Behaviour and fate of technetium in marine biota

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Abstract

Technetium kinetics were studied in marine organisms using the radiotracer ^{95m}Tc. Bioavailability of technetium was found to be relatively low in all the species examined with the exception of nereid worms. The highest tissue concentration factors were noted in the hepatopancreas of shrimp and viscera of mussels. Regardless of the mode of incorporation into tissue all the organisms tested demonstrated a strong degree of radionuclide retention.

Résumé

La cinétique d'accumulation et de perte du technétium dans différents organismes marins a été étudiée en utilisant un isotope du technétium, le ^{95m}Tc comme indicateur nucléaire. Les facteurs de concentration atteints sont relativement bas pour les espèces étudiées, exception faite des polychètes. Les plus hauts facteurs de concentration sont trouvés dans l'hépatopancréas pour les crustacés, et la masse viscérale pour les moules. Quel que soit le mode de marquage pratiqué tous les organismes étudiés montrent un assez fort degré de rétention du technétium.

Despite projections showing future increases in the inventory of the long-lived fission product technetium-99, very little information is available on the behaviour of this radionuclide in the marine environment. We have conducted radiotracer experiments to study the biokinetic behaviour and fate of technetium in a variety of marine species. The experimental procedure was greatly facilitated by using the gamma-emitter ^{95m}Tc which allowed direct whole body counting of organisms without any prior chemical extraction.

Mussels (<u>Mytilus galloprovincialis</u>) exposed to ^{95m}Tc (pertechnetate, +7) in sea water accumulated the radionuclide very slowly, reaching whole body concentration factors of only 1.3 after one month. Mussel tissues took up ^{95m}Tc to varying degrees; shell, muscle, mantle and gills were low with concentration factors ranging between 1.2 and 2.2. The highest concentration factors were found in byssus (8) and the viscera (17). Compared to the water pathway alone, additional uptake through the food chain had virtually no effect on resultant tissue concentrations primarily because of the very low degree of accumulation of ^{95m}Tc by the phytoplankton upon which the mussels were feeding. Transfer of contaminated mussels to clean sea water resulted in an approximate 40%

loss of ^{95m}Tc during the first 24 hours. After this time depuration slowed considerably and a biological half-time for technetium turnover of about 143 days was computed between day 10 and 126 of loss in running sea water.

The gastropod (Aporrhais pespelicani) reached comparable levels of activity. Whole body concentration factors ranged from 1.4 (+7) to 2.9 (+4) following 26 days exposure to ^{95m}Tc in contaminated sea water.

The bioavailability of ^{95m}Tc was greater in the shrimp (Palaemon elegans); after a similar exposure to the radionuclide whole body concentration factors were approximately 8. Only very small amounts of technetium were taken up by shrimp muscle and exoskeleton whereas concentration factors in the hepatopancreas were as high as 180. Temperature had relatively little effect on the uptake process. When ^{95m}Tc was fed to shrimp, assimilation coefficients ranged from 26% for Tc (+7) to 79% for Tc (+4). The assimilated fraction of the incorporated radionuclide was fixed in hepatopancreas, muscle and exoskeleton and was strongly retained. Furthermore, it appeared that the assimilated fraction of reduced ^{95m}Tc (+4) ingested with food was excreted from tissues at a more rapid rate than the oxidized pertechnetate (+7) form. However, technetium may not behave the same in all crustacean species; preliminary experiments with small marine isopods indicate very low uptake from water (CF=3.5) after similar exposure times followed by very strong retention ($Tb_{\frac{1}{2}}$ = 300d).

Benthic polychaetes (Nereis diversicolor) displayed a much higher affinity for technetium than either molluscs or crustaceans. Concentration factors of about 180 for Tc (+7) and 60 for Tc (+4) were noted after only 14 days and there was no indication of an approach to steady state.

Comparisons of our data with those from similar experiments on plutonium biokinetics [1] lead us to conclude that technetium (+7) is far less available for uptake by molluscs and shrimp than is plutonium. On the other hand, a similar degree of uptake was noted for the two long-lived radionuclides in benthic worms. Considering the variable behaviour of technetium in the organisms tested, it is not yet possible to generalize about its bioavailability in marine biota.

References

[1] FOWLER, S.W., HEYRAUD, M., BEASLEY, T.M., Experimental studies on plutonium kinetics in marine biota, In: Impacts of Nuclear Releases into the Aquatic Environment, IAEA, Vienna (1975) 157-177.

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Paper presented by S.W. Fowler (Monaco)

Discussion

A. AVOGADRO: How did you measure the oxidation kinetics of Tc(+4) in sea water?

S.W. FOWLER: We took advantage of the fact that the reduced forms (+4) are coprecipitated by $Fe(OH)_3$ whereas pertechnetate (+7) is not.

C. PAPADOPOULOU: Did you analyse together the byssus and the byssus gland. I ask this because the byssus gland concentrates some elements to higher levels than byssal threads.

S.W. FOWLER: No, our ^{95m}Tc analyses were only made on byssal threads but we have analyzed byssus gland and found similar levels.