Flux of Plutonium through Marine Biota

by

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Abstract

Experiments with crustaceans showed that ^{237}Pu uptake from water and subsequent loss was strongly dependent upon molting with cast molts containing large fractions of the accumulated isotope. Uptake from water by mussels was a relatively slow process; subsequent loss of the radioisotope resulted in a Tb½ of 945 days for the long-lived component. Surface adsorption appears to be a principal mecanism for plutonium accumulation.

Résumé

Des expériences réalisées chez des crustacés ont montré que la fixation du ^{237}Pu à partir de l'eau ainsi que son élimination ultérieure dépendaient fortement des mues, une fraction importante de l'isotope accumulé étant contenue dans les exuvies. Chez les moules, la fixation à partir de l'eau était un processus relativement lent; la perte ultérieure du radioisotope résultait en une Tb½ de 945 jours pour le compartiment le plus lent. L'adsorption de surface apparaît comme étant l'un des principaux mécanismes de l'accumulation du plutonium.

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Plutonium has entered the marine environment principally by way of fallout from nuclear testing and controlled release from nuclear reprocessing plants. With the advent of the fast breeder reactor generation one can expect that plutonium levels in marine ecosystems are likely to increase. The fact that plutonium can be readily concentrated by marine biota necessitates undertaking studies aimed at assessing its fate in marine ecosystems. Thus, experiments were designed to measure plutonium kinetics in representative organisms from different trophic levels and to clarify the pathways by which this important element is cycled in the marine environment. The use of a specially prepared isotope, ^{237}Pu, which decays by electron capture (99 %) allowed measurements to be made with standard NaI(T1) scintillation techniques.

Euphausiids *(Meganyctiphanes norvegica)* were allowed to accumulate ^{237}Pu (VI) from sea water for one week. Molting strongly influenced the uptake pattern with molts containing 70 to 100 % of the isotope accumulated by the animal. After 7 days concentration factors ranged from approximately 40 to 90, the highest value noted in an individual which had not molted. Such high percentages of ^{237}Pu in molts clearly indicates the importance of surface adsorption in the accumulation of this isotope from water.

Following uptake the animals were placed in clean sea water to measure ^{237}Pu loss. As in the case of uptake, molting strongly influenced plutonium loss from euphausiids. Cast molts lost ^{237}Pu to water

Rapp. Comm. int. Mer Médit., **23**, 7, pp. 161-162 (1976).

relatively slowly retaining approximately 35 % of the isotope after 7 days; hence, sinking molts from planktonic crustaceans could provide a mechanism for the downward vertical transport of plutonium in the sea.

To assess the importance of food as a source of plutonium to plankton, euphausiids were fed a single ration of ^{237}Pu (IV)-labelled *Artemia.* Animals excreted ingested ^{237}Pu in a matter of hours and virtually all the excreted plutonium was found in the feces. Fecal pellets lost plutonium to water only very slowly, 25 % remaining after 48 days. Thus, sinking fecal pellets which decompose slowly could also act as an important route for the transport of plutonium from the surface layers to bottom sediments.

Mussels *(Mytilus galloprovincialis)* and benthic shrimp *(Lysmata seticaudata)* were allowed to accumulate ^{237}Pu (VI) from sea water for 25 days. Accumulation by shrimp was slow and the degree of uptake was strongly influenced by molting. A concentration factor of 19 was measured in one individual which had not molted during uptake. Molts cast during the first 18 days of uptake contained from 92 to 100 % of the animals' ^{237}Pu content, again indicating the high affinity of plutonium for surface areas. Rinsing the molts in O.1N HC1 removed from 35 to 50 % of the ^{237}Pu during the first hour. Repeated acid rinsing over the next 6 hours failed to leach the residual ^{237}Pu indicating relatively tight binding for a large fraction of the sorbed plutonium.

Mussels slowly accumulated ^{237}Pu from sea water reaching concentration factors ranging from 26 to 70 after 25 days. Substantial amounts of ^{237}Pu, as high as 63 % of the animal's total activity, were noted in the byssal threads. Concentration factors in byssus ranging from 1860-4100 attest to the ability of this tissue to accumulate plutonium. Mussels without byssus, dissected at the end of uptake, contained 80-89 % of the total plutonium concentration in the shell, again reflecting the strong affinity of this isotope for exposed surface areas. As much as 25 % of the sorbed isotope was removed from the shell after 2 hours of acid rinsing; further rinsing had no effect on desorption of the residual isotope from the shell.

Following uptake, several mussels and shrimp were placed in flowing sea water and ^{237}Pu loss was measured for several weeks. Shrimp lost plutonium relatively slowly until they molted, at which time the majority of the isotope was lost with the molt. After about one month, mussels lost ^{237}Pu from a pool containing 64 % of the accumulated isotope at an exponential rate with a biological half-time of 945 days. The loss of a substantial fraction of accumulated plutonium from mussels appears to be a relatively slow process when compared to that of other radioisotopes measured in the same species.