Vertical Distribution of ^{55}Fe in the Ocean

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Summary

The highest concentrations of ^{55}Fe in the ocean are found in the epipelagic and mesopelagic zones with only low concentrations occurring in benthic animals and sediments. ^{55}Fe in the sediment appears in a very thin surface layer in the equatorial Pacific so that great care in sampling must be exercised to ensure accurate measurement.

Résumé

Les concentrations les plus fortes de ^{55}Fe dans l'océan ont été mesurées dans les zones épipélagiques et mésopélagiques, alors que seulement de très faibles teneurs ont été détectées chez les animaux benthiques et dans les sédiments. Dans la partie équatoriale de l'Océan Pacifique le ^{55}Fe n'est présent dans les sédiments qu'au niveau d'une couche superficielle très fine; il est donc nécessaire d'opérer avec beaucoup de soins pour obtenir de bon résultats.

Iron-55 has been one of the major radionuclides in fallout since the atmospheric testing by the U.S.S.R. and the United States in the early 1960's. It entered the biosphere and has been measured in both oceanic and terrestrial organisms, but concentrations were higher in marine organisms because iron, an important trace element, is scarce in the ocean (Palmer, Beasley and Folson,1966). Pacific salmon, which contained particularly high activities of ^{55}Fe, were studied by Jennings and Osterberg (1973) over a four year period and they found

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that the amounts of ^{55}Fe in salmon diminished with a biological half-time of about one year. Measurements on a variety of other organisms yielded similar results (Beasley, Conard and Held, 1972). This decrease from year to year in the surface layer where salmon feed, must be accompanied by an increase in the deeper layers of the ocean. In order to determine the locations of ^{55}Fe in the water column we have analyzed samples of marine organisms collected near the surface, at intermediate depths and near the bottom and, from different locations, oceanic sediments.

Comparisons of the specific activities of ^{55}Fe in organisms from the epipelagic, mesopelagic and bathyal zones off the Oregon coast show most of the ^{55}Fe in the epipelagic and mesopelagic zones, with far less at the ocean bottom. The activities appear to be slightly higher in the mesopelagic zone than in the epipelagic zone although the differences may be too small to be significant.

Physical and biological models of vertical transport in the ocean have often been treated separately in the literature but usually not together, despite the fact that the processes that transport radionuclides from the surface layer, where they are introduced as fallout, to deeper layers in the ocean are probably a combination of physical and biological processes. We calculate that 90-97% of iron in the sea is in the water and that only 3-10% is contained in the organisms which suggests that ^{55}Fe might be transported more by physical mixing than by biological processes. The relatively high concentration of ^{55}Fe in marine animals, particularly large fish and micronekton such as euphausiids, fishes and shrimp, however, suggest strongly that biological processes are important in the vertical distribution of ^{55}Fe, perhaps much more than physical processes, in certain areas.

Although the rates and mechanisms of vertical transport of ^{55}Fe in the sea are not well understood, it seems clear that some ^{55}Fe will eventually be deposited in sediments. Samples were taken by a box core in the equatorial Pacific during April and May 1975 to measure the amount of ^{55}Fe in the sediment. Our results show that small quantities of ^{55}Fe do occur in the sediments, on the average 0.8 picocuries per gram dry sediment with a range from below detectable limits to 3 picocuries per gram.

Since almost all the samples from the sediment surface had detectable amounts of ^{55}Fe, a subcore 10 cm deep was checked to locate the depth of ^{55}Fe penetration. None of the samples from the subcore contained any detectable ^{55}Fe.

The lack of radioactivity with depth and the range of activities found in the surface samples indicates that the ^{55}Fe may lie in a very thin surface layer. Substantial portions of this thin surface layer undoubtedly resuspend in the water by the movement inherent in sampling and may be lost when the water trapped above the core is drained from the box core container. Depending on the extent of scouring of the box core surface, quite different amounts of ^{55}Fe could be detected. It is suggested that for measurements of this type the water above the core be collected and analyzed for ^{55}Fe along with the surface sediment sample.

References

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10. Jennings C.D. - Vertical distribution of ^{55}Fe in the Ocean (presented by Fowler S.W.)

Discussion

Livingston H.D. (USA) : The observation of ^{55}Fe being confined largely to the near surface sediment layer is not necessarily unconsistent with Pu and Cs sediment distribution patterns. In coastal sediments ^{55}Fe has been shown to be moving upwards vertically towards the sediment/water interface and is being lost from the sediments. It is not improbable that the same process could be occurring in deep sea sediments though at reduced rates compared with nearshore shallow sediments (comment).