RADIOACTIVE CONTAMINATION AT MARALINGA.

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Atomic weapons tests were conducted in Australia at three locations between 1952 and 1963. There were twelve trials where nuclear explosions took place (major trials), and many other trials where devices and components associated with the development of atomic weapons were burnt or exploded with conventional explosives (minor trials).

Radioactive residues from the major trials have not proved to be of radiological consequence in the long term, and it has been estimated that remaining activation and fission products will cease to be of any concern beyond about 2030 (Lokan, 1985).

Between 1960 and 1963, however, a series of safety trials involving plutonium were carried out at the Taranaki site at Maralinga, where twelve firings were conducted in three series of trials from firing pads within a few hundred metres of each other, leading to the local dispersal of some 22 kilogram of plutonium-239. Shallow burial pits were constructed close to each firing pad, and much of the material was ultimately buried in these pits. The remainder of the plutonium was carried in wind-borne plumes, and was generally deposited down range to the north of the firing pads. The distribution of plutonium on the ground, for the first several kilometres, was reconstructed at the end of the series (Turner, 1964) from measurements taken at the time, and indicated the presence of four plumes, made up of overlays of individual firings, extending several kilometres from the firing pads.

Between 1984 and 1986 the Australian Radiation Laboratory conducted extensive field investigations to map the extent and distribution of these plutonium plumes. The distribution of americium-241, which is a decay product of plutonium-241 present in the original material, was determined from its 60 keV gamma ray using portable thin-crystal sodium iodide scintillation detectors. In addition soil samples were collected to a depth of 2.5 cm from some 400 sites within 1 kilometre of the firing sites, and a further 350 samples from sites between 1 and 100 kilometres. These were analysed with the aid of high-resolution gamma ray spectroscopy, to determine the concentration of americium-241 in Bq/kg in surface soil. The results of these analyses are presented in Figure 1. Independent studies of the ratio of americium-241 to plutonium-239 (Tracy, 1987) for Taranaki soil samples indicate a ratio of about 1 : 8.4, and imply surface concentrations along the plume axes, which are an order of magnitude greater than was originally inferred.

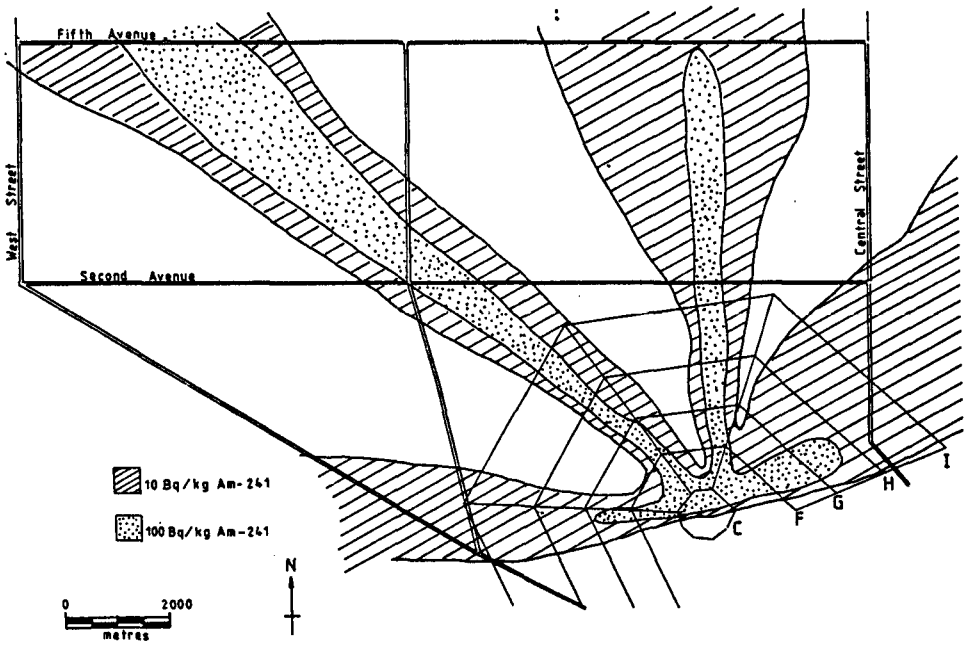

Figure 1: Am-241 contamination levels based on soil samples measured in 1984-1986.

The main feature of the plumes is that they are quite narrow, and contrary to an expectation that surface contamination would gradually be dispersed in this sandy semi-arid environment, they appear to have undergone little observable change in the past twentyfive years. In addition, the evidence to date suggests that there has been little downward migration of plutonium, as depth profiles have indicated that most (90 per cent) of the activity still lies in the top centimetre of soil.

In order to obtain further detail about the character of the dispersed plutonium, eight sites within the four identified plumes were selected for further study. Composite soil samples from each site, which covered an area of 100 x 100 m, were analysed to determine the average concentration and uniformity of the soil contamination. Mean concentrations in soil, expressed in terms of americium-241, at distances of 1.5 and 5 km from the firing pads are presented in Table 1.

Table 1.

Mean Concentrations in Plumes (Bq/g of Americium-241)

Distance from Firing Pad (km)	West	North West	North	North East
1.5	0.35	0.52	1.07	0.75
5	0.01	0.71	0.17	0.10

The values in Table 1 represent the averages of about fifty soil samples drawn from each site, and individual samples commonly showed sample to sample variations in excess of an order of magnitude. For the the site in the north plume at a distance of 1.5km from the firing pads concentrations varied from 0.04 to 4.2 Bq/g of americium-241. Some of the more active samples from this and other sites were successively subdivided, and it was shown that individual particles of diameters between 100 and 200 micron accounted for most of the activity in these cases.

The distribution of activity as a function of particle size, which is of great importance to the future assessment of potential inhalation hazard, was investigated at each site by separating the soil into different size fractions with the aid of a set of graded sieves. Average mass and activity distributions are presented in Table 2, which indicate that in general the "fine fraction" (< 45 micron) , which represents only three per cent of the mass, contains about thirty per cent of the activity.

Table 2.

Distribution of Mass and Activity in Taranaki Soil.

Size Range (micron)	Percentage of Mass	Percentage of Activity
1000 - 710	2	0.3
710 - 500	12	3
500 - 250	37	12
250 - 125	24	11
125 - 75	14	32
75 - 45	8	13
< 45	3	29

The "fine fraction" was investigated further for samples from the 1.5 km site on the North West plume, using a micro particle classifier to obtain mass and activity distributions as a function of size. These results, which are preliminary at this stage, and may not be generally representative, are presented in Table 3. The size ranges given are "optical" diameters, rather than aerodynamic diameters, as the classifier was calibrated by comparison with visual assessment of sizes under a microscope. It should be noted that the size ranges are approximate only, as the cut-off sizes for the particle classifier are density dependent, and density variations in the soil have not been taken into account.

Table 3.

Activity and Mass Distributions for Soil below 45 Micron.

Size Range (micron)	Percentage Mass	Percentage Activity	Specific Activity (Bq/g Am-241)
< 3	2	1	1.6
3 - 4	2	1	1.5
4 - 6	11	7	1.8
6 - 12	17	15	2.5
12 - 17	18	15	2.4
17 - 25	19	14	2.2
25 - 45	31	47 *	4.4

Overall americium-241 concentration : 2.9 Bq/g

* May be due to a single high activity particle.

Table 3 demonstrates nevertheless that for this site at least, the activity concentration does not vary sharply with particle size within the respirable range - say up to 6 micron in diameter, corresponding to an aerodynamic diameter of about 10 micron - but stays relatively constant at 1.5 to 1.8 Bq/g of americium-241 or 12 - 15 Bq/g of plutonium-239.

This work is part of a broader study of the plutonium environment at Taranaki, which is addressing the inhalation pathway, and requires much more information about the physicial and chemical nature of the plutonium, dust loadings for both normal and atypical conditions and potential occupancy before any realistic dose assessment can be undertaken.

It is a pleasure to acknowledge the technical assistance of Myra Wilks in the preparation and sizing of the soil samples.

References:

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