RESULTS OF THE IAEA WHOLE BODY COUNTING PROGRAMME IN THE SOVIET UNION

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ABSTRACT

In 1990, the IAEA conducted a whole body counting programme in the Soviet Union as part of its project on The Radiological Consequences in the USSR from the Chernobyl Accident: Assessment of Health and Environmental Effects and Evaluation of Protective Measures. Approximately 9,000 people from 9 towns in three republics were counted to corroborate measurements of internal ^{137}Cs contamination in the effected population made by the Soviet specialists following the accident. A mobile whole body counting facility, equipped with 4 chair counters was loaned to the Agency by the SCPRI, France for use in the measurement programme.

INTRODUCTION

As part of the IAEA international assessment programme carried out in 1990-91, a project was implemented by the IAEA to provide independent measurements of the internal doses currently received by individuals in 9 selected settlements in the USSR [1]. During the period 5 July to 7 September 1990 a whole body counting campaign was conducted in the BSSR, RSFSR and UkrSSR, using a mobile whole body counting van provided by the SCPRI, France. Nearly 10,000 total measurements were made including reference measurements of a calibration phantom, as well as of van staff, for quality control. The results for 9,058 people are reported here.

COUNTING PROCEDURE

The mobile van is equipped with four chair counters. Each counter has a 7.62 × 7.62 cm cylindrical NaI crystal housed in a collimated lead shield. The person is positioned for counting so that the shield is centered on the chest, over the region of the lungs, and in contact with the body. The counting period was 5 minutes. The background rates for the counters were determined by inserting a conical plastic plug into the collimator.

During counting, the person being measured provided some self shielding, thus reducing the counter background. Unfortunately, the degree of self shielding was variable, depending on the mass of the person. This is a particularly a problem in evaluating results for small children. Since the counting procedure as established by SCPRI was intended to be used for adults, it did not make provision for corrections based on wide variations in body mass.

The data were processed with a multichannel analyzer and a portable computer using software developed at SCPRI. The SCPRI data-unfolding process is intended to accommodate up to three radionuclides. However, the counting statistics were often poor, so only results for ^{137}Cs are presented in this report. From information provided by whole body counting specialists in Kiev and Minsk, based on their counting results, the ratio of ^{137}Cs to ^{134}Cs was approximately 6.5. Results of this ratio for an environmental sample, dried green peas grown in the Chernobyl region and assayed in December 1990, ranged from 7.9 to 8.8. This would be equivalent to 7.2 in August 1990, the mid-point of the whole body counting project.

The limit of detection (LOD) as defined by the data-processing software of the mobile van is three times the background count standard deviation. Because of the high variability in background from one town to another, the LOD is variable. In addition, the efficiency depends significantly on the size of the person being counted. Therefore, a single value cannot be quoted. However, a typical LOD for an adult is about 0.74 kBq (0.02 μCi), while for a small child the value drops to about 0.19 kBq (0.005 μCi).

COUNTER CALIBRATION

Since the mobile van was designed for operational emergency response applications, the calibration is based on a 70-kg reference man, 170 cm tall. The design of the counters in the counting van is such that only activity in the torso is detected. For adults this means that the mass of tissue seen by the counter is roughly constant. Following a review of the counting procedure, it was concluded that the calibration was reasonably accurate in the weight range 50 to 90 kg. However, for individuals outside that range the results could be significantly in error. For a child weighing 20 kg with a height of 100 cm, for example, the original calibration would overestimate the caesium burden by a factor of 2.6. Therefore, it was recommended that a modified correction factor based only on weight be used:

$$CF = \frac{70}{Weight\ (kg)} \qquad (1)$$

During the measurement programme, a plastic cylindrical phantom containing ^{137}Cs was used to check the counter performance on a daily basis. In addition, a few members of the van staff had measurable levels of ^{137}Cs. They were also counted at regular intervals.

At the end of the counting programme, the van returned to Seibersdorf. At that time, the calibration of each counter was checked with a standard bottle phantom obtained from the Battelle Pacific Northwest Laboratory in the USA. The phantom contained 11.2 kBq ^{137}Cs in a solid polyurethane tissue substitute.

RESULTS

Summary statistics and internal dosimetry results for the nine settlements in the BSSR, RSFSR and UkrSSR are presented in Table 1. Since the measurements were made at only one time, it is impossible to determine time dependent changes in the internal body levels. Therefore, a constant intake was assumed. A conversion factor for specific body burden to dose rate of 2.5 μSv/a per Bq/kg was used to calculate annual dose.

The results for a given population can be expected to have a log normal distribution. The distribution of specific body burdens for the settlement of Novozybkov, the largest population counted is shown in Figure 1, with an estimate of the best fit for a log normal distribution. The quality of fit varies from village to village. In some cases, non-statistical factors influence the results. For example, the assignment of the value of the detection limit to those measurements at or below that limit obviously biases the low activity results upwards.

This effect can be seen more clearly in the cumulative normal probability plots of the log of the specific body burden. The overlying straight line represents the distribution that would be expected for a population having a log normal distribution without additional influences. These plots also demonstrate deviation from the expected distribution at higher values of the specific body burden. The reason for this deviation has not been definitely identified. A possible explanation is that it is the result of a small subset of the population that does not observe the dietary restrictions imposed by local authorities, or that dietary habits (such as eating large quantities of forest mushrooms) predispose members of the population to higher body burdens.

REFERENCES

1. International Advisory Committee, 1991, The International Chernobyl Project: Assessment of Radiological Consequences and Evaluation of Protective Measures, Technical Report, IAEA, Vienna

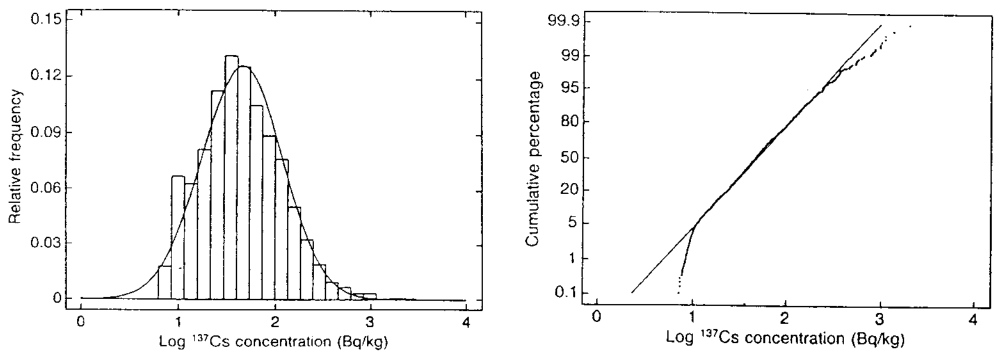

Fig. 1: Relative frequency and log-normal probability distributions for the Novozybkov population sample (1455 people)

Table 1 - IAEA, USSR whole body counting project results summary

Settlement	Statistical quantity	Weight (kg)	Age (years)	^{137}Cs specific body burden (Bq/kg)	Annual dose based on specific body burden (mSv)
BYELORUSSIA					
Bragin *Population sample:* 1154	Average	71.5	40.1	44.4	0.11
	Median	73	39	32.1	0.08
	Standard Dev.	19.5	17.6	90.5	0.23
	Maximum	135	89	2110	5.3
Veprin *Population sample:* 1064	Average	64.6	36.5	46.7	0.12
	Median	69	38	24.2	0.06
	Standard Dev.	22.7	20.0	78.1	0.20
	Maximum	125	86	1370	3.4
Korma *Population sample:* 719	Average	67.6	38.5	50.6	0.13
	Median	70	38	36.4	0.09
	Standard Dev.	22.3	19.2	66.5	0.17
	Maximum	118	85	933	2.3
RUSSIAN REPUBLIC					
Novozybkov *Population sample:* 1455	Average	69.3	40.4	78.0	0.20
	Median	72	42	43.4	0.11
	Standard Dev.	20.1	17.7	131	0.33
	Maximum	130	85	2200	5.50
Zlynka *Population sample:* 998	Average	66.7	38.7	116	0.29
	Median	70	39	67	0.17
	Standard Dev.	21	19.3	172	0.43
	Maximum	120	96	1990	5.0
UKRAINE					
Daleta *Population sample:* 194	Average	55.8	22.0	396	0.99
	Median	55	16	279	0.70
	Standard Dev.	25.2	16.4	425	1.1
	Maximum	115	67	3750	9.4
Ovruch *Population sample:* 1153	Average	69.3	38.6	185	0.46
	Median	72	42	77.9	0.20
	Standard Dev.	20.9	16.9	353	0.89
	Maximum	130	80	4060	10
Polesskoe *Population sample:* 1003	Average	73.9	36.8	76.2	0.19
	Median	75	36	29.9	0.08
	Standard Dev.	19.8	15.8	158	40
	Maximum	140	76	1960	4.9
Rakitnoe *Population sample:* 1320	Average	67.1	33.9	144	0.36
	Median	70	35	77	0.19
	Standard Dev.	20.1	15.6	203	0.51
	Maximum	120	76	2524	6.30