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Effective Dosimetric Half-Life of ^{137}Cs Soil Contamination

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INTRODUCTION

In the early 1960s, an area of privately-owned swamp adjacent to the US Department of Energy's Savannah River Site (SRS), known as Creek Plantation, was contaminated by site operations. Studies conducted in 1974 estimated that approximately 925 GBq of ^{137}Cs was deposited in the swamp. Subsequently, a series of surveys—composed of 52 monitoring locations—was initiated to characterize and trend the contaminated environment. The annual, potential, maximum doses to a hypothetical hunter were estimated by conservatively using the maximum ^{137}Cs concentrations measured in the soil.

The purpose of this report is to calculate an "effective dosimetric" half-life for ^{137}Cs in soil (based on the maximum concentrations) and compare it to the effective environmental half-life (based on the geometric mean concentrations).

DESCRIPTION OF THE ACTUAL WORK

During 20 of the 32 years from 1974 to 2005, soil samples were collected from all—or a biased subset—of the established 52 monitoring locations on Creek Plantation and analyzed for ^{137}Cs.[1] Initial survey results indicated a maximum ^{137}Cs concentration of 19.5 Bq/g in soil. By 2005, the maximum concentration had declined to 2.4 Bq/g. Table I provides the maximum measured ^{137}Cs concentrations by year.

There are no permanent residents in the Creek Plantation swamp, nor is it likely because of the inhospitable conditions existing there. Therefore, only the recreational hunter and fisherman are considered reasonable and realistic exposure scenarios. For this assessment, only the recreation hunter scenario is addressed, which includes the following exposure pathways: (1) external exposure to gamma rays, (2) inhalation of resuspended particles, and (3) incidental ingestion of soil.

As described in Fledderman et al. [1], the potential dose to a hypothetical hunter on Creek Plantation is calculated annually at SRS using the RESRAD dosimetry code.[2]

Since site-specific information concerning actual hunting usage times on Creek Plantation are not available, exposure parameters were estimated. The assumed exposure time is 120 h, which is based on 8 h/d for 15 d (a full 2-week vacation) because part of the Creek Plantation operates as a vacation-type hunt club for the Plantation's owner, family, and acquaintances. The assumed soil ingestion rate and inhalation rate are 0.1 g/d and 0.96 m^3/h, respectively. These are based on the RESRAD default values.[2] A circular area of contamination was conservatively set at 10 m^2, with the hunter stationed in the center. Table I shows the potential hunter doses calculated using the maximum measured concentrations by year.

TABLE I. Maximum Measured ^{137}Cs Soil Concentrations and Potential Hunter Doses (1974-2005).

Year	^{137}Cs Soil Concentration (Bq/g)	Hunter Dose (mSv)
1974	19.5	0.092
1975	9.66	0.046
1976	6.44	0.030
1977	7.25	0.034
1982	5.85	0.028
1985	4.22	0.020
1986	4.99	0.024
1987	6.59	0.031
1988	6.62	0.031
1989	5.73	0.027
1990	3.67	0.017
1991	10.2	0.048
1993	3.88	0.018
1994	7.33	0.035
1996	3.66	0.017
2000	3.77	0.018
2001	2.84	0.013
2002	2.05	0.010
2004	1.85	0.009
2005	2.39	0.011

RESULTS

To calculate the "effective dosimetric" half-life for ^{137}Cs in soil based on the data presented in Table I, the following equation was used:

$$T_{eff} = \frac{0.693}{\left(2.303/t\right)\left(\log d_i/d_f\right)}. \quad (1)$$

where t is the time duration in years, d_i is the initial dose (or concentration) and d_f is the final dose (or concentration).

As can be seen from Table I, the potential hunter dose varies directly with the maximum measured ^{137}Cs concentration. Since the maximum ^{137}Cs concentration was the parameter directly measured, it was used in the regression analysis shown in Fig. 1.

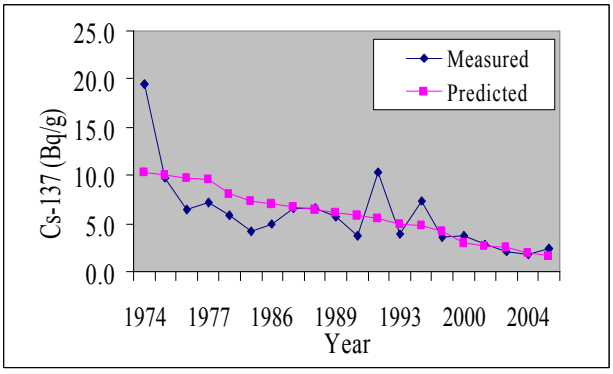

Fig. 1. Measured and predicted maximum ^{137}Cs concentrations in soil by year.

Using the predicted maximum concentration values from the regression analysis (which was highly significant with a slope of -0.281 and $P<0.001$), the "effective dosimetric" half-life for ^{137}Cs in soil was determined to be about 12 years.

In Paller et al. [1], the effective environmental half-life of ^{137}Cs in soil was estimated to be 14.9 years based on the geometric mean of all data obtained from the 52 Creek Plantation monitoring locations.

The relatively shorter "effective dosimetric" half-life of ^{137}Cs in the Creek Plantation floodplain implies that calculated potential maximum doses (based on maximum concentrations) decline more quickly than do the doses based on the standard effective environmental half-life (based on mean concentrations).

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