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Pesticides in Homes in Western Australia

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The organic pesticides are widely used. Organochlorines, in particular, have been the most desirable of all due to their persistence, low volatility, effectiveness against target pests and their low cost per treatment (Louis and Kisselbach, 1987). The same convenient properties that make the pesticides so stable in the environment have caused them to become ubiquitous, contaminating all areas including the indoor air of treated houses (Savage, 1989).

In the past, the focus of concern has primarily remained on contamination from foods, water and the ambient environment (through prolonged and excessive use of pesticides on the agricultural scene). More recently concern has been raised about the exposure risk from pesticides in domestic indoor air (Dingle, 1988, USEPA, 1990) This is not surprising since it has been estimated that people in developed countries, on average, spend 80% of time inside the home (Wiley et al., 1990). Dingle (1988) was particularly concerned with pesticide application practices.

Wright et al (1994) found that chlorpyrifos was present in ambient air of houses 8 years after termiticide application. Asakawa et al (1994) found chlordane in the air of houses treated with termiticide. The persistence of termiticides raises health concerns as long term chronic exposure may cause health problems, as found in the case of chlordane (USEPA, 1988). Gamo et al (1995) found that termite control workers had a greater loss of life expectancy risk than occupants of treated houses when using either chlorpyrifos or chlordane. Jitunari et al (1995) also studied termite control workers, finding that chlordanes were deposited in large amounts in these individuals. Where chlorpyrifos was concerned, termite control workers had an loss of life expectancy of 31 days compared to 2.8 days for occupants of treated houses. Davis & Ahmed (1998) estimated that children are exposed to levels of chlorpyrifos 21 - 119 times higher than the recommended reference dose of 3 mu g/kg/day. Sim et al (1998) stated that termite control of residence is an important risk factor for cyclodeine insecticide absorption.

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MATERIALS AND METHODS

A study of pesticides in the indoor air of 22 residences was undertaken. Homes were monitored at the request of the occupant and were not part of a statistically random sample. A questionnaire on pesticide treatment details was completed by the home occupants. Seven houses were monitored on at least one other occasion to determine the effect of pesticide concentrations over time. The homes were monitored in at least two locations, a bedroom and a living area.

Monitoring and analytical procedures were performed at Analytical Reference Laboratory (ARL) Pty. Ltd. Air was sampled through a solid sorbent tube (XAD-2 resin) at an accurately known flow rate between 0.8 and 1.2 L/min. Sampling was performed over 24 hours. The XAD-2 resin was desorbed with solvent. Swabs were taken from an accurately known surface by wiping with cotton wool and solvent. The cotton wool was extracted with solvent and the extract concentrated to a suitable volume. The cotton wool was analysed after cleaning and no pesticide residues were found. All analytes were measured by capillary gas chromatography, electron capture detector (GC-ECD) with two columns of different polarity. These were DB17 (15m, 0.32mm i.d., 0.5µm film thickness) and 3% OV 2250n (1.8m, 4mm, 80/100 mesh size, and an inert support). The injection port temperature was 250° C, the detector temperature was 300° C, and the carrier gas used was nitrogen. The quantities of the residue were measured using the peak height. The detector was calibrated by injecting a standard mixture containing the compounds to be monitored. The reproducibility of the detector response was examined and a coefficient of variation of less than 5% was found. The linearity of the detector response was determined by analysing 5 standard solutions in hexane, ranging from 10ug/l to 2ug/l.

Authentic pesticide standards were obtained from the Australian Government Analytical Laboratories, commercial suppliers and from pesticide manufacturers, all were accompanied by a purity certificate and are registered in the Standards authority.

RESULTS AND DISCUSSION

Levels of pesticides were detected in 19 of the 22 houses monitored. The most frequently detected pesticides, in order, were heptachlor, dieldrin, chlordane, aldrin and chlorpyrifos. Mean concentrations for each of the pesticides are shown in Table 1. Mean levels of chlorpyrifos were found at significantly higher concentrations than the other pesticides examined, the mean of 2.554 $\mu g/m^3$ was approximately 2 times higher than heptachlor and more than 6 times the other pesticides detected. This was possibly due to the increasing use of chlopyrifos as an alternative to the organochlorine pesticides used for termite control in Western Australia (Dingle, 1988). Anderson and Hites (1989) also found elevated levels of chlorpyrifos in living areas. They suggested that the increased levels were consistent with resident usage. However, in the context of this study all of the home occupants reported that they did not use any domestic pesticides containing chlorpyrifos.

Elevated levels of heptachlor are consistent with the frequent use as the organochlorine pesticide of preference by the pest control industry (Dingle, 1988). Dieldrin was found in many of the samples of indoor air at levels generally below 0.08 $\mu g/m^3$. Dieldrin is not registered for use in Western Australia, however, dieldrin is an oxidised metabolite of aldrin (Anderson and Hites, 1989), which is registered for use as a termiticide according to Australian Standards (Dingle, 1988).

Site monitoring revealed significant differences between levels in different living areas within the home. Of the 42 bedrooms monitored in the 22 homes, mean levels of pesticides ranged from 0.017 to 4.023 $\mu g/m^3$, the 7 kitchens from non-detectable to 2.88 $\mu g/m^3$, and the 48 general living rooms (including lounge and dining room) 0.086 to 0.992 $\mu g/m^3$. The bedrooms had the highest recorded levels with a mean chlorpyrifos concentration of 4.023 $\mu g/m^3$. This has significant implications for exposure because of the large amount of time people spend in the bedroom. The highest concentrations in other locations within the home, were found in the kitchen and general living areas, which had mean levels of heptachlor at 2.88 and 0.992 $\mu g/m^3$ respectively. By contrast, Wright et al (1988, 1991), reported that no significant differences were found between rooms in different living areas of homes. Although only one home had basement levels monitored, it showed elevated levels of aldrin and dieldrin, 2.1 and 0.37 $\mu g/m^3$ respectively, compared to living room concentrations of 0.063 and 0.035 $\mu g/m^3$ respectively. The levels of pesticides in living areas, compared with the levels in non-living areas (basements, crawl spaces) were in accordance with other studies, with basements showing higher levels than general living areas (Anderson and Hites, 1989, Louis and Kisselbach, 1987, Wright et al, 1988, 1991).

Table 1. Pesticide concentrations in homes where pesticides were detected.

Pesticide	Mean conc. $\mu g/m^3$	Range $\mu g/m^3$	SD	No.
Heptachlor	1.2	0 - 7.4	2.55	20
Aldrin	0.38	0 - 2.1	0.61	16
Dieldrin	0.08	0 - 0.8	0.19	19
Chlordane	0.13	0 - 0.95	0.22	18
Chlorpyrifos	2.23	0 - 16	5.58	8

A significant correlation was found between the period between application and monitoring and concentration of heptachlor ($r=0.991$, $r^2=0.982$) and chlordane ($r=0.587$, $r^2=0.344$). Persistence is a known property of the organochlorine pesticides. In one home (home 5), detectable levels of aldrin, dieldrin, chlordane and heptachlor were found 27 years after the last recorded pesticide treatment. Levels of heptachlor recorded in this home were 0.035 $\mu g/m^3$. By contrast, house 2, treated 30 years prior to monitoring, had no detected levels as did house 8, which was treated 6 years prior to monitoring. Dearth and Hites (1991) found that even after 10 years, levels of chlordane had not declined significantly and Bennett et al (1974) reported persistence for up to 21 years. Wright et al (1988, 1991) suggested differences in levels may be due to varying soil types, structural differences between houses, type of pesticides last used and time of last treatment. While additional factors may be application method and concentration of pesticide applied.

No significant correlation was found for aldrin or dieldrin and time after pesticide application. However, Bennett et al (1974) found aldrin levels decreased over time but remained in detectable levels for more than 15 years (and up to 21 years).

The organochlorine pesticide reported by the home occupant to be applied by the pest control operator were closely correlated with the pesticide found at the highest concentration. However, levels of chlorpyrifos did not correlate with the reported use of the pesticide. Multiple pesticides were also detected in a number of homes. In 3 of these homes all the organochlorine pesticides monitored were detected and in one home heptachlor, chlordane, dieldrin and chlorpyrifos were recorded. In 3 other homes mixtures of 3 pesticides were detected in the air. This may reflect the persistence of pesticides over multiple treatments, application equipment not being adequately cleaned out or mixtures of pesticides being illegally applied to homes.

In 7 of the 22 homes, monitoring for pesticides occurred on two or more occasions over a period of up to 3 years, enabling a longitudinal comparison of concentration. Trends in the levels of pesticides present did not show uniformity. In 4 of these houses where chlordane and heptachlor were recorded, levels were found to increase significantly over this period ($r=0.873$, $r^2=0.763$ and $r=0.579$, $r^2=0.335$ respectively). The increase in concentrations may be a result of post-treatment care (eg. ventilation), recent disturbances of the site (movement of soil) or changes in climatic factors which affect the volatilisation and distribution of the pesticides. These results also highlight the limitations of monitoring at a single point in time in an attempt to describe exposure concentrations.

Levels of aldrin and dieldrin declined over time ($r=0.302$, $r^2=0.091$ and $r=0.161$, $r^2=0.026$ respectively). This trend is consistent with other studies (Wright and Leidy, 1982).

Six swabs samples were collected from homes where contamination was suspected. There was no significant correlation between air levels of pesticides and surface swab samples. Dieldrin was present in 5 samples (air and swab).

Studies in the past have found over use of pesticides for termite control and subsequent misapplication in homes in Western Australia (Dingle, 1988). Concerns have also been raised over the levels of pesticides in the air which result from misapplication. Misapplication in the form of spills were reported in 3 (14%) of the 22 homes. Comparison of levels of pesticides from homes in which spills were reported and homes where spills were not reported suggests that the misapplication of pesticides contributes significantly to contamination of indoor air. Concentrations recorded in homes where 'spills occurred' and where 'no known spills occurred' are shown in Table 2. Chlorpyrifos levels had the highest ratio between spill and non-spill homes. Where spills occurred there was a mean air concentration 75 times higher (spill conc. =8.65µg/m^3, non-spill conc. =0.116µg/m^3). Following this, the pesticides in order of decreasing ratios (spills:non-spills) were heptachlor 37:1, dieldrin 20:1, chlordane 5.6:1 and aldrin at 4.2:1 (see Table 2). Although limited by the small number of homes monitored where spills occurred, these results provide some basis to identify homes where spills may have occurred. Houses without spills may be presumed to have background levels around 0.14µg/m^3 of total pesticides in the air, while those recording spills have elevated mean levels around 2.96µg/m^3 or greater of total pesticides in the air, over 21 times higher.

Table 2. Pesticide levels in homes - spills and non-spills (S,NS).

Pesticide	Spill mean conc.	No spill mean conc.	Ratio
	µg/m^3 (range) [n]	µg/m^3 (range) [n]	S:NS
Heptachlor	4.1 (1.3 - 6.9) [2]	0.11 (0 - 0.57) [13]	37 : 1
Aldrin	0.9 [1]	0.38 (0 - 2.1) [10]	4.2 : 1
Dieldrin	0.8 [1]	0.04 (0 - 0.37) [13]	20 : 1
Chlordane	0.28 (0.26 - 0.3) [2]	0.05 (0 - 0.14) [11]	5.6 : 1
Chlorpyrifos	8.65 (1.3 - 16) [2]	0.12 (0 - 0.49) [5]	72 : 1

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