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BACKGROUND VS. Sr^{90} IN MILK

by

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One of the chief difficulties which arises when attempts are made to set up acceptable mpl of radioactive contamination in population vectors of exposure is the necessity to decide just how much radiation damage a given population is willing to sustain in order to get the "good things" that the environmental contaminating processes may produce. These "good things" include strengthened national defense, cheaper and more plentiful power, and advances in medicine, agriculture, and industry.

Many theoreticians in the field of public health who have come up against the nearly insoluble problem of equating damage to life with the advantages of the atomic age are now resorting to the device of comparing a given exposure to the universally sustained exposure to background radiation.

This background radiation consists of contributions from cosmic rays from outer space, external radiations from possibly 50 naturally-occurring radioisotopes in the air and lithosphere, and finally from the naturally-occurring radioisotopes inside the body.

Dr. Willard F. Libby, Commissioner, United States Atomic Energy Commission, has stated:(1)

"First, we must consider what part of the natural radiation, if any, is similar to the radiation of strontium-90 in biological effect so we can say without doubt and hesitancy that the physiological effects, whatever they are, will be the same for the same energy absorbed. Fortunately, the cosmic rays seem to fit this bill. In other words, we are at liberty to compare the cosmic ray radiation dosages with the dosages from radiostrontium in our bone structure. The reason this is permissible is that the ionization density along the tracks of the mu-mesons which are the principal cosmic ray components at sea level and at altitudes of 5,000 feet are nearly the same as those of the yttrium-90 beta rays, the principal radiation which radiostrontium emits; that is, radiostrontium has a radioactive daughter, yttrium-90, which emits a very energetic beta ray and the ionization density along the track of this radiation is very similar to that of the mu-mesons of the cosmic rays and their disintegration electrons, and it is generally accepted by health physicists and radiobiologists that radiations of the same ionization density have very similar, if not identical biological effects for the same energy absorbed. The high energy of the yttrium-90 gives it an average distance of penetration in tissue of 2 millimeters so any effect of local non-uniformity of deposition of strontium-90 in the bone is removed. The cosmic ray exposure is, of course, uniform throughout the bone structure. Therefore, we can equate cosmic ray dosage with strontium-90 dosage and thus it is possible for us to say that the difference between one altitude and another is equal in effect, other effects being equal, to a certain number of Sunshine Units in bone."

Therefore the following computation is offered to help elucidate the relationship between the radiation dose sustained by a population due to exposure to natural background and that sustained by a population due to a given level of contamination of milk by Sr^{90}. This equation is possible since the quantity of milk consumed by the population of the United States is known even though the precise amount consumed by each individual during a specified period is not known. Using a factor for the retention of ingested Sr^{90} by the human body, it is at once apparent how much Sr^{90} is deposited in human bone per year in a given population.

Calculation A

Total dose due to background sustained by the population of the United States:

Dose (in rems) = (average background dose per person) (See reference 2) (number of people in U.S.)

$$= 1.35 \times 10^{-1} \text{ reps} \times 1.8 \times 10^{8}$$

$$= 2.43 \times 10^{7} \text{ reps to total population.}$$

Calculation B

Total dose to a population from Sr^{90} contamination of the population exposure vector milk:

Assuming an ingestion period of 1 year to conform with background dose estimates (above), the following formula can be used to compute population dose:

$$\text{Dose (rems)} = \frac{74 \text{ fwa Io Teff} \sum E \text{ (RBE) N } (1-e^{-0.693t/\text{Teff}})}{m}$$ (See reference 3)

where

fwa = fraction of ingested Sr^{90} which is retained by body. Assume 0.3 (From reference 4).

Io = μc of Sr^{90} ingested in U.S. = 6×10^{10} kg x Sr^{90} content of milk (assume 1 $\mu\mu c$/kg) (See reference 5).

Teff = 6.4×10^3 days.

$\sum E(RBE)N_{bone}$ = 1.1 (See reference 6).

t = 35 x 365 days. Based on average life span of 70 years minus average age of population, 35 years.

m = 7×10^3 grams for an average adult.

Then the equation becomes:

$$D_{rems} = \frac{74 \times 0.3 \times 6 \times 10^{10} \times 1 \times 6.4 \times 10^3 \times 1.1 \times 0.75 \times 10^{-6}}{7 \times 10^3}$$

= 10^6 rems for 1 $\mu\mu c$/kg of Sr^{90} only for 1 year. But since Sr^{90} cannot be kept free of Y^{90}, which has a half life of 65 hours and would therefore come to equilibrium rapidly (400-500 hours) compared to the exposure time (t) of 35 years, we must repeat the calculations for Y^{90} dose. However, since the only difference in the two calculations is the value for $\sum E(RBE)\mu$ for Y^{90} of 4.4 as opposed to that for Sr^{90} of 1.1, therefore

if Sr^{90} dose = 1×10^6 rems

the Y^{90} dose = 4.4×10^6 rems and the

total dose = 5.4×10^6 rems/1 $\mu\mu c$/kg of Sr^{90} in milk, or

$\frac{6 \times 10^{10}\ kg}{1.6 \times 10^9}$ = 3.3×10^2 kg/p per yr = 330 kg = 330 quarts

$$\frac{2.4 \times 10^7}{5.4 \times 10^6} = 4.5\ \mu\mu c/kg \text{ of } Sr^{90} \text{ in milk.}$$

Conclusion

We can therefore conclude that 4.5 $\mu\mu c$/kg of Sr^{90} in milk will ultimately deliver to the population a dose of radiation equal to that sustained per year due solely to background.

4.5 $\mu\mu c$/kg / 1 g Ca/kg = 4.5 S.U. (3 mrem/year) = 13.5 mrem (40) = 540 mrem = .540 rem osteoc.

5400 mrem / 3 = .180 rem marrow

natural bkg = 5 r/30 years = .167 r/year

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