra and Rn as Tracers of Submarine Groundwater Discharge. Leader: Henrieta Dulaiova

13:30-13:55 G. Wang, Z. Wang, S. Wang, Y. Xu, W. Jing, M. Dai: Fluctuation of submarine groundwater discharge with tides in a coastal coral reef system in Sanya, China

13:55-14:20 J. Scholten, C. Rocha, J. Wilson, M. Pham, C. Veiga-Pires, J. Aníbal: Estimating submarine groundwater discharge into the Ria Formosa lagoon, Portugal: Uncertainties in the lagoon-open ocean radium exchange

14:20-14:45 R. Peterson, R. Viso, I. MacDonald, S. Joye: Ongoing Fluid Discharge Near the Macondo Wellhead Revealed by Radium Isotopes

14:45-15:15 Break

15:15-15:40 D. E. Hammond, S. L. Colbert, H. Talsky, R. J. Schwartz: Use of Pore water Rn and Ra Profiles to Evaluate the Nature of Flow through Permeable Coastal Sands and Nutrient Inputs in Huntington Beach, Southern California

15:40-16:05 V. Rodellas, J. Garcia-Orellana, G. Basterretxea, A. Tovar-Sánchez, D. Sánchez-Quiles, P. Masque: When Ra isotopes trace vessel circulation…

16:05-16:30 A. Eisenach, J. Rapaglia, J. Scholten and A. Vafeidis: Finding the needle in a haystack: utilizing a GIS to aid in SGD research

16:30-16:55 M. Schubert, R. Stollberg, K. Knoeller, J. Wilson, C. Rocha: Evaluation of a three step approach for the straightforward localization of SGD zones

19:00-20:30 Newport Sunset Sail (POSSIBLE)

Tuesday (6/5)

Session: Ra and Rn as Tracers of Submarine Groundwater Discharge. Leader: Doug Hammond

08:30-08:55 J. L. Kelly, H. Dulaiova, C. R. Glenn: Quantifying groundwater discharge from the largest spring complex in the Hawaiian Islands

08:55-09:20 J. Ellis, N. T. Dimova, G. Tick, D. Honeycutt: Numerical modeling for evaluation of SGD rates constrained by radon-derived assessments

09:20-09:45 N. Su, W.C. Burnett, K. Eller, H.L. MacIntyre, B. Mortazavi, J.D. Liefer: Radon and Radium in Little Lagoon: Implications for Harmful Algal Blooms

09:45-10:10 J. Garcia-Orellana, V. Rodellas, N. Casacuberta, E. López-Castillo, M. Vilarrasa, V. Moreno, E. Garcia-Solsona and P. Masqué: Coastal groundwater discharge: a source of natural radioactivity

10:10-10:40 Break