Observed and Predicted ^{90}Sr and ^{137}Cs Levels in Milk

A RELATIONSHIP between the radioactive contamination of milk, the rate of fallout and the deposit on soil has been suggested by Tajima[1]. $C = prFr + pdFd$, in which C is the mean annual contamination of milk (pCi ^{90}Sr/g Ca), Fr is the annual deposit (mCi $^{90}Sr/km^2$), Fd is the cumulative deposit of ^{90}Sr (mCi $^{90}Sr/km^2$) and pr, pd are the proportionality factors related respectively to Fr and Fd.

In the United Kingdom, the data provided from an extensive country-wide survey led Bartlett *et al.*[2] to introduce a third term into this equation, which becomes $C = prFr + plFl + pdFd$ where Fl is the deposit in the last half of the previous year and pl is the "lag-rate" factor.

As Stievenart *et al.*[3] emphasize, the numerical values of proportionality factors mentioned in the literature are very disparate and hardly comparable, because of the choice of the different periods. It therefore seemed interesting to investigate whether, in the case of milk collected in Belgium during 1964–1969, the prediction formulae and the numerical values of proportionality factors (Table 1) suggested by Euratom[3], the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) modified by Euratom[3], and by Bartlett and Russell[2] gave values for C in agreement with observation. The figures used for the determination of Fr and Fd are those of the fallout measured in Mol[4–8], the observed level of contamination in milk, obtained from a country-wide survey of the radiocontamination of the food chain in Belgium[9,10].

Table 1 Prediction Formulae for Milk Contamination (Year n)

Terms of equation	Euratom	UNSCEAR	United Kingdom
C (12 months mean ratio pCi ^{90}Sr/g Ca of pCi ^{137}Cs/l. in milk)	1 May n –30 April $n+1$	1 Jan n –31 Dec n	1 Jan n –31 Dec n
Fr (annual deposit)	1 April n –30 Sept n	1 Jan n –31 Dec n	1 Jan n –31 Dec n
Fl (deposit in last half $n-1$) year			1 July –31 Dec $n-1$
Fd (cumulative deposit)	31 March n	30 June n	30 June n
pr (rate factor)			
^{90}Sr	1.95	0.95	0.70
^{137}Cs	7.01	4.48	3.00
pl (lag-rate factor)			
^{90}Sr	—	—	1.13
^{137}Cs	—	—	6.00
pd (soil factor)			
^{90}Sr	0.26	0.23	0.11
^{137}Cs	1.03	1.27	0.03

For 1964–1969, the Euratom formula gives the smallest difference between the predicted and observed values for ^{90}Sr. The formula of UNSCEAR, used with proportionality factors recounted on the whole of the data observed in the countries of Euratom, gives higher values, especially since 1967, because of the excessive contribution of the "soil factor", pd. Russell *et al.*[11] found a similar disagreement between the values predicted, respectively, by the methods of UNSCEAR and Bartlett *et al.*[2]; the cause could be the loss of ^{90}Sr through the leaching of the rooting zone and the grazing of the grass, which are under-estimated in the UNSCEAR formula. According to Stievenart *et al.*[3], the quantity of ^{90}Sr in the rooting zone would diminish by about 5% per year. We find good agreement between the formulae of Euratom and the United Kingdom on the percentage of contamination attributable to uptake from soil in Belgium.

The use of the Euratom formula gives predicted values systematically higher than those observed for ^{137}Cs whereas the United Kingdom formula gives the reverse; the biggest variations appear in 1965. The cause of this discrepancy is not the value of $prFr$: the contribution of the direct retention of ^{137}Cs by grass is about 47% if the Euratom formula is used, and about 38% with the United Kingdom formula for 1964–1969. Concerning the contribution of the indirect contamination, Bartlett *et al.* distinguish between uptake of ^{137}Cs by the roots of the grass, which is of little importance and leads to a low value for pd, and the uptake of ^{137}Cs from the "mat", in which case the ^{137}Cs remains available during the months which follow a deposit. It results in the high value for pl (lag-rate factor). Stievenart *et al.*[3] do not make this distinction. They used a high value for pd but they apply to Fd a reduction coefficient (0.55) in such a way that $pdFd$ reflects mostly the lag-rate phenomenon due to the "mat".

Several publications dealing with the radioactive contamination of the environment by world-wide fallout have pointed out that the correlation between the deposition of activity and the resulting levels in milk was not always clear, because of the number of factors involved. Among them, we emphasize the importance of the climatic and soil conditions, which influence the yield of the pasture and the level of grass contamination. The use of the prediction formula suggested by the Euratom and United Kingdom experts gives a good agreement (5%) between the predicted and observed levels of ^{90}Sr in milk collected in Belgium. The UNSCEAR formula gives values which are too high (27% for 1964–1969). As for ^{137}Cs, the Euratom and United Kingdom formulae give, respectively, values which are too high and too low—about 20% for the whole period considered. The UNSCEAR formula gives values of about 12% too low. Finally, large variations have been observed related to the type of soil and the quality of pasture. In the case of ^{137}Cs, some milk has a level of contamination four times higher than the country-wide mean; for ^{90}Sr, the maximal variation is 1.5 times.

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