AN AIR MONITORING PROGRAMME IN THE ENVIRONMENT OF A MAJOR NUCLEAR ESTABLISHMENT: OPERATION AND RESULTS

A. Knight, B.M.R. Green, M.C. O'Riordan, and G.S. Linsley

National Radiological Protection Board, Harwell, Didcot, Oxon. OX11 ORQ, UK.

During the Windscale Inquiry in 1977 (1), the Board was asked by the Inquiry Inspector to measure the levels of airborne alpha activity in Ravenglass, a village on the coast approximately 10 km south of the British Nuclear Fuels Ltd., Windscale works. (Windscale is a fuel reprocessing plant). During a four week period in September 1977, the mean level of ^{239} + ^{240}Pu was 5.2 μBq m^{-3} and that of ^{241}Am was 4 μBq m^{-3}. These levels were clearly elevated above average weapons fallout values (0.8 and 0.1 μBq m^{-3} respectively) but they were well below the maximum permissible concentrations in air for members of the public prevailing at that time (2200 and 7400 μBq m^{-3}) (2). In presenting its results at the Inquiry however the Board commented that the sampling was not sufficiently prolonged to enable annual average doses to be assessed with confidence. Furthermore, the levels might be higher at other locations.

The Board decided therefore to mount a programme of measurements in West Cumbria with the principal objective of assessing the exposure of the local communities to airborne radioactivity over a sufficiently long time to be confident that the results were indeed representative; a period of one year was deemed sufficient. It was also hoped to obtain some information about the immediate source of the airborne activity as well as the effect of environmental conditions, such as the weather, on the levels.

The programme of sampling ran from the summer of 1978 to the summer of 1979.

SELECTION OF SITES

A fully comprehensive sampling programme would have utilised a dense array of samplers around the Windscale works. However, because of financial limitations, the problems of analysing large numbers of air filters, and the difficulty of finding suitable sites, a smaller programme with five sites was mounted.

Sites were required which were reasonably secure and which had supplies of mains electricity. The air samplers were to be located remote from buildings, firstly to ensure representative environmental sampling and secondly because of the noise levels from the samplers. Five sites which met these requirements were located in the areas of St. Bees, 10 km to the north; Egremont, 7 km north-east of the works; Holmrook, 6 km to the south-east; Seascale, 3 km to the south and Eskmeals, 13 km south of the works. The sites were chosen to coincide with local centres of population, (St. Bees, Egremont, Seascale), as well as covering inland (Egremont, Holmrook) and coastal (St. Bees, Seascale, Eskmeals) locations. The Eskmeals site was a very open one approximately 100 m from the beach.

EQUIPMENT

The air monitoring equipment in Cumbria consisted of 6 high

volume air samplers, one of which was controlled by a switch sensitive to wind direction, and a cascade impactor. A high volume sampler was installed at each site; the wind direction sensitive sampler and cascade impactor were installed for 9 months at Eskmeals and then 3 months at Seascale.

Each high volume air sampler consisted of an upward facing filter holder at a height of 1.5 m from ground, coupled to a high velocity centrifugal fan (Secomak 575/1) and a rotary inferential gas flow meter (PCC). Polystyrene fibre filters (Microsorban 98) size 260 mm x 210 mm were used. Each sampler was housed in a wooden shelter approximately 1.3 m x 1.3 m x 2 m high with a sloping inlet on each side. The inlets measured 200 mm x 200 mm and were covered by a metal screen (6 mm mesh with 1.5 mm ribs) to minimise vandalism. The air from each sampler was exhausted at roof level, a deflector plate directing the air flow up and away from the inlets. The air flow rate using the above configuration was greater than 1 m^3/minute. The shelters were designed to provide good security and weather protection, while allowing radily respirable particles (i.e. particles up to about 10 μm AMAD) to be sampled adequately. However, larger particles are also important since the effective dose equivalent per unit intake for a $^{239+240}Pu$ class W aerosol remains fairly constant up to approximately 100 μm AMAD (3). The apparatus described above will sample some particles of this size but with a reduced and unknown efficiency. It is believed however that the aerosol in the shelter is likely to be less depleted than it would be inside an ordinary house where windows and doors are normally closed. Consequently an overestimate is likely to be made of the concentration to which most people are exposed because of the high indoor occupancy factors that prevail. The concentration of larger particles out of doors is however likely to be under-estimated. A subsidiary experiment is being carried out to determine the overall degree of depletion of the aerosol caused by the shelters.

As noted above, one of the samplers at Eskmeals was controlled by a switch sensitive to wind direction. A wind vane on a 4 m high mast activated a switch with a time constant of 120 sec when the wind was coming from the sea within an angle which was adjusted to $\pm 67\frac{1}{2}^{o}$.

The cascade impactor (BGI-30 with model 1A sampler) was kept in its normal aluminium shelter with the top removed. This was housed in one of the wooden shelters described above with the first stage at a height of 1.5 m. The impactor is a single slit device with four impactor stages and a final filter. Glass-fibre filter papers, moistened with olive oil, were used for the impactor stages with Microsorban as the final filter. The flow rate was almost 1 m^3/ minute and was maintained constant by a pressure transducer in a feed back loop. The impactor has an effective cut off diameter of about 10 μm for the first stage and about 1 μm for the final stage.

During the one year operating period filters were changed weekly. The centrifugal fans used with the high volume samplers proved to be very reliable. The cascade impactor motor was not however so suitable for continuous running. Several replacement motors had to be used and brushes had to be changed frequently. Trouble was also experienced with the air flow rate meters which were repaired frequently.

The sites were not very accessible to the public and vandalism was not a problem. At one of the sites, nevertheless, the noise levels were unacceptable to local residents. The sampling programme ran for a year with no major problems.

ANALYSIS OF FILTERS

Each Microsorban filter was pressed into a shape 80 mm dia x 3 mm thick prior to γ counting with a lead shielded 105 cc Ge (Li) detector or a 75 cc Ge (Li) detector with an anticoincidence shield. Both detectors were housed in a steel room with 150 mm thick walls. Each Microsorban filter and each glass-fibre cascade impactor filter was counted for 1000 minutes and the activities of the following γ emitting nuclides was determined:
^{54}Mn, ^{95}Zr, ^{103}Ru, ^{106}Ru, ^{125}Sb, ^{131}I, ^{137}Cs, ^{141}Ce and ^{144}Ce

After γ counting, the ordinary high volume sampler filters were ashed individually. Cascade impactor filters covering a 2 week sampling period were combined before ashing. The ashed samples were totally dissolved in hydrofluoric acid and the plutonium and americium isotopes separated out using ion exchange resins. The samples were electroplated onto stainless steel discs and the $^{239+240}Pu$, ^{238}Pu and ^{241}Am activities were determined by α counting using surface barrier detectors under vacuum. Yields were monitored using suitable tracers.

RESULTS AND DISCUSSION

It is possible to present only a selection of early results in this paper: a full report is being prepared.

TABLE 1. Gross activity concentrations in West Cumbria, June to December 1978, μBq m^{-3}

	Nuclide	Seascale	Holmrook	Egremont	St.Bees	Eskmeals	Fall-out
Acti-nides	$^{239+240}Pu$	7.1	1.8	1.5	3.8	6.1	0.4
	^{238}Pu	1.5	0.4	0.4	0.7	1.4	0.02
	^{241}Am	3.3	0.7	0.6	2.1	3.7	0.05
γ-emitters	^{144}Ce	240	330	360	360	230	190
	^{106}Ru	610	230	280	280	320	160
	^{137}Cs	990	500	420	260	230	70
Distance from Windscale works km		3	6	7	10	13	-

The numbers in Table 1 are the means of the weekly values. The concentrations varied widely from week to week, however. For example, at Seascale the $^{239+240}Pu$ values ranged from 0.7 to 20 μBq m^{-3} and the ^{137}Cs values ranged from 30 to 4100 μBq m^{-3}.

Considering first the actinides, the results for the 3 coastal sites (Seascale, St. Bees, Egremont) are similar to those found at Ravenglass a year earlier. All results are clearly elevated above

average fallout values. The derived air concentration (DAC) for members of the public is assumed to be 2500 μBq m^{-3}, i.e. one tenth of the value in ICRP-30, for each of the actinides in lung class W. (4). The actinide concentrations are clearly well within appropriate limits even when considered jointly.

Results for the γ emitters are also elevated above average fallout values, ^{144}Ce marginally so, ^{106}Ru more noticeably and ^{137}Cs rather markedly. However, the most restrictive DAC for both ^{144}Ce and ^{106}Ru is 5 x 10^6 μBq m^{-3} for lung class Y and the DAC for all compounds of ^{137}Cs about 5.8 x 10^7 μBq m^{-3}. The levels in Cumbria are four to five orders of magnitude below these DACs.

From Table 1, it can also be seen that the coastal sites (Seascale, Eskmeals, St. Bees) have the highest actinide results. The concentrations of γ emitting radionuclides however fall off with distance from the Windscale works, clearly so where there is a strong signal-to-noise ratio as in the case of ^{137}Cs.

Complete analysis of meteorological and other data is proceeding but partial analysis suggests that at coastal sites the concentration of actinides is dependent on wind persistence and to a lesser extent on wind speed. Analysis of the results from the directional and continuous samplers at Eskmeals shows that actinides concentrations are higher when the wind is off the sea, but that the same is not true for the γ emitting nuclides.

Because of certain metrological constraints, the results from the cascade impactor at Eskmeals are not so accurate as the others. However, some indication of the particle sizes can be given. Approximate AMADs in μm are as follows $^{239+240}Pu$ 15, ^{238}Pu 15, ^{241}Am 10, ^{144}Ce 1, ^{106}Ru 2, ^{137}Cs 3. Fallout of course has a particle size less than 1 μm. The higher AMADs for the actinides probably points to different immediate sources of actinides and γ-emitters. The results are consistent with the hypothesis that the major source of actinides is the sea; but the situation for γ-emitting nuclides is more complex.

REFERENCES

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