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ZINC-65 IN SEA WATER

SYMBOL: HSA:IBW

The effect of short-lived radionuclides induced in soil or sea water might have considerable effect upon aerial monitoring within a few days of time zero. Also, if certain long-lived nuclides were produced, and if these were concentrated by marine life, then detectable quantities would be found in fish. Therefore, a series of calculations were made to determine the level of induced radionuclides in sea water.

The calculations are based on two assumptions. First, it is assumed that the explosion takes place in an infinite medium. Under these conditions there is an expanding sphere of neutrons which are thermalized rapidly.

Secondly, it is assumed that one neutron per fission is available for production of $(n\gamma)$ or other reactions in the sea water. Although this assumption may not be rigorously accurate, it can be used as a basis for calculations. Since 1.38×10^{23} fissions are produced per KT of fission yield, it is assumed that this number of neutrons is available for nuclear reactions in sea water (or other substances). Using this value, one mole of neutrons will be available from 4.22 KT of fission yield.

The curies of radioactivity due to impurities in sea water can be calculated using the following formula:

$$A_o = \frac{N_o n' \sigma' \lambda}{\Sigma n\sigma (3.7 \times 10^{10})}$$

where:
- A_o = curies at t = 0
- N_o = 6.02×10^{23} neutrons
- n' = number of atoms of impurity/ml
- σ' = atomic cross section of element
- $\Sigma n\sigma$ = summation of number of atoms of each element times its cross sections (including stable to stable reactions)
- λ = decay constant of nuclide in atoms/second

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The concentration of zinc in sea water is 7 X 10^{-8} gr/ml. Therefore, one mole of neutrons would yield 2.12 mc of Zn^{65}, 0.58 curies of Zn^{69m} and 3.07 curies of Zn^{69} at zero time. If the Zinc-65 is distributed in the water at a concentration of 1 d/m/liter to a depth of 100 meters, then approximately 5 square miles would be contaminated per megaton of fission yield. In these calculations the effect of resonance levels has not been considered. This might increase the total activity and the area contaminated.

Free neutrons will be produced in the fusion reaction and therefore, there will be a proportionate increase in radionuclides from this source. Under some conditions other nuclides might be produced from higher order reactions involving protons, alpha and (n, 2n) reactions.

It is interesting to note that cobalt-60 is produced in sea water also. The concentration is about 2/5 that of zinc-65. Therefore it should be readily found associated with the zinc. Since the chemistry and radiation of these two nuclides are similar, the cobalt has not been detected. However, experiments are in progress to separate and identify it.

Since Zinc-65 may be produced in copper and zinc in the test device by (p, n) and (n,γ) reactions, it should be found in fallout at least within the immediate area. However, we have not found zinc-65 in fallout, and Donaldson did not find it in Rongelap or Kabelle soils, vegetation or rats. This nuclide has been found by the Japanese, Donaldson and NYOO in fish only. This evidence strongly points to the production of zinc-65 by direct irradiation of sea water, but does not eliminate entirely, the irradiation of zinc and copper metals in the test device.