

WHOLE-BODY MONITORING OF A LARGE POPULATION SAMPLE

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ABSTRACT

The results of a survey in which 1220 volunteers were monitored using the Addenbrooke's whole-body counter during the period April 1988 - March 1991 are presented. The decline in radiocaesium post Chernobyl was registered and special techniques of spectral analysis and data averaging were used to establish a maximum likely average radiocaesium body burden in the adult population. Other man-made radionuclides (eg. ^{99m}Tc , ^{131}I) were occasionally detected and the likely origins investigated. The presence of radon decay products in variable amounts influences the minimum detection level of other radionuclides and some consequences of this interference are discussed.

INTRODUCTION

One of the recommendations of the Black report (1) investigating the possible increased incidence of leukaemia near to a nuclear fuel reprocessing plant in the North West of England was that there should be more research using whole-body monitors into levels of radioactivity occurring in the general population. Cambridgeshire was selected as a suitable location to obtain baseline data on a large number of volunteers because it has a low level of environmental radioactivity.

In addition to ^{137}Cs and ^{134}Cs from Chernobyl, we were interested in measuring ^{99m}Tc and ^{131}I since, along with tritium (not detectable in a whole-body counter), they account for over 90% of all radioactive discharges in the locality (2).

THE POPULATION SAMPLE

1220 volunteers were each monitored for 1000 s in the whole-body counter. For statistical analysis of the local population, only persons who had lived in Cambridgeshire for more than three years and had not been knowingly exposed to radionuclides were included. This reduced the total number to 1032, 314 adult males, 521 adult females, 68 male children and 129 female children. Combining the children together into one group provides a total of about 200 which is probably larger than any single group of children monitored previously.

RESULTS AND DISCUSSION

1) Radiocaesium from Chernobyl

The average $\text{Cs} : ^{40}\text{K}$ ratios each month for all adult males throughout the study are shown in Figure 1. During the period April 1988 - July 1989 this ratio was 2.34%. The ratio was 2.06%

for adult females but the lowest recorded ratio was for male children (1.47%); just significantly lower than that for female children (1.90%).

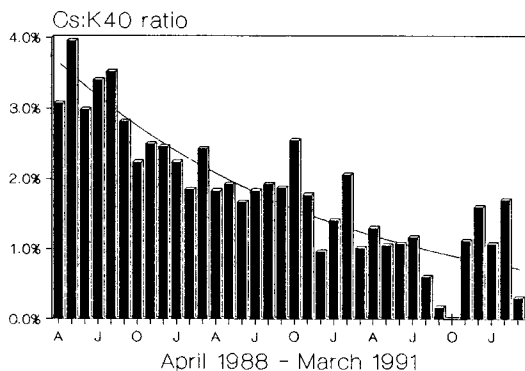


Figure 1. Monthly average contamination of adult male volunteers expressed as a ratio of radiocaesium to ^{40}K .

Although radiocaesium was readily detectable in all volunteers at the start of the study, by August 1989 results suggested that there was no definite evidence of caesium in some of the spectra and during the final twelve months from April 1990 there was no discernible trend in caesium levels (Fig. 1). Using a suitable model of exponential decay based on our own data, the average estimated effective dose per person to the population of Cambridgeshire from caesium radionuclides released from Chernobyl during the period April 1988 to March 1991 was 8.4×10^{-6} Sv for men, and 5.7×10^{-6} Sv for women.

For a single 1000 s measurement using the Addenbrooke's whole-body counter estimates of the minimum detectable amounts (MDA) of activity for ^{137}Cs and ^{134}Cs are 60 Bq and 30 Bq respectively. The major limitation is statistical, thus for large numbers of volunteers an averaging process may be used to obtain a more accurate figure for the population as a whole.

The spectra obtained since April 1990 have been summed for the four groups of volunteers. Unfortunately, analysis of the 662 keV peak from ^{137}Cs is confounded by a variable and unknown contribution from ^{214}Bi , a radon daughter, which emits 610 keV gamma rays. If we assume that all counts detected were due to caesium then the maximum remaining average level of caesium was 10 Bq for adult males and females. For the group of adult males the energy of the detected peak was half way between the peaks of ^{214}Bi and ^{137}Cs . This suggests that the average level of caesium activity remaining is probably about 5 Bq for adult males. For the group of female adults the peak detected was at 614 keV which suggests that most of the activity present was due to radon. For the male and female children, no peak could be detected in the summed spectrum during this phase of the study, so activity levels are even lower.

2) Other Man-made Radionuclides

In this category we have included manufactured articles containing radium. Fourteen volunteers had measurable activity either in or on their person and these are summarised in Table 1. On each occasion an explanation for the observed activity could be readily determined and the levels of activity were extremely small. Release of ^{99m}Tc and ^{131}I result from their widespread use in medicine for diagnosis and therapy respectively. It is notable that in 9 of the 14 cases where radioactivity was detectable, one of these two radionuclides was involved.

The benefit of adding spectra from different volunteers was again illustrated by looking for the 364 keV peak of ^{131}I in the summed spectra for 22 adult male volunteers who were all measured after the caesium activity from Chernobyl had become undetectable. The limit on detection is again set by radon decay products - the 350 keV peak from ^{214}Pb in this case. Radon decay products were known to be present in the summed spectrum because other peaks (eg. 610 keV from ^{214}Bi) were detected. Nevertheless, the minimum level of detectability for ^{131}I was reduced to 30 Bq from 60 Bq for a single 1000 s measurement.

Table 1. Man-made radionuclides detected in or on volunteers.

Nuclide	Number of cases	Estimated Activity (Bq)	Reason for Contamination
^{99m}Tc	6	<1000	subjects had been in Nuclear Medicine waiting room prior to monitoring.
^{22}Na	1	1000	accidental spillage during Nuclear Medicine test.
^{226}Ra	1	200	luminous watch after removal.
^{86}Rb	2	2000 600	used in studies at Medical Research Council laboratory on site.
^{232}Th	1	100	a physics teacher, Thorium was used at school. (could have been natural, poor statistics)
^{131}I	3	1000 200 100	all visitors to patients on radionuclide therapy ward.

When spectra for volunteers in all four groups were combined, the average activity in the energy window corresponding to ^{131}I was 10 Bq per person. However the energy of the peak suggests that most, if not all, of the peak was due to ^{214}Pb . We conclude that the only real evidence for ^{131}I activity in this sample of volunteers resulted from close contact with patients being treated with this radionuclide for therapeutic purposes.

3) Radon

The whole-body monitor has a very low radon level, so we were able to look for radon daughters in volunteers. Approximately 15 persons had unusually high levels of radon

daughters compared with the rest of Cambridgeshire volunteers. Rather more showed probable activity. There is no reasonably practical method of calibrating the whole-body counter for quantification of radon daughters (^{214}Pb and ^{214}Bi) but the activities seem to be in the range 200 - 1000 Bq. In some cases these can be traced to contact with a radon source such as an old luminous watch but other cases can only be explained by the presence of increased radon levels at home.

Measurement of radon contamination from the radon daughter gamma emission is difficult. Volunteers are measured fully clothed and radon daughters can be deposited onto dust from atmospheric radon thereby contaminating clothing and adding to the activity measured from internal radon. The biological half-life of inhaled radon is not known but is likely to be of the order of a few hours or less although the daughters are likely to remain in the body for longer. Hence, the ratio of radon daughters to radon is uncertain and the levels of radon daughters will depend on how recently the volunteer was exposed to radon.

CONCLUSION

Overall the project has achieved the primary objective, which was to establish a substantial database for a large group of volunteers from the same part of the U.K. The Chernobyl accident provided a fortuitous opportunity to validate the methodology on human volunteers rather than phantoms and the study continued for long enough to establish baseline data in the post-Chernobyl era. These data should prove valuable in helping to monitor the future effects on the population of the release of man-made radionuclides into the environment.

REFERENCES

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