ESTIMATION OF SUBMARINE GROUNDWATER DISCHARGES USING RADON AND RADIUM ISOTOPES IN THE MAR MENOR LAGOON (SPAIN) AND THE PORT-MIOU CALANQUE (FRANCE).

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Abstract

Submarine Groundwater Discharge (SGD) may represent important inputs of water and associated elements to the coastal zone. We evaluated such SGD fluxes on two contrasting environment: the Mar Menor lagoon (Cartagena, Spain) and the Port-Miou karstic springs (Marseille, France). In both cases we used radon and radium mass balances to quantify and/or locate SGD. In the Mar Menor we combined radon and radium surveys with an hydrodynamic modeling of the lagoon.

Keywords: Radionuclides, Lagoons, North-Western Mediterranean, Coastal systems

Coastal areas are vulnerable environments undergoing increasing anthropogenic pressures. Various processes can affect them, and one particularly important is the degradation of water quality in the continent or in the ocean. In this context, the groundwater discharge into the coastal zone has received increased attention in the last years as it is now recognized that this process may represent an important pathway for the delivery of nutrients, and metals to the ocean. SGD have been evidenced as submarine springs (karstic springs) or diffuse seepage across the seafloor. SGD could be freshwater (Submarine Freshwater Groundwater Discharge, SFGD) or recirculated saline groundwater (RSGD), i.e. seawater intrusion into coastal porous sediments, mixed with continental freshwater discharged back to the sea. SGD fluxes are less affected by surface drought than rivers and can occur all the year, in contrast to Mediterranean temporary rivers. Furthermore, because groundwaters can have higher concentrations of dissolved chemicals (nutrients, metals) than most terrestrial surface waters, SGD can make a disproportionately large contribution to the flux of dissolved constituents from continent to ocean. In the Mediterranean Sea, SGD was not studied at the global scale, whereas an estimate from UNESCO (2004) indicates that the karstic areas bordering 65% of the coastline could contribute for 75% of the total freshwater runoff mostly through SGD. However, recent papers underlined the occurrence of SGD in Spain, France or Italy and revealed the different influences they could have on coastal fluxes of elements ([1], [2], [3], [4]).

In the two studied areas we used radon and radium isotopes as tracers of SGD. These elements are enriched in groundwater compared to coastal waters and the estimation of their budget in a coastal area allows locating and quantifying SGD.

^{222}Rn was analysed with a RAD-7 system on 250 mL bottles (groundwater and river water) or in continuous by surface water pumping on-board of small vessel along the coast. 15 L of water were collected for radium isotopes, preconcentrated on Mn-fiber. And analysed using a RaDeCC system designed by Moore and Arnold [5].

In Mar Menor (Spain), we used an approach combining radon (^{222}Rn) and radium (^{223}Ra, ^{224}Ra) surveys together with an hydrodynamic modeling of the lagoon. This allowed to decipher the radionuclide signal issued from surface water, atypically highly enriched in radionuclides and nutrients, than those issued of SGD. Radionuclides mass balances provide SGD fluxes of water of 26-58 (^{222}Rn), 10-20 (^{224}Ra) and 18 m^3/s (^{223}Ra). The budget evidences that sea-level variation is likely to be an important process for this SGD by adding recirculated seawater from the sediment to the water column, while fresh groundwater discharge from the aquifer is about 1% of total SGD. This corresponds to a fresh groundwater input of 0.2 m^3/s that is similar to river flux (0.33 m^3/s) and clearly lower than inter and outer water fluxes exchanged with the Mediterrenean Sea.

The Port-Miou karstic submarine spring (France) is typical of brackish groundwater discharging through karst conduits, and it was investigate in order to validate the mass balance model approach. Combining ^{222}Rn, ^{223}Ra and ^{224}Ra mass balances with water and salt budgets, we obtained a SGD value of 3.6 m^3/s, consistent with the discharge estimated by an hydraulical approach based on pressure sensors. This validation allows the use of ^{222}Rn as a tracer for other important karstic areas in the Mediterranean Sea (Croatia, Greece, ….) where discharges data are not available.

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