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Title: The bioaccumulation of ^{210}Po in plankton and its potential use as an organic carbon tracer at the DYFAMED site in the Northwestern Mediterranean

Abstract:

The natural radionuclide polonium-210 becomes concentrated in marine biota and may be an excellent tracer for the export of particulate organic matter from the sea surface to depth. Based on laboratory experiments, ^{210}Po's distribution inside plankton is similar to that of protein, and the radionuclide is lost from decomposing marine particles as organic carbon is lost. Preliminary profiles of particulate polonium at the DYFAMED site correspond well to particulate organic carbon (POC) profiles. Results from controlled laboratory uptake, trophic transfer, desorption, and decomposition experiments will be used to interpret field data.

Polonium-210 (half-life = 138 d), the final alpha-emitting product of the ^{238}U decay series, is produced in seawater from the decay of its grandparent ^{210}Pb. ^{210}Po is found at sub-trace concentrations in seawater (10^{-20} M) and displays a nutrient-like profile with depth, partly as a result of the distribution of ^{210}Pb (1). ^{210}Po becomes highly concentrated in marine organisms and can contribute significantly to human radioactivity exposure through seafood consumption (2). In addition, due to its high particle reactivity, polonium has been used to trace the vertical flux of particulate matter in the ocean (3,4). Unlike thorium-234, which is a well-documented particle surface area tracer (5), ^{210}Po has a high specific affinity for organic matter and protein (3) and may provide more information about the organic carbon content of sinking particles.

In order to understand more about the behavior of this element in the marine environment, we have developed a model for the biological accumulation of ^{210}Po from the dissolved phase in which the surface area and protein content of phytoplankton cells can be used to consistently predict the cellular concentration of polonium:

$$Po_{cell} = [Po_{water}] \{K_{SA} * SA + K_P * P_{cell}\}$$

where Po_{cell} is cellular ^{210}Po, Po_{water} is the ambient concentration of polonium in the water, K_{SA} and K_P are the surface area and protein uptake coefficients, SA is surface area, and P_{cell} is cellular protein (6). Further, the assimilation of polonium by zooplankton grazers directly reflects the partitioning of cellular polonium in the phytoplankton food, as seen in Figure 1, consistent with our findings for other elements (7). In other words, if 30% of cellular ^{210}Po is found in the cytoplasm of a phytoplankton cell, a grazer will effectively assimilate 30% of the polonium in its gut.

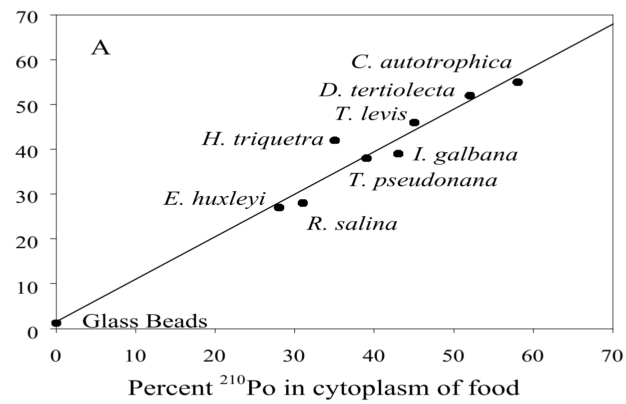

Figure 1. The assimilation of ^{210}Po by copepods corresponds to the percentage of ^{210}Po in 8 species of phytoplankton food cells and control glass beads. Regression line is not statistically different from 1:1.

These two pieces of information allow us to predict the concentration of polonium in phytoplankton, zooplankton and their fecal pellets, all of which can be a driving force behind sinking flux (8). With the predictable uptake and retention of ^{210}Po, and our knowledge of the loss of polonium with decomposition we may be able to interpret radionuclide field data with more confidence.

Preliminary results from the DYFAMED site indicate that the depth profile of particulate ^{210}Po matches the profile of particulate organic carbon (POC). In contrast, the disequilibrium between ^{238}U and ^{234}Th may be more indicative of total mass flux. This difference may be due to polonium's greater affinity for organic matter and its incorporation into biological material. Thorium, on the other hand, is found primarily bound to the surfaces of cells and organisms (8). This study may be the first time that laboratory results describing ^{210}Po's behavior have been compared to field data. We propose that the use of polonium, along with its grandparent ^{210}Pb and/or ^{234}Th, may answer some of the questions about currently used techniques for the estimation of POC flux (9).

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