Bull. Environ. Contam. Toxicol. (1993) 51:185–192

Environmental Contamination and Toxicology

Aldrin Contamination at a School in South Australia

Ian C. Calder, Edwards J. Maynard, and Leonid Turczynowicz

Environmental Health Branch, Special Programmes Section, Environmental Health Branch, and Hazardous Substances Section, Environmental Health Branch, Public and Environmental Health Service, SA Health Commission, PO Box 6 Rundle Mall, Adelaide, South Australia, 5000, Australia

Streaky Bay is a rural community with a population of 3300 located on the west coast of South Australia, approximately 720 km by road from Adelaide. The Streaky Bay School has both primary and secondary students and is located on a site within 200 metres of the shoreline, close to the centre of the township. The school comprises a complex of brick buildings and outbuildings that includes staff offices, open space primary and secondary activity areas, a canteen, workshop, home economics centre, art/craft room, laboratory, library and associated utility areas. School facilities are also used by members of the local community.

Between August and November 1986 a termite treatment was conducted on the site by a local licensed pest control operator. During the procedure, the termiticide, a 0.5% aqueous aldrin emulsion, was alleged to have contaminated carpets, floors, fittings, books and furniture. It was suggested that school children had suffered symptoms attributable to aldrin intoxication such as vomiting, diarrhoea, lethargy, headaches and irritability.

The school was closed in early March 1987 and an investigation of the incident carried out by the Public Health Service of the South Australian Health Commission. Extensive decontamination followed and the school re-opened in late April 1987. Concerns were again raised in April 1988 which led to another series of tests. This paper presents a summary of the data obtained during these investigations and the conclusions reached.

MATERIAL AND METHODS

Air sampling for aldrin/dieldrin was undertaken in accordance with US National Institute for Occupational Safety and Health (NIOSH) Method 5502 (1984). Samples were generally taken 1 to 1.5 metres above floor level. Air samples were drawn through glass fibre prefilters, then through impingers containing iso-octane

Send reprint requests to L. Turczynowicz at the above address.

absorbing solution. Pumps were calibrated and air was collected over a 4-5 hour period approximating 150 - 200 litres of air. Pre-filters and entrainment solutions of iso-octane were analysed for both aldrin and dieldrin with the limit of detection equivalent to an airborne concentration of 0.05 ug/m^3. The determination of surface contamination was based on the 'wipe' procedure of Marlow and Wallace (1983). Sampling sites defined with a template of 10 cm x 10 cm were wiped with new white tissue using AR grade 2,2,4 - trimethylpentane as the solvent. Residual solvent was collected from the defined area using a second tissue. Both wipes were combined in a sample container for analysis. Carpet samples were taken using a 1 inch (2.54 cm) wad punch with the whole sample being placed directly in the sample container. All equipment was carefully washed with solvent between samples. The method employed for the collection of soil samples involved excavating adjacent to the site to reveal the soil profile to a depth of 400mm. A core of approximate volume 40 x 40 x 400mm, was then extracted down the soil profile, labelled and site identified. All equipment was cleaned with solvent between sampling.

Wipe, carpet and soil samples were extracted with hexane, the extract concentrated and cleaned up by filtering through florisil, using adaptation of the method employed by the US Food and Drug Administration (1968). Concentrated extracts were analysed using a Varian 3400 GC with dual electron capture detectors, dual columns of differing polarity (OV17 and OV225) and hydrogen carrier gas. Output was interpreted utilising a HP 3390A Integrator. Limits of determination for aldrin and dieldrin were 0.001 mg/kg for soils, 0.05 ug/m^3 for air and 0.01 or 0.1 ug/100cm^2 for surface swabs. An estimate of variance was put at $\pm$5% at the limits of determination. Analyses were conducted by the Pesticide Section, Chemistry Division, Department of Services and Supply, Adelaide.

Venous blood samples (10 ml) were collected and after separation of serum, samples were extracted with hexane. The extracts were concentrated and analysed using an HP 5790A capillary gas chromatograph with a HP electron capture detector. An SGE fused silica bonded phase column was used with output interpreted utilising a HP 3392A Integrator. The detection limit for dieldrin was 0.5 ng/ml with a variability of 0.3 ng/ml at the lower end of the range. The analyses were carried out by the Toxicology Laboratory, Division of Clinical Chemistry, Institute of Medical and Veterinary Science, Adelaide with the method based on that of Bristol et al (1982).

RESULTS AND DISCUSSION

Air monitoring results are summarised in Table 1. Most values are at or near the limit of determination of 0.05 ug/m^3. No pre-treatment figures are available, but post-treatment values obtained are comparable with those in the study by Marlow and Wallace (1983). The set of data are internally consistent.

Geometric means are 0.09 ug/m^3 for the first series, 0.11 ug/m^3 for the second, 0.05 ug/m^3 in the third series and 0.06 ug/m^3 in the final air monitoring study. The anomalous result of 6.4 ug/m^3 was excluded as repeat monitoring did not confirm the result.

Six soil samples were analysed in September 1988. Four samples were less than 0.001 mg/kg. Aldrin was detected in one sample at 0.083 mg/kg. Dieldrin was recorded in two samples at 0.004 and 0.006 mg/kg.

Table 1. Streaky Bay Aldrin Air Concentrations (ug/m^3)*

Location	March 1987	May 1988	August 1988	September 1988
Front Foyer	0.05	6.40	<0.05 $^{s}_{s}$	-
Sub-Jnr Primary++	0.10	0.10	-	<0.05
Junior Primary	0.05	0.05	-	0.15
Library++	0.11	0.20	-	-
Library	0.05	0.40	0.07 $^{s}_{s}$	-
Secondary	0.05	<0.05	-	0.07 $^{s}_{s}$
Science Laboratory	<0.05	<0.05	-	0.07 $^{s}_{s}$
Woodwork	0.40	0.20	-	<0.05
Store Room	0.29	0.10	-	<0.05
Canteen	-	-	-	<0.05
Home Economics	-	-	-	<0.05

FOOTNOTES:

* Limit of Determination = 0.05 ug/m^3

\+ Results are total aldrin plus dieldrin in pre-filters and solutions.

++ Close to floor.

$^{s}_{s}$ Mean of two or more analyses.

Predecontamination results from hard surface areas such as bookshelves, chairs, tables, books, walls, cupboards and both concrete and vinyl floors are summarised in Table 2. The carpet samples showed high levels of aldrin, in particular the Library and Primary Activity areas had levels up to 77,000 ug/100 cm^2 and 31,600 ug/100 cm^2 respectively (Table 3).

Post-decontamination testing of surfaces recorded reduced levels of aldrin with results obtained within the range of <0.02 - 5.6 ug/100 cm^2. Subsequent testing 14 months after this series recorded concentrations ranging from <0.01 to 0.97 ug/100cm^2 for aldrin and <0.01 to 0.11 ug/100cm^2 for dieldrin. It should be noted that the surface testing conducted in June 1988 placed an imposed bias towards those sites where high initial levels had been recorded. A comparison of pre- and post-decontamination test results is presented in Table 2. Serum dieldrin concentrations were employed as an index of exposure to aldrin with a total of 150 individuals being tested in 1987. These data are presented in Table 4.

Table 2. Surface Environmental Test Results at Streaky Bay Area School (ug/100 cm^2)

	Pre-Decontamination Aldrin Only			Post-Decontamination March/April 1987 Aldrin Only			Post-Decontamination June 1988 Aldrin and Dieldrin		
Surface Type	Range	Number	Mean	Range	Number	Mean	Range	Number	Mean
Cement	<0.02-12.4	10	*1.1	<0.02-5.6	17	*0.11	<0.02-0.76	16	*0.10
			+2.8			+0.63			+0.20
Brick	<0.02-0.18	27	*0.02	<0.01-0.23	10	*0.02	<0.02-<0.07	6	*<0.02
			+0.03			+0.04			+<0.03
Vinyl	<0.01-6.5	33	*0.07	0.01-0.4	13	*0.05	<0.02-1.17	12	*0.06
			+0.48			+0.08			+0.16
Textile	0.01-0.1	3	*0.02	0.03-1.6	9	*0.11	<0.02-0.18	16	*0.03
			+0.04			+0.32			+0.04
Sealed Timber	<0.02-21.7	34	*0.12	<0.02-0.22	14	*0.07	<0.02-<0.18	16	*0.33
and/or Laminate			+3.66			+0.09			+0.04
Metal	<0.02-8.2	20	*0.06	<0.02	2	*<0.02	-	-	-
			+0.8			+<0.02			
Ceramic Tile	-	-	-	<0.01-0.59	15	*0.03	<0.02-<0.05	5	*<0.03
						+0.06			+<0.03

* Geometric Mean

\+ Arithmetic Mean

Table 3. Aldrin Levels in Carpet Cores

RANGE (ug/100 cm^2)	NUMBER
<5.0	8
5.0-10.0	3
>10.0-100	10
>100-1000	19
>1000-10000	13
>10000	9
TOTAL	62

Three people whose levels were very high were considered to be occupationally exposed during the initial clean-up. People tested were divided into two groups on the basis of whether or not their exposure was considered to be at the school. In 1987, the arithmetic mean for all exposure groups was 1.41 ng/ml with a maximum of 9.3 ng/ml. 67 of these individuals were also tested in 1988 with mean serum dieldrin of 0.74 ng/ml and maximum of 2.2 ng/ml (Table 5). Paired sample t-tests conducted on 1987/88 serum dieldrin results for these 67 individuals exposed to the pesticide residues within the school indicated a significant difference between the means. ($t = 3.69$, $p < 0.001$, $x_{1987} = 1.58$ ng/ml, $x_{1988} = 0.74$ ng/ml)

Table 4. Serum Dieldrin Levels in 1987

	Control Group					School Exposed Group				
Age(yrs)	5 or <	6-12	13-18	19>	Total	5 or <	6-1	13-13	19<	Total
Range (ng/ml)										
<0.5	1	1	-	2	4	9	22	6	6	43
0.5-1.0	-	-	-	3	3	2	17	4	14	37
>1.0-2.0	-	-	-	-	-	5	19	3	6	33
>2.0-3.0	2	-	-	1	3	0	6	2	2	10
>3.0-4.0	-	-	-	1	1	-	2	-	2	4
>4.0	1	-	-	-	1	1	4	2	4	11
Total	4	1	-	7	12	17	70	17	34	138

Media attention in 1988 again raised concerns about exposure to organochlorine pesticides which resulted in an offer of repeat blood tests to all people in the town. Environmental tests were also carried out. Of the 161 serum dieldrin concentrations determined in 1988, 24 were identified as being from individuals not exposed to the pesticide residues at the school and could be considered as background community levels. Statistical comparison with this group and the exposed group did not demonstrate any significant difference between the means of the groups. ($t = -0.21$, $p < 0.818$, $x_{unexposed} = 0.69$ ng/ml, $x_{exposed} = 0.71$ ng/ml). The blood tests established that exposure of all the people tested had returned to background levels. For the 67 individuals who had tests in both 1987 and 1988 it could be shown that there was a statistically significant

Table 5. Comparison of Paired Results for 1987 and 1988 for school Exposed Groups (%)

RANGE (ng/ml)	1987	1988
<0.5	35.8	46.3
0.5-1.0	25.4	35.8
>1.0-2.0	19.4	14.9
>2.0-3.0	7.5	3.0
>3.0-4.0	3.0	0
>4.0	8.9	0

difference with the mean falling from 1.58 ng/ml in 1987 to 0.74 ng/ml in 1988. From the data available it could be concluded that the decontamination was effective.

Aldrin is rapidly metabolised to dieldrin which is then equilibrated between body compartments within a few days of absorption (Heath and Vandekar, 1964; Hayes, 1974). Serum dieldrin levels were measured initially to establish whether significant exposure and absorption to aldrin had occurred at the school. Initial results indicated inappropriate exposure had occurred thus blood tests were offered to all people at the school and an extensive environmental assessment undertaken. Due to the poor volatility of aldrin and/or dieldrin dermal absorption and ingestion were considered to be the principal exposure pathways. The results of the blood testing of the children and adults at the school are shown in Table 4. Compared with the background levels of dieldrin for the general population, of around 2 ng/ml, they demonstrated that three months after completion of the treatment, excessive exposure had occurred.

Testing of hard surfaces using wipes (Table 2) and carpet cores (Table 3) showed that the contamination was widespread. The levels on many of the hard surfaces were low due to the normal cleaning of the school since the treatment had been completed. The decontamination involved replacement of the carpet and extensive cleaning of hard surfaces. Hard surfaces were scrubbed using water with double strength detergent and sealed with a methyl methacrylate polymer. The aim of the decontamination was to achieve levels which were comparable to those which would have been present if the treatment had been carried out appropriately. Post decontamination testing showed acceptably low levels on all hard surfaces tested in 1987 and again in 1988. Comparison of these data is shown in Table 2. Some data were also available for tests in buildings in the nearby town of Ceduna and elsewhere in Streaky Bay (Table 6).

It is clear from these comparisons that the decontamination was effective and levels were no higher than would have been expected following a proper treatment and may have been significantly lower. Attempts to use air sampling as a means of establishing the presence of high levels of aldrin and the effectiveness of decontamination were unsuccessful. Air results did not reflect

Table 6. Aldrin Testing of Hard Surfaces at Ceduna and Streaky Bay

Ceduna	Range	Number	Mean
Public Buildings	<0.02-5.60	14	*0.16
			+0.08
Streaky Bay			
Public Buildings	<0.01-0.65	9	*0.02
			+0.09
Private	<0.01-0.40	9	*0.06
Dwellings			+0.10

* Geometric Mean

\+ Arithmetic Mean

levels known to be present in carpets prior to their removal and generally levels were low and near the limit of detection for the method used.

The possibility that the aldrin exposure caused adverse effects was of particular concern to the people involved. The half life of dieldrin, based on occupational studies, is considered to be about nine months (Jager, 1970). Based on this half life and a mathematical relationship between blood levels and total daily intake of Hunter and Robinson (1967) it was concluded that for chronic exposure, over the treatment period, it was unlikely that any acute adverse effects would have occurred. Attendance records for the children over the period of treatment were compared with the records for the previous five years. No evidence of an increase in absenteeism was found in the analysis.

The difficulties of establishing a causal relationship between symptoms such as headache and nausea and exposure of this kind were recognised, given the reporting bias associated with such a highly publicised event. A myriad of exposures and illnesses are known to produce these common symptoms. In view of the low exposure to aldrin, as reflected in the low serum concentrations, and the number affected, a viral illness was considered the most likely explanation. While solvent exposure, in this case to xylene, may cause headache and nausea, the large dilution involved with an aqueous emulsion rendered this possibility implausible.

Follow-up blood tests were offered to all individuals with serum dieldrin levels above 4 ng/ml. It was expected that after closure and decontamination of the school that aldrin exposure would be effectively zero and serum dieldrin levels would return to background levels. For six people this occurred and the apparent half lives for the reduction ranged from 4-6 months, however, there are many uncertainties and this apparent result should not be considered significant. Serum dieldrin levels for the three individuals who were considered to be occupationally exposed did not return to background but steadied at levels of between 40 ng/ml and 15 ng/ml. Investigation of the source of their continued exposure showed exposure outside the school and their apparent high

readings at the time of the school incident may not have been due entirely to exposure at the school.

Overall, this incident demonstrated that it is possible to rehabilitate a building contaminated with aldrin by poor work practices during treatment for protection against termites. The process was expensive and involved destroying large amounts of carpet and extensive cleaning and sealing. The final condition of the building was comparable to any other which has been appropriately treated with organochlorines for termite protection.

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Received August 19, 1992; accepted February 3, 1993.