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Application of natural radium isotopes and radon to assess submarine groundwater discharge and coastal water mixing rates

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ABSTRACT

Chemical differences between coastal and offshore waters occur as a result of several processes. The inflow from rivers and desorption from riverborne particles enrich coastal waters in some elements, while the chemical reactions associated with this mixing may remove other constituents. Anthropogenic inputs associated with industry, shipping, mining, sewage and a host of other factors contribute pollutants to these waters. Another factor that is becoming recognized as a significant control on coastal water chemistry is submarine groundwater discharge (SGD). This process may contribute both natural and anthropogenic components and may also remove certain components as coastal waters circulate through shallow aquifers. The distribution of naturally occurring radionuclides can provide important insights into the mobility of pollutants and rates of natural geochemical processes. Modeling of local mass balance by physical and tracer techniques can supply quantitative estimates of transport rates. The distribution of naturally occurring radionuclides can provide important insights into the mobility of pollutants and the rates of natural geochemical processes. Modeling of local mass balance by physical and tracer techniques can supply quantitative estimates of transport rates. The exchange rate between coastal waters and the open ocean is a key parameter that must be known in order to estimate chemical fluxes between the continent and the ocean. Knowing the exchange rates allows oceanographers to estimate fluxes

of conservative tracers and reaction rates of non-conservative components. These exchange rates may be derived from physical measurements, models and tracers. Short-lived radium isotopes (^{223}Ra $t_{1/2}$ = 11.4 days; ^{224}Ra $t_{1/2}$=3.6 days) have been used to estimate exchange rates. The rates of SGD along coastal margins are controlled by inland recharge rates, the underlying geologic framework and oceanographic processes on the coast. Fresh water that flows down gradient from the water table toward the sea may discharge either bas diffuse seepage close to shore, or directly into the sea either as submarine springs or wide-scale seepage. The hydraulic gradient that drives fresh water toward the sea can also drive seawater that has intruded into underlying deposits back to the ocean, creating a salt-water circulation cell. Wherever multiple aquifers and confining units co-exist, each aquifer will have its own freshwater/saltwater interface, and deeper aquifers will discharge farther offshore. SGD can be spatially as well as temporally variable, since there exists a variety of both natural and anthropogenic influences (e.g., sea level, tides, storms, precipitation, dredging, groundwater withdrawals) that can have strong effects. An ideal SGD tracer should be highly enriched in groundwater relative to seawater, behave conservatively and be easy to measure. The four Ra isotopes and ^{222}Rn follow these constraints reasonably well and have recently been used to identify and quantify SGD to various coastal areas. One strong advantage of these radiotracers is that the coastal water column effectively integrates the SGD signal over broad spatial and temporal scales.

Talk Outline

1. Introduction and Overview: definition of submarine groundwater discharge (SGD), historical research on the subject, implications to the chemistry and ecology of the coastal zone.

2. Measurement Techniques I: seepage meters, geochemical tracers, hydrological modeling.

3. Measurement Techniques II: geochemical tracers (^{222}Rn and Ra isotopes)

4. Case Study: results from SGD measurements in Ubatuba, Brazil

5. Biogeochemical and Management Implications: source of nutrients, disseminated pollution, water resource and coastal zone management issues.