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SHORT COMMUNICATION

RADIATION DOSE TO SRI LANKAN INFANTS FROM CAESIUM 137 IN CONTAMINATED MILK

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Abstract: The radiation dose to infants due to ingestion of milk containing the maximum limit of radioactivity in milk powder imported to Sri Lanka has been calculated. The radioactivity of ^{137}Cs was used as an index of fission products for setting radioactivity limits. The computation for milk powder was based on an average daily intake of 125 g by infants, (a critical group of population) during the first year after birth. The recommended dose commitment to the general public is 1 mSv/y. The maximum permissible limit of 20 Bq/kg of ^{137}Cs in milk powder as stipulated by the Atomic Energy Authority for milk powder imported to Sri Lanka would yield a dose equivalent of 12.6 μSv/y from ^{137}Cs.

Key Words: Caesium^{137}, infants, milk powder, radiation dose

INTRODUCTION

The Chernobyl accident which occurred in April 1986 resulted in the atmospheric release of ^{137}Cs estimated to have been 70 - 100 PBq .[1-3] The principal radionuclides of radiological significance emitted from the accident and which had the greatest potential for contributing to the human dose were isotopes of iodine and caesium - ^{134}Cs and ^{137}Cs. The dose associated with ^{131}I and ^{134}Cs have already been delivered and are no longer present in the environment due to their short half lives of 8 days and 2.1 years respectively. ^{137}Cs dominates the pathways of internal dose from ingestion of contaminated food because of the longer half life of 30y.

In the absence of accepted allowable radioactivity levels for consumer items public apprehension prevailed especially in countries importing food from regions contaminated by the Chernobyl accident. It was strongly felt that protection of the public from ingestion of radiation contaminated food should be optimised by setting permissible levels of radioactivity. The levels were determined by the Atomic Energy Authority which is the national regulatory authority responsible for radiation protection. Permissible levels and material for such restrictions are determined by the inherent properties of radionuclides. The maximum permissible concentration of ^{137}Cs in milk powder imported to Sri Lanka for consumption was set at 20 Bq/kg by gazette notification.[4]

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METHOD AND CALCULATIONS

Basis of selecting ^{137}Cs in milk to assess radioactivity

Of the different fission products released and dispersed ^{90}Sr and radiocaesium contributed mainly to doses received from the Chernobyl accident. Although the total amount of ^{131}I released was much higher than any other fission products this radionuclide was of less concern because of its short half life. Both ^{137}Cs and ^{90}Sr have long half lives but the amount of ^{137}Cs released was 4 - 5 times higher than that of ^{90}Sr. ^{137}Cs emits a 0.662 MeV gamma photon of significant intensity and can be measured in a relatively short time. ^{90}Sr emits beta radiation and requires extensive chemical separation for measurement. ^{137}Cs + ^{134}Cs represent 66% of the total dose from all fission products[5] and the proportion of ^{134}Cs to ^{137}Cs is 1:2 amounting to 44% by ^{137}Cs alone. Therefore to control radioactivity concentration in food ^{137}Cs was used as an "index" representing a radiation contamination. As Sri Lanka imports milk powder from Europe and as milk is a major component of the diet of a child under one year, annual radiation dose received by drinking milk containing 20 Bq/kg is discussed below.

Annual radiation dose to a child during his first year due to daily intake of milk containing 20 Bq/kg of ^{137}Cs

The dose of radiation from an ingested or inhaled radioisotope depends on its activity, energy and the type of particles emitted in radioactive decay, and the mass of the organ the isotope is deposited in. The internal dose from an isotope of activity C(t) in a particular organ is given by.[6]:

$$H = 1.384\text{x}10^{-2} C(t)\frac{\xi}{M}\ \mu\text{Sv/d} \qquad \text{.................. (1)}$$

where ξ is the effective energy factor and M the mass of the organ in kg.
The above equation was used to determine the radiation dose equivalent a new born infant will receive if it is fed milk food containing ^{137}Cs at a contamination level of 20 Bq/kg for one year. This is the worst case scenario as the dose received by older children will be less because of their greater body weight.

The activity of ^{137}Cs was calculated assuming an infant consumes 125 g of milk powder per day, which corresponds to an uptake of 2.5 Bq/day of ^{137}Cs at a contamination level of 20 Bq/kg.

The activity of ^{137}Cs can be calculated from :

$$C(t) = q\frac{C_d}{\lambda}(1 - e^{-\lambda t}) \qquad \text{................ (2)}$$

where C_d is the daily uptake, q the fraction retained in the organ and λ the effective decay constant which accounts for the combined effect of radioactive decay and removal of ^{137}Cs by biological functions. The biological half-life of ^{137}Cs in infants is 20 days and the retention fraction (q) is 0.4.[7] Fig. 1 gives the activity of ^{137}Cs during the first twelve months if the daily uptake is 2.5 Bq/d.

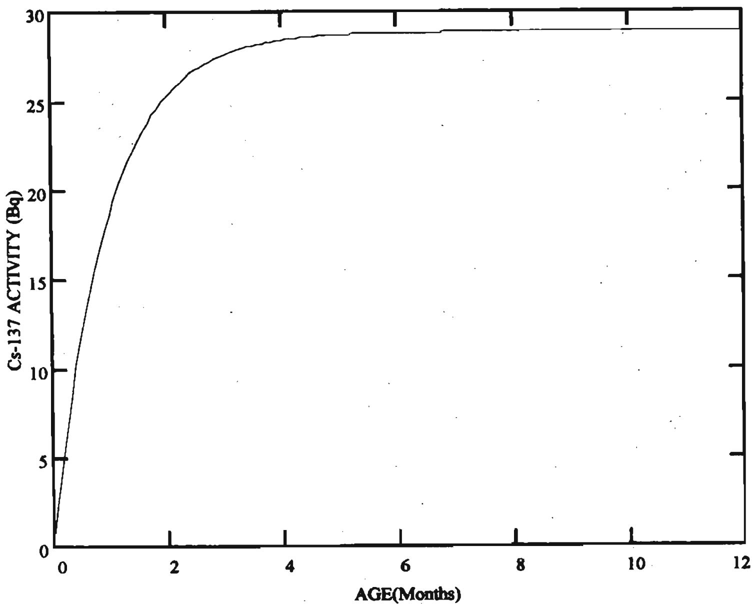

Figure 1 : Activity of Cs-137 vs age.

Since the body weight increases with the growth of the child, it was treated as a variable and the total annual dose was calculated by numerically integrating the dose rate over a period of one year obtained using the average body weight of a Sri Lankan child during the first twelve months after its birth.[8] The variation of the dose rate during the first twelve months is given in Fig.2.

Using an effective energy factor of 0.59 MeV for ^{137}Cs[9], the annual dose received by an infant during the first twelve months after its birth was calculated from the equation :

$$H = 30\int_0^{12} 1.384x10^{-2} C(t)\frac{\xi}{M(t)}dt \ \mu Sv \qquad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

where t is the time in months.

The numerical integration yields a dose equivalent of 12.6 μSv from ^{137}Cs alone. Since the dose from ^{137}Cs is approximately 44% of the total dose the estimated total dose to an infant due to consumption of milk food with a contamination level of 20 Bq/kg of ^{137}Cs, during the first year after its birth is 28.7 μSv.

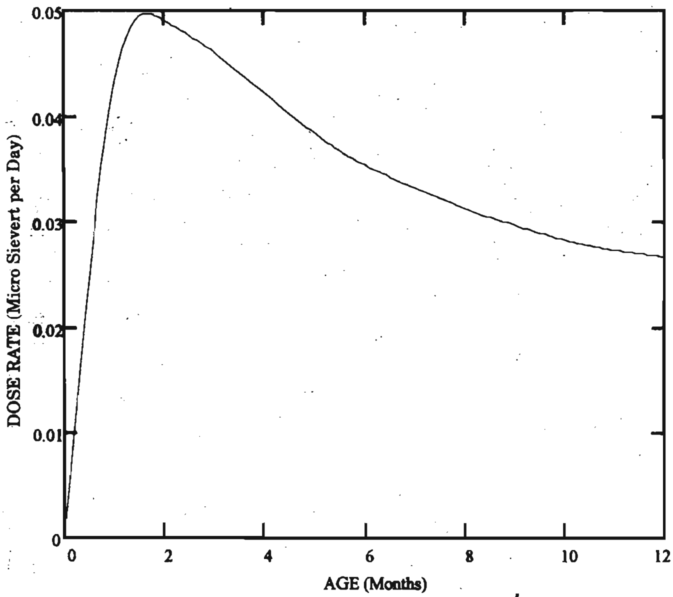

Figure 2 : Dose rate vs age.

DISCUSSION

Man has been continuously exposed to varying amounts of ionising radiation from natural sources such as cosmic radiation and radionuclides present in the Earth's biosphere. During this century man made sources of radioactivity have altered the natural radiation environment.

According to the current radiobiological theory, the process leading to a stochastic effect can originate at any dose level, however small, the probability of occurrence of an effect being proportional to the incurred dose. Therefore any significant rise in the background radiation level due to deposits of natural radioactivity, radioactive fallout and indiscriminate applications of ionising radiation and radioactive material may constitute a danger to the population.

World average total exposure due to natural radiation is 2.4 mSv/y.[10] An ongoing radiation survey in Sri Lanka has shown that in four provinces the external background radiation level has an average value of 1.3 mSv/y excluding certain beach areas where values as high as 45 mSv/y were observed. However, no study has yet been done in Sri Lanka to assess internal doses resulting from ingested radionuclides. Of the total radiation exposure the internal to external ratio can be considered to be 0.3 : 1[10] as uranium is present in negligible amounts in Sri Lankan soils. The internal exposure would thereby be 0.43 mSv/y and the total public exposure would be around 1.75 mSv/y from both external and internal sources of background radiation.

The maximum limit of 20 Bq kg^{-1} of ^{137}Cs activity in milk powder was recommended with the view that the population of Sri Lanka should not be exposed to any significant amount of additional dose due to radioactivity intake through radiation contaminated milk. The effective dose equivalent to members of the public other than from natural sources of radiation as recommended by the ICRP is 1 mSv/y.[11] The value 20 Bq/kg was calculated assuming an infant up to one year age, a critical group of the population. In a worst case scenario the effective dose equivalent from milk contaminated with 20Bq/kg of ^{137}Cs would be 28.7 μSv during the first year after birth to an infant. This is 2.9% of the maximum annual permissible dose for an adult and about 1.4% of the natural background radiation and is no more than the statistical variation in the natural background radiation.

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