The Moisture Effect on ^{223}Ra and ^{224}Ra Measurements Using MnO_2-Cartridges

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Important processes in the ocean can be evaluated with radioactive nuclides, including radium isotopes. Radium is considered a relatively soluble element, and its isotopes (the quartet ^{223}Ra, ^{224}Ra, ^{226}Ra and ^{228}Ra) have been widely used as tracers of submarine groundwater discharge and sediment-water column exchange, as well as to estimate vertical and horizontal mixing rates in the open ocean [1]. The specific activity of radium isotopes in seawater is particularly low. The radiometric measurement of radium isotopes thus requires the collection of large volumes of seawater, especially for the short-lived isotopes, ^{223}Ra and ^{224}Ra. The most recent approach for quantifying radium isotopes in seawater has been developed in advance of the international GEOTRACES program, which is capable of filtering at flow rates more than eight times greater than the previous implemented pre-concentration methods [1]. However, as occurs with the fibers [2], the measurement of short lived radium isotopes by emanation method has its efficiency affected by MnO_2-coated cartridge surface conditions and water content, which has not been tested.

Methods

Two acrylic grooved cartridges (CUNO 3M; 7.5 cm length) standards were prepared with stock solutions of ^{232}Th (with daughters ^{228}Ra, ^{228}Th, and ^{224}Ra in equilibrium) and ^{227}Ac (with ^{223}Ra in equilibrium) [1]. After completely drying, an amount of water equivalent to 5 % of the cartridges weight was added to each of them in each step. After adjusting the water content, the cartridge-holders containing the MnO2-cartridges were weighed (±0.05 g), and the water contents of the 43.25 g (^{224}Ra) and 44.05 g (^{223}Ra) MnO_2-cartridges were calculated. The moistening processes continued until the Radium Delayed Coincidence Counter – RaDeCC [3] was visibly moistened (100 % of moisture). The relative count uncertainties averaged 4.4% for the ^{224}Ra (Channel 220), and 7.1% for the ^{223}Ra (Channel 219).

Emanation Efficiency on the 220 Channel

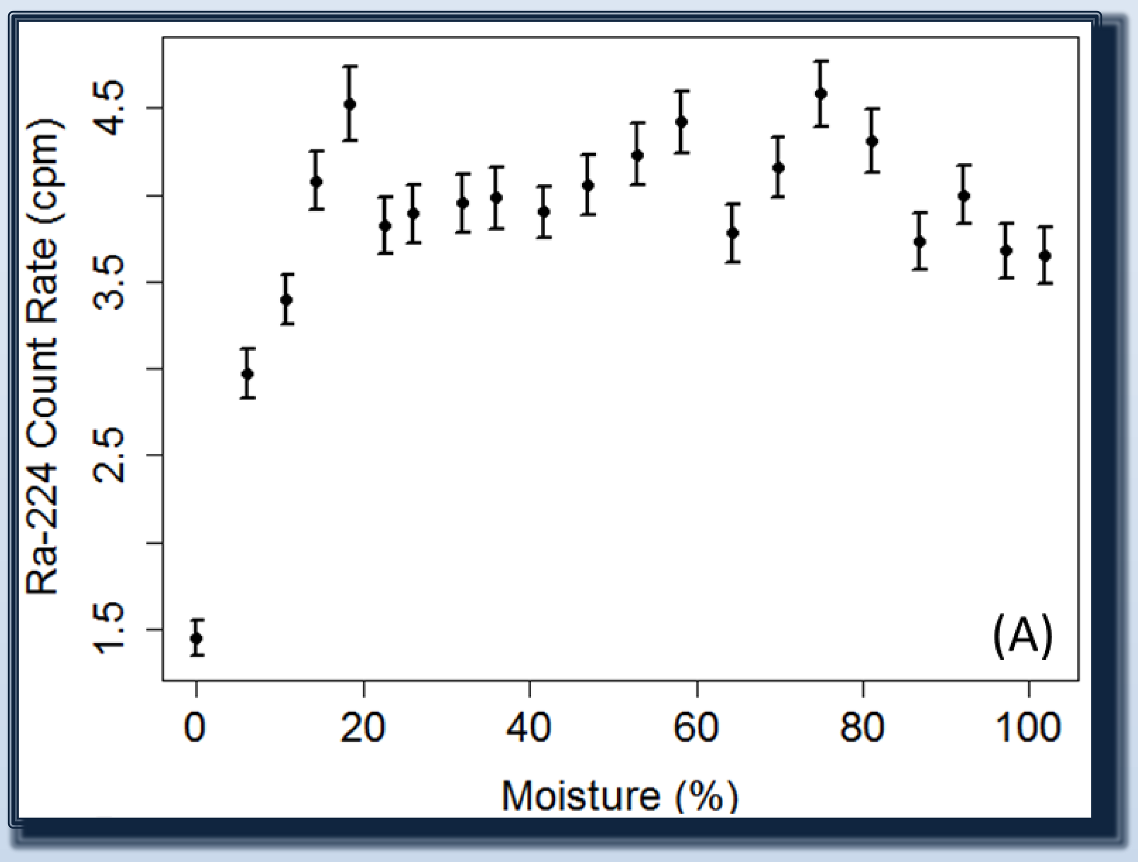

Figure 1. Count rate for of ^{224}Ra MnO_2-cartridge standard as a function of the water content.

- For the 220 channel, the results show that the count rate (and therefore the emanation efficiency) variation occurs mainly between 0 to 15% of moisture (Fig.1).
- Under moisture conditions higher than 15%, the emanation efficiency seems to reach an optimum plateau until 100% of moisture.
- The optimum moisture condition of the MnO_2 cartridge found for 220 channel differs slightly from the ideal water content found for the ^{224}Ra measurements using the MnO_2 acrylic fiber, which was from 30 to 100% [2].
- Different moisture conditions of the acrylic fibers were examined semi-quantitatively [4], searching for differences in the probability of detecting ^{219}Rn relative to ^{220}Rn. It was concluded that the ^{220}Rn and ^{219}Rn produced should have ample time to diffuse through the water film and enter the helium stream.

Emanation Efficiency on the 219 Channel

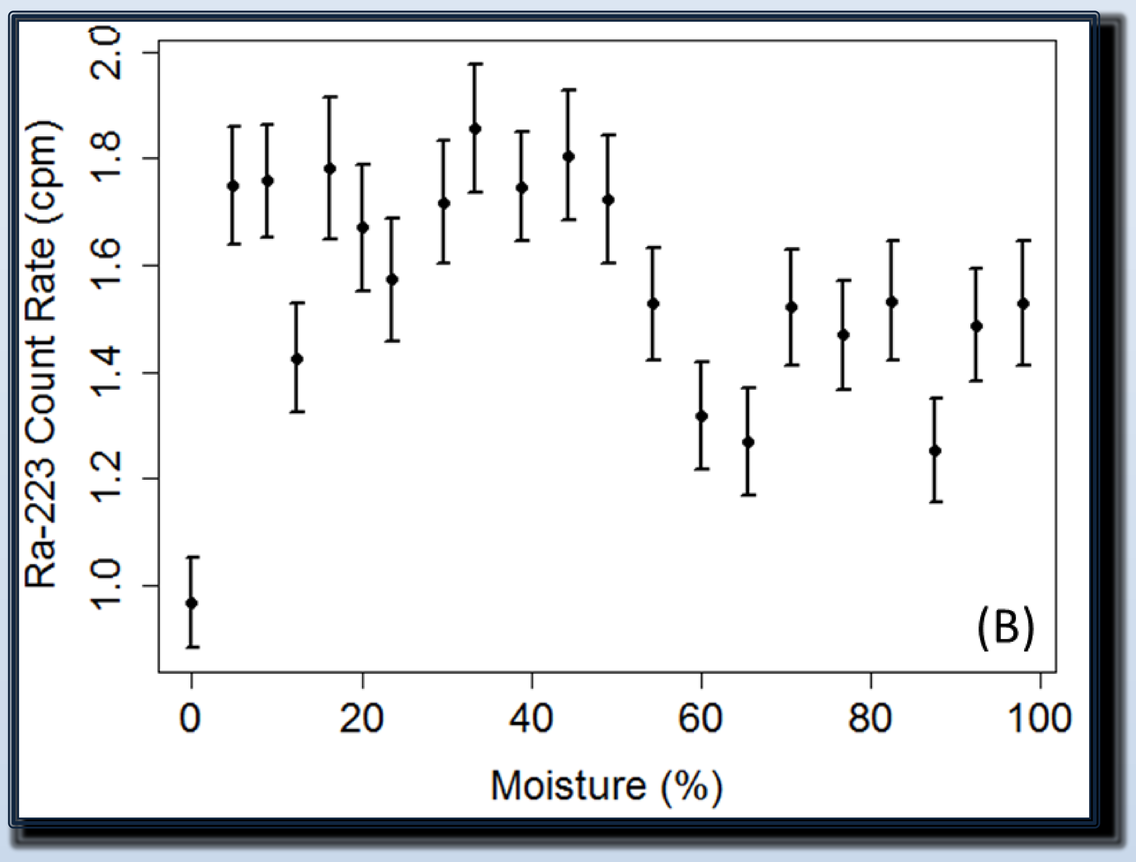

Figure 2. Count rate for of ^{223}Ra MnO_2-cartridge standard as a function of the water content.

- The count rate for the 219 channel reaches the optimum plateau under 5% of moisture, and when it is more than 50 % moistened, the emanation efficiency seems to decrease (Fig.2).
- The calibration of the 219 channel has been target of discussion, since its efficiency is always lower than the efficiency found for the 220 channel.
- [2] found a significant decrease in the effective ^{220}Rn emanation efficiency for a water/fiber ratio lower than expected. They attributed this to the increase of continuity fiber-water-fiber, which would significantly increase the distance that ^{220}Rn must diffuse to reach the helium stream.
- Since the half-life of ^{219}Rn is shorter, this effect is possibly greater for the ^{219}Rn emanation efficiency under lower water/cartridge ratios, which could be a reason for the frequently observed lower efficiency of the 219 channel.

References

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